AEG

Load Impact Evaluation of California Capacity Bidding Programs

PY2023 Evaluation Plan

Prepared for: PG&E, SCE, and SDG&E

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Date: September 29, 2023

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INTRODUCTION AND KEY ISSUES

This evaluation plan describes AEG's approach to conducting a load impact evaluation of the Capacity Bidding Program (CBP) offered by three investor-owned utilities (IOUs) in California: Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E). The evaluation is conducted under the guidance of the Demand Response Measurement & Evaluation Committee (DRMEC). The DRMEC consists of representatives from the three IOUs and the California Energy Commission (CEC). PG&E is managing the contract for this joint study for the three IOUs.

CBP is a statewide price-responsive DR program available at the three IOUs, although the IOUs' programs differ slightly in program features and operation. Customers may sign up directly with the IOU as a self-aggregator or they can participate through a third-party demand response aggregator.

Report Terminology

TERM	DEFINITION
PROGRAM	**A combination of IOU, Customer Class, and Notification Type.** For example, SDG&E has two programs: (1) SDG&E Non-residential Day Ahead and (2) SDG&E Non-residential Day Of.
PRODUCT	**A product offering within each program.** For example, the PG&E Day Ahead program has three products: (1) Elect, (2) Elect+, and (3) Prescribed.
CUSTOMER CLASS	Defined as **Residential or Non-residential**.
NOMINATION	**A monthly nominated resource by program, product, aggregator, and Sub-LAP.** Each nominated resource has a corresponding capacity nomination (MW) and enrolled customers.
DISPATCHED	**An entity called to a market-triggered event.** For example, a dispatched resource, dispatched customers, dispatched capacity, etc. Not all nominated entities are dispatched.
AVERAGE EVENT DAY	For each product, calculated as **the average of all events dispatched** regardless of event hours and number of Sub-LAPS. The program-level average event day is the sum of all product-level average event days. Load impacts are reported for each program and product's most dispatched event hour.
REPORTING HOUR	**The hour reported for the ex-post average event day.** This hour is the most dispatched event hour for each program and product.
DELIVERY PERFORMANCE	A percentage metric equal to the ex-post aggregate load impacts **divided by the overall dispatched capacity**. It was referred to as "nomination achievement" in the PY2020 report.
ADJUSTED DELIVERY PERFORMANCE	A percentage metric equal to the ex-post aggregate load impacts **divided by the reporting hour (HE19 for SDG&E or HE20 for PG&E and SCE) dispatched capacity**. We calculate an adjusted metric to measure performance because our definition of the average event day includes events that did not dispatch capacity during the reporting hour.
IMPACT DEGRADATION RATE	**An assumption developed for a simulated 5-hour RA window** based on historical events. This assumption represents how customers, on average, can maintain impacts throughout events called for longer durations.

Research Objectives

The key objectives for the program year 2023 (PY2023) are as follows:

- An ex-post impact analysis to estimate hourly and average daily load impacts for each event day and for the average event day for each program year. These results will be presented for each IOU's CBP products and programs. They will be provided for the average customer, for all customers in aggregate, and for each of the following participant segments:
  - Each Sub-Load Aggregation Point (SubLAP),
  - Each industry type,
  - Each customer size,
  - AutoDR participants,
  - Dually enrolled DR customers, and
- An ex-ante impact analysis to estimate hourly load impacts for eleven[1] years following the current program year. These results will be estimated based on each IOU's and CAISO's 1-in-2 and 1-in-10 weather conditions for a typical event day and each monthly system peak day. These results will be presented separately for each IOU's CBP program for both program-specific and portfolio-adjusted scenarios. The impacts will be provided for all hours in which the program is available, as well as, during the resource adequacy (RA) window for the average customer, all customers in aggregate, and for each of the following participant segments (as applicable):
  - Each Sub-Load Aggregation Point (SubLAP),
  - Each Local Capacity Area (LCA), and
  - Each customer size.
- A supplemental analysis to satisfy the requirements Part B of the Long-Term Procurement Plan (LTPP) for all three IOUs.
  - For SCE and SDG&E, Part B reports portfolio ex-ante load impacts for an August system peak day in a 1-in-2 weather year by WECC transmission level busbar.
  - For PG&E, AEG will provide support to satisfy PY2023 portfolio-wide requirement Part B of the LTPP.
- An analysis to estimate the incremental impacts attributed to dual enrollment to AutoDR programs.

Key Issues for the PY2023 Evaluation

Discussions during the project initiation meeting held on September 18, 2023, focused on changes to the programs and new issues to address during the PY2023 analysis of load impacts:

- <u>Project timeline</u>: Similar to PY2022, expecting public posting of reports in approxmately March 10^{th} – 22^{nd}, 2024
- <u>Ex-ante analysis</u>:
  - Update RA window shape assumptions using PY2023 ex-post findings.

[1] For PG&E and SDG&E, ex-ante impacts will be provided for a 12-year time horizon, which includes the weather-normalized impacts for the current program year and the next 11 years.

- RA window shift starting in 2023, applies to all 3 IOUs:
  - 5:00-10:00 PM for March and May, and 4:00-9:00 PM for all other months.
- Additional analysis: TA/TI incremental analysis can be removed; AutoDR is still in interest.
- Reporting:
  - Keep the PY2022 reporting format, with IOU specific sections.
  - SDG&E requested adding a slice-of-day estimates tab to the ex-ante table generator.
  - SDG&E requested calculating the impact for Ex-Post:
    - Impact on Nominated customers vs. Dispatched customers (Awarded customers), as an additional layer of estimating the program performance
  - Adding dispatched capacity into the ex-post table generators.
  - Re-evaluate the approach to reporting delivery performance.
    - Produce an average event hour; consider subLAP level average.
    - Maintain the existing approach to the average event day with the 24-Hour load profile.

The following summarizes the expected program changes for each IOU.

PG&E

- Program changes effective March 8, 2021:
  - 5-in-10 baseline option for residential customers.
  - The nomination deadline is now between the 1st to the 15th of prev. month.
  - The bidding deadline for Elect/Elect+ is now 3 days before trade day.
  - Prescribed, 1-4 hour option is now allowed for nominations <100kW in a subLAP provided a match can found to make up to 100KW or more in the same subLAP among the other retail resources nominated
  - Increased the maximum number of events per month to six.
- Changes for PY2022:
  - Implemented the $650 per MW bid cap on the Elect product.
  - Implemented optional weekend events in the Elect and Elect+ products.
  - Increased October capacity incentive.
- Expecting Residential participants; received October 2023 nominations.

SCE

- There are no substantial changes to Non-residential CBP.
- Submitted 2022 DR Application A22-05-004; not yet approved at the time of the Kick-off; expected CPUC decision in late 2023. The proposed changes to be effective in 2024 are as follows:
  - Discontinue the Day Of program and products,

- Switch to a summer-only program (May through October),
- Change the CBP dispatch window to 4 PM to 9 PM, aligning with the RA window,
- Require aggregators to commit to bidding into an entire season, allowing for month-to-month adjustments on capacity nominations,
- Adjust the 15-day limit to a 75-day limit for bid entry.
- Increase the maximum number of events allowed per month from 5 to 6 events, with the same number of available hours (30 hours per month).

SDG&E

- The Residential CBP estimates will be included in a separate PY23 Residential CBP pilot report.

Plan Organization

The remainder of this evaluation plan is organized into the following sections:

- Section 2 presents an overview of the study method.
- Section 3 lists the types and sources of data necessary for the evaluation.
- Section 4 presents the detailed plan by task and subtask.
- Section 5 shows the schedule for the evaluation activities and deliverables by task.
- Section 6 outlines quality control mechanisms and processes for ensuring that all tables, figures and values, and input and output data are internally consistent and accurate in final reporting.

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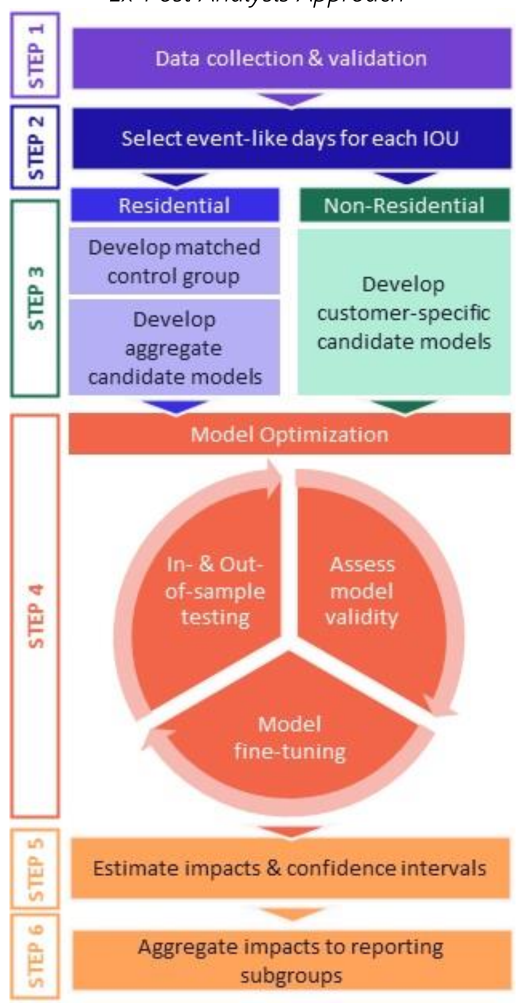
STUDY METHOD

AEG's overall method will follow the DR Load Impact Protocols and is designed to meet the specific objectives of the project. We will continue to conduct the evaluation independently for each IOU to account for differences between each IOU's CBP participants. However, the same basic methodology will be employed across all three IOUs to maintain consistent and defensible results. We will work closely with the IOUs throughout the evaluation to ensure our models appropriately and accurately estimate both ex-post and ex-ante impacts.

Ex-Post Impact Analysis

Ex-Post Analysis Approach



The figure to the right shows the overview of our ex-post analysis approach, and each step is detailed in Section 4.

With the addition of PG&E's Residential participation starting in PY2020, it is essential to highlight the key differences in the approaches for the two customer classes.

For non-residential participants, we will continue to utilize a within-subjects design using customer-specific hourly regression models. It remains the most flexible, consistent, and appropriate solution for CBP's evaluation goals and population distributions. AEG has well-established processes and algorithms that deliver efficient analysis execution and outputs from start to finish. Each step has been refined over AEG's years of experience on aggregator-managed DR program evaluations.

For residential participants, we will utilize a matched control group design using aggregate hourly regression models. This is the best practices approach for participant populations with less variable loads, which can leverage the higher statistical power with more customers included in each model. A matched control group also more effectively estimates the counterfactual load in the absence of a randomized control trial. Through AEG's experience with the statewide Critical Peak Pricing (CPP) evaluations, we adapted our processes and algorithms for aggregate-level modeling and successfully utilized them in several residential analyses, including PY2020 and PY2021 PG&E Residential CBP and PG&E Residential SmartRate™.

Ex-Ante Impact Analysis

In this section, we discuss our approach to the ex-ante load impact analysis. AEG will remain mindful that ex-ante forecast is evaluated under current circumstances and will work with each IOU to determine if additional adjustments should be applied to each program year's ex-ante. As an instance, when the COVID-19 global pandemic commenced in March 2020, AEG reviewed the necessity of further adjustments linked to the pandemic's economic impact. While no definitive findings were established to validate assumptions or changes reflecting COVID-19 conditions, the acknowledgment of this evaluation remains appropriate.

The figure below shows our approach, and we discuss each step of the analysis in Section 4.

Ex-Ante Analysis Approach

Additional: Power BI Dashboard

AEG's project team aims to deliver a comprehensive Power BI Dashboard, complete with data validation, ex-post and ex-ante outputs by March 2024.

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DATA SOURCES

The data request includes the items listed below. Specifics related to each data item are included in the data request file embedded in Appendix A.

- Aggregator monthly bid and nomination data
- Customer characteristics and participation information
- Customer characteristics for residential non-participant pool
- Local capacity area and local busbar identifier
- CBP event data including product, dates, time, and duration of each event, and trigger information
- Other DR program event data (for dually enrolled participants)
- Post-event estimated load impacts provided to CAISO
- Hourly interval usage data
- Actual hourly weather data by weather station
- IOU and CAISO 1-in-2 and 1-in-10 hourly weather scenarios for monthly peak day and typical event day
- Eleven-year enrollment forecast data for each program and reporting subgroup
- Information on recent and expected program changes
- Outage Data by account
- Award date and Flex Alert date

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DETAILED WORK PLAN

Task 1: Schedule and Conduct Project Kickoff Meeting

The project began with a project initiation meeting held on September 18, 2023. The meeting kicked off the project and focused on planning for the PY2023 evaluation. Meeting participants included representatives from the PG&E, SCE, SDG&E, and AEG. This evaluation plan incorporates the results from the meeting.

Prior to the meeting, AEG delivered a meeting agenda and a PowerPoint slide deck to help guide the discussion. AEG then followed up with a memorandum that summarized discussions during the meeting and listed the actions agreed upon by the parties. Appendix B contains these two documents in the form of embedded links to the files.

Task 2: Evaluation Plan

This document constitutes the evaluation plan for PY2023.

Task 3: Data Collection and Validation

Data Collection

Our team will prepare a comprehensive data request in MS Excel format for each IOU that details the data AEG will need to complete the evaluation of ex-post and ex-ante load impacts. The request will itemize each data item by category and serve to organize and track our data collection efforts throughout the evaluation process. We will submit data requests and collection trackers to each IOU. Similar systems have proved effective in mitigating miscommunications and identifying inaccurate or missing data items before they have any substantial impact on the evaluation timeline or costs.

We will use the data request file to track the receipt of data, including listing the filename and date received for each item. We will also utilize bi-weekly check-in meetings to keep track of the data collection progress and identify/discuss any issues as soon as they arise.

Data Validation

To perform the analysis across all three IOUs, we will construct a database that houses the utility data and information we collect for the impact evaluation. The database will serve as the foundation for the data validation process.

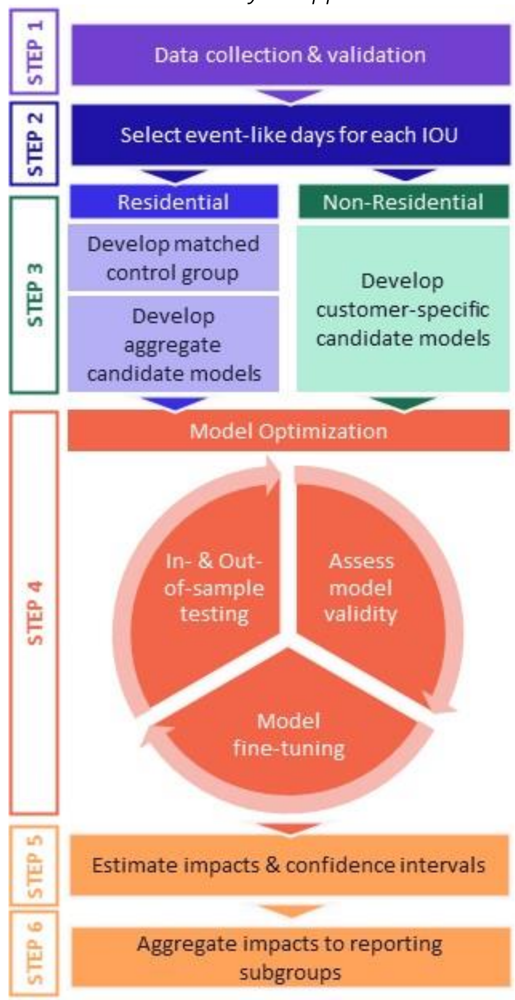
AEG's current validation process includes screening the interval data for zero usage intervals, missing intervals, potentially erroneous peaks and valleys, and other erroneous intervals while being mindful of the risks posed by over-omitting data. We utilize this automated approach to flag possible erroneous intervals. Still, we are careful to consider how event days may differ from non-event days and how each customer class may require a distinct set of screening algorithms. For example, non-residential participants can potentially have event days that contain zero intervals and outlier reads, depending on their curtailment approach. However, for residential participants, zero intervals and outlier reads are more likely to indicate missing data or power outages. We also apply the same zero, missing and erroneous checks on the hourly temperature data. Lastly, we make sure the time zones are assigned correctly in both data sets.

We will document the counts of intervals or customers removed from the analysis for each IOU, customer class, industry type, and customer size (as appropriate) during each step in the data validation process to determine the reasonableness of omissions from a top-down perspective. In addition, we will spot-check a small sample of dropped intervals from each segment to confirm the appropriateness of omissions in those cases and incorporate any updates to the data validation process as needed to ensure we use the best available data for the analyses.

Task 4: Ex-Post Impact Analysis

The figure to the right shows the overview of our ex-post analysis approach. Step 1 is discussed under Task 3. The remaining steps are discussed in the following subsections.

Ex-Post Analysis Approach



Step 2. Event-Like Day Selection

The selection of comparable non-event days (i.e., event-like days) is essential to several of the evaluation activities. Event-like days will be used in the matched control group development and the out-of-sample testing in model optimization. In matched control group development, these event-like days will serve as the basis for matching participants to non-participants by ensuring that matched customers consume energy similarly on days that are comparable to event days. In out-of-sample testing, we will use event-like days to test the predictive abilities of each model as part of our model optimization process, employed regardless of the analysis design.

The event-like days should include 5 to 15 days which are comparable to called CBP events in weather, day of the week, and month of the year. As in many of our previous CA DR evaluations, we will select the group of days that collectively minimize the Euclidean distance (ED) across multiple weather-based criteria.[2] This well-established approach will identify the set of days that are as similar as possible to actual event days. We describe the ED matching method in more detail in a subsequent subsection on Matched Control Group Development.

[2] In previous CA DR evaluations, we included three weather variables in the Euclidean distance metrics calculation to select event-like days: (1) daily maximum temperature; (2) average daily and daily maximum temperatures; and (3) average daily temperature. We will work with each IOU to determine which weather variables are best suited for selecting days that are most similar to CBP events. The ED metrics previously used can be calculated by the following equation:

$$ED = \sqrt{(MaxTemp_{event} - MaxTemp_{non-event})^2 + (MinTemp_{event} - MinTemp_{non-event})^2 + (MeanTemp_{event} - MeanTemp_{non-event})^2}$$

Step 3. Analysis Designs by Customer Class

In this section, we discuss the analysis designs for both non-residential and residential customer classes.

Non-Residential Analysis Design

AEG will continue utilizing a within-subjects, customer-specific modeling approach for all non-residential participants across all three IOUs. Given the evaluation objectives and the potential differences across service territories, customer-specific models offer the most flexible, consistent, and appropriate solution for several reasons:

- Commercial and industrial customers often vary significantly from one another in load shape, weather response, and overall size. Customer-specific models allow us to capture differences between customers; therefore, they can better model changes in energy usage than an aggregated model. The models can easily control for variation in load due to weather conditions, geography, and time-related variables (day of the week, month, hour, etc.). They also control for unobservable customer-specific effects that are more difficult to account for in aggregate regression models.
- The data conforms to a repeated-measures design because the events are called only on isolated days over the program year, and the participants face similar TOU rates on all other days. A repeated-measures design means that all participants are subjected to the treatment simultaneously, repeatedly throughout the study. In this case, the control is defined as an absence of the treatment or the non-event days.
- The models estimate individual customer impacts that can be summed together to estimate impacts for any reporting subgroup, including but not limited to IOU, program, product, aggregator, LCA, SubLAP, industry type, or customer type.

Develop Candidate Customer-Specific Models. It is not practical to develop models individually for thousands of participants; therefore, AEG will develop a set of candidate models that will go through our model optimization process to select the best model for each participant.

In general, we think of regression models as being made up of building blocks, which are in turn made up of one or more explanatory variables. These different sets of variables can be combined in various ways to represent different types of customers. The blocks can be generally categorized into either "baseline" variables or "impact" variables and could be made up of a single variable (e.g., cooling degree hours (CDH)) or a group of variables (e.g., days of the week). The baseline portion of the model explains variation in usage unrelated to DR events, while the impact portion explains the variation in usage related to a DR event.[3]

The table below presents the different explanatory variables that may be used to create candidate models for CBP participants. We will first develop a set of candidate models that will likely represent a wide variety of customers and their impacts. We will use our judgment and experience and work closely with each IOU to develop an initial set of 10 to 15 models to run through our optimization process.

[3] Any unexplained variation will end up in the error term.

Explanatory Variables Included in Candidate Models

Variable Name	Variable Description
	Baseline Variables
$Weather_{i,d}$	Weather-related variables including average daily temperature, cooling degree hour (CDH), heating degree hour (HDH), and lagged versions of various weather-related variables. We expect to use different CDH/HDH base values depending on the service territory.
$Month_{i,d}$	A series of indicator variables for each month.
$DayOfWeek_{i,d}$	A series of indicator variables for each day of the week.
$OtherEvt_{i,d}$	An indicator variable for event days of other DR programs (for dually enrolled customers).
$AvgLoad_{i,d}$	The average of each day's load in a specified window. We expect to test different non-event windows through the model optimization process.
Baseline Interaction Variables	A set of interaction terms between different baseline variables.
	Impact Variables
$P_{i,d}$	An indicator variable for CBP event days.
$Product_{i,d}$	A series of indicator variables for each product offering within an IOU's program.
$P * Month_{i,d}$	An indicator variable for CBP event days interacted with the month.
$P*EventHour_{i,d}$	An indicator variable for CBP event days interacted with an indicator for the hour the event is called.
$P*EventWindow_{i,d}$	An indicator variable for CBP event days interacted with an indicator for the window the event is called

Residential Analysis Design

AEG will continue utilizing a matched control group and aggregate modeling approach for all residential participants across all three IOUs, as applicable. This analysis design is appropriate for several reasons:

- Residential participants do not typically have highly variable loads. This allows for the effective use of aggregate models, which have higher statistical power with more customers included in the model.
- Utilizing a matched control group enables us to estimate event-day impacts against counterfactual load developed from non-participant consumption on the actual event day.
- The models will estimate the load impacts for each combination of reporting subgroups required in the CPUC LIP. The results for each combination can be easily aggregated to represent impacts for each of reporting subgroups required by the CPUC LIP.

Matched Control Group Development. To create the matched control group, we plan to use a Stratified Euclidean Distance Matching (SEDM) technique that we have used successfully with many other utilities in more than a dozen evaluations, including the PY2020 and PY2021 statewide CBP evaluation. The SEDM technique includes the following steps.

Step 1: Define the participant and non-participant populations and the treatment and pre-treatment periods for each participant. At this stage, we will assess the eligibility of participant and non-participant customers for matching based on the availability of event-like day usage data, dual participation in other DR programs, demographic information, etc. We will work with each IOU to develop these criteria. Next, we will assign the participant and eligible control group customers to strata based on categorized characteristics and will match participants to eligible control customers within their assigned strata. We will stratify based on LCA or subLAP, but we will work with each IOU to determine the appropriate strata definitions. This stratified approach ensures that we match customers with similar characteristics to one another, enabling us to better control for some of the unobservable attributes that affect the way customers use energy. Note that each stratum should have an appropriate ratio of eligible control customers to participants to ensure accurate matches. We typically recommend a 5-to-1 ratio of control customers to participants, but larger ratios can yield better matches.

Step 2: Perform the one-to-one match based on the hourly demand data of event-like days. As discussed earlier, we use the event-like days to establish that the control and treatment customers would likely have consumed energy similarly on CBP event days in the absence of the program. We will use an ED metric to determine the similarity in load shapes on event-like days between each treatment customer and eligible control customer, assessing the similarity in usage patterns using the following three demand variables:

- The average demand on event-like days during the event window.
- The demand on event-like days during the typical system peak hour.
- And the average demand on event-like days during the hours outside the typical event window.

Within strata, we will match each treatment customer to every eligible control customer and calculate the ED according to the equation below. Each matching variable will be weighted to reflect its relative importance in identifying similar usage patterns, with event window hours having the most weight and the average demand outside the typical event window having the least weight.

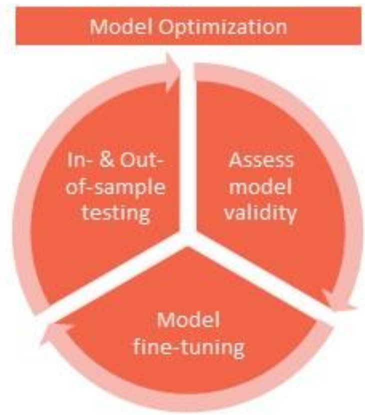
$$ED = \sqrt{w_1(avgevnt_{Ti} - avgevnt_{Ci})^2 + w_2(systempeak_{Ti} - systempeak_{Ci})^2 + w_3(avgnonevnt_{Ti} - avgnonevnt_{Ci})^2}$$

We will finalize the one-to-one match of control to treatment customers by selecting the control customer who minimizes the ED. Once the matching process is complete, we will thoroughly review the match using the appropriate t-tests and visual inspection of the event-like day load shapes.

Develop Candidate Aggregate Models. AEG will develop a set of candidate models that will go through our model optimization process, similar to the process described for non-residential participants. These candidate models will be developed for a matched control design using aggregate models. In other words, we will include indicator variables for participants in the baseline block and potentially interaction variables with this participant indicator variable.

AEG anticipates that the residential programs will require only a handful of model subgroups, each needing around five candidate models. The model optimization process will serve as a starting point to our model selection, leveraging automated algorithms that we have developed for previous C&I DR evaluations, and will play a key role in assessing model validity to justify our confidence in our impact estimates.

Step 4. Model Optimization and Selection



Through our optimization process, we will select and validate hourly regression models for each segment and class such that they:

- Accurately predict the actual participant load on CBP events, and
- Accurately predict the reference load, or what customers would have used on CBP events in the absence of an event.

To meet these two goals, we will take each set of candidate models developed in the previous step and run them through our optimization process that includes a three-part cycle consisting of (1) testing the models' abilities to predict in-sample and out-of-sample, (2) assessing model validity, and (3) fine-tuning the models. We discuss each part below.

In-Sample and Out-of-Sample Testing. We use in-sample tests to assess how well each model performs on the CBP event days, which helps us understand how well the model predicts the actual load. We use out-of-sample tests to assess how well each of the candidate models predicts customers' loads on event-like days, which indicates how well each model may predict the reference load.

- To perform the in-sample test, we fit each candidate model to the entire data set. The results of these fitted models are used to predict the usage on CBP event days. The models should be able to accurately predict customers' actual consumption on these days, having controlled for the impacts of the event hours. We assess the accuracy and bias of the predictions by calculating the mean absolute percent error (MAPE)[4] and mean percent error (MPE)[5], respectively. We refer to these metrics as the in-sample MAPE and MPE.
- To perform the out-of-sample test, we fit each candidate model to the data set excluding event-like days. The results of these fitted models are used to predict the usage on event-like days. We similarly assess the accuracy and bias of the event-like day predictions by calculating the MAPE and MPE, which we refer to as the out-of-sample MAPE and MPE.

These two tests result in several in-sample and out-of-sample metrics. To determine the best model for each segment in terms of its abilities to predict both the reference load and the actual load for each segment with accuracy and limited bias, we will combine the two tests into a single metric as follows:

$$\boldsymbol{metric_{ic}} = (0.4 * MAPE_{in}) + (0.4 * MAPE_{out}) + \big(0.1 * abs(MPE_{in})\big) + \big(0.1 * abs(MPE_{out})\big)$$

The best model for each segment will minimize this overall metric.

[4] The mean absolute percent error (MAPE) is defined as: $MAPE = \frac{100\%}{n}\sum_{h=1}^{n}\left|\frac{Actual_h - Estimate_h}{Actual_h}\right|$

[5] The mean percent error (MPE) is defined as: $MPE = \frac{100\%}{n}\sum_{h=1}^{n}\frac{Actual_h - Estimate_h}{Actual_h}$

Assessing Model Validity. AEG will confirm that all best models for each participant (non-residential) or segment (residential) collectively deliver acceptable levels of accuracy and bias by calculating the weighted average MAPE and MPE at the program level. Valid models will result in low or very close to zero MAPE and MPE.

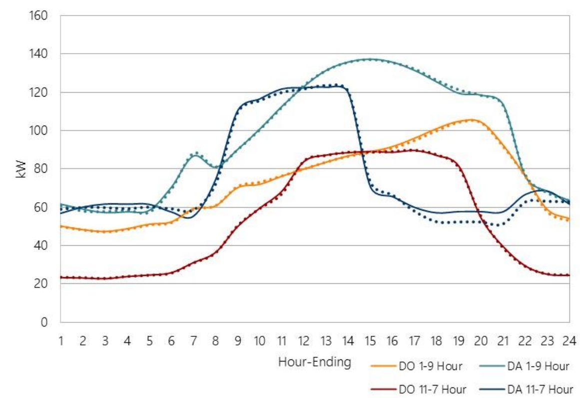
The table to the right provides an example of the weighted average MAPE and MPE for the final set of models estimated for SDG&E customers during a previous CA statewide CBP evaluation for each SDG&E program. Across all programs, AEG constructed models with MAPE values of less than 4% and MPE values within ±1%, indicating that the selected models were able to predict customer consumption in-sample and out-of-sample with a high degree of accuracy and low level of bias.

SDG&E Weighted Average MAPE and MPE

	Out-of-Sample		In-Sample	
Program	**MAPE**	**MPE**	**MAPE**	**MPE**
Day Ahead	3.08%	-0.09%	2.04%	-0.05%
Day Of	1.70%	0.40%	1.62%	-0.16%

The figure to the right provides the average event-like day predicted and actual loads from the out-of-sample tests from the same evaluation. As expected, the final models predicted load very close to the actual load, which tells us that, on average, the hourly regression models accurately estimated customer loads on event-like days and can likely produce accurate reference loads during the events. We expect similar results when we use our well-established optimization process.

SDG&E Actual and Predicted Loads on Event-Like Days



Model Fine-Tuning. We also routinely use visual inspection of the results as a simple but highly effective tool. We will look for specific aspects of the segment-level predicted and reference load shapes during the inspection to tell us how well the models perform. We use any observations derived from these inspections to make any necessary edits to the model specifications obtained from the optimization process. For example:

- We check to make sure that the reference load is closely aligned with the actual and predicted loads during the early morning and late evening hours when there is likely to be little effect from the event. Large differences can indicate that there is a problem with the reference load either over or underestimating usage in the absence of the rate.
- We closely examine the reference load for odd increases or decreases in the load that could indicate an effect that is not properly being captured in the model.
- We also look for bias both visually and mathematically. Identification of bias and its source often allows us to adjust the models to capture and isolate the bias-inducing effects within the model specification.

Step 5. Estimate Load Impacts and Confidence Intervals

The following example illustrates the process of estimating the impacts from the final model for a single modeling segment (i.e., one non-residential participant or one residential program). The process will be the same for both residential and non-residential models with the following differences:

- The non-residential load impacts will be estimated individually for each participant from the customer-specific models.
- The residential load impacts will be estimated for each combination of reporting subgroups required in the CPUC LIP.

In this simple example below, α_t, δ_t, and CDH_t, make up the baseline blocks of the model, and explain variation in kwh_{it} unrelated to demand response events. The remaining variables, $EVNT$, and the interaction term $(\alpha_t * EVNT)$ are the impact blocks and explain the variation in kwh_t related to a CBP event.[6] An hourly model like the equation below can be equivalently estimated as one model with hourly dummy variables or as 24 separate hourly models.

$$kwh_{it} = \beta_0 + \beta_1\alpha_t + \beta_2\delta_t + \beta_3 CDH_t + \beta_4 EVNT + \beta_5(\alpha_t * EVNT) + \varepsilon_{it}$$

Where:

kwh_{it} is the consumption of customer i in hour t.

β_0 is the intercept.

β_n is the coefficient associated with each explanatory variable.

α_t is a vector of baseline explanatory variables (e.g., average load, baseline interactions, etc.).

δ_t is a vector of calendar variables (i.e., month, year, and day of the week).

CDH_t represents the cooling degree hours for hour t.

$EVNT$ is a dummy variable indicating that hour t was on a CBP event day.

$(\alpha_t * EVNT)$ is an interaction between the event indicator and the subgroup indicator variables.

ε_{it} is the error for customer i in time t.

This type of time-series data is likely to have both autocorrelation and heteroskedasticity. To address autocorrelation, we will utilize two techniques: (1) estimate 24 separate models for each hour to remove autocorrelation from hour to hour, and (2) incorporate seasonal indicators to minimize autocorrelation. To address heteroskedasticity, we will use the Huber-White robust error correction.

Using the model above as an example, we will estimate the load impacts as follows:

- First, we will obtain the actual and predicted load for each segment on each hour and day based on the specification defined in the model equation.
- Next, we will use the estimated coefficients and the baseline portion of the model to predict what this segment would have used on each day and hour if there had been no events. We call this prediction the reference load.
- We will calculate the difference between the reference load (the estimate based on the baseline blocks) and the predicted load (the estimate based on the baseline + impact blocks) on each event day. This difference represents our estimated load impact for each segment.

To show the actual observed load (and avoid confusion associated with the predicted load), we will re-estimate the reference load as the sum of the observed load and the estimated load impact.

Because the impacts are statistical estimates, it is essential to establish a range or confidence interval around the estimates resulting in the uncertainty-adjusted load impacts required by the CPUC LIP. We will

[6] Any unexplained variation will end up in the error term.

utilize a statistical package to output the standard errors of the point estimates. The standard errors can then be used to calculate a confidence interval at various levels (e.g., 50%, 70%, 90%, etc.) for each segment.

Step 6. Aggregate Load Impacts to Reporting Subgroups

For non-residential participants, we will estimate the load impacts individually for each participant, which can be easily aggregated to represent impacts for each of the required reporting subgroups for each of the three IOUs. In some cases, we may need to apply average per-customer impacts as a proxy for the impacts realized by one or more customers on a given event day if part of their data is invalid and, therefore, omitted during the data validation process. In these cases, we will determine the aggregate impact for a particular subgroup based on the per-customer estimate of the customers with valid data within that subgroup and the total dispatched accounts associated with that grouping for the given event. This process allows us to avoid under-reporting the impacts due to missing or invalid data.

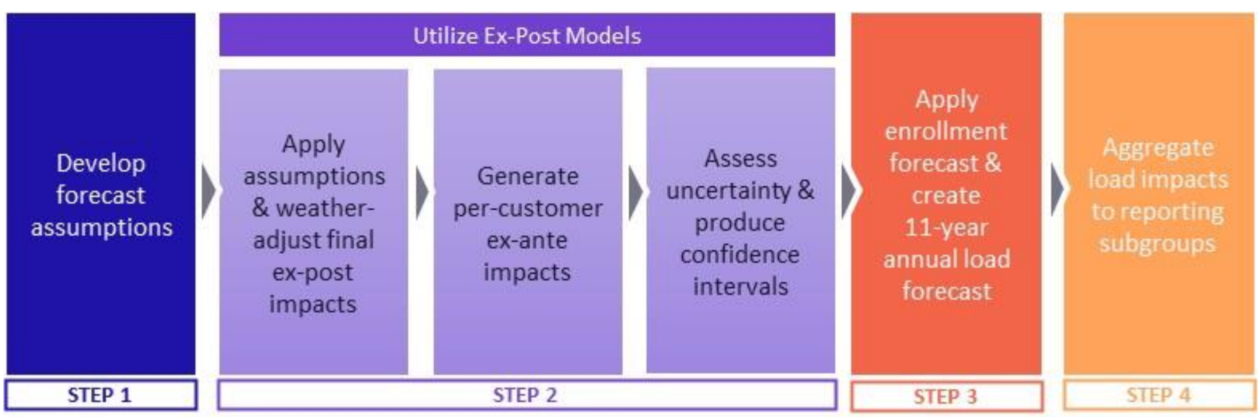
For residential participants, we will estimate the load impacts for each combination of reporting subgroups required in the CPUC LIP. This results in a per-customer estimate for each combination of subgroups, which can be easily aggregated to each reporting subgroup by multiplying by the number of participants within each combination.

To estimate statistical certainty for each reporting subgroup, we can assume that the estimates are independent across participants, and consequently, estimates are independent across modeling segments. Thus, the variance of the sum is the sum of the variances. We can follow this approach to obtain the confidence intervals for each reporting subgroup and each IOU service territory.

Task 5: Ex-Ante Impact Analysis

The figure below shows our approach, and we discuss each step of the analysis in the following subsections.

Ex-Ante Analysis Approach



Step 1. Develop Forecast Assumptions

During each program year's kickoff meeting, we talked through each IOU's CBP proposed and approved program changes in the context of the ex-ante load impact forecast. We will continue discussions via several check-in meetings through the forecast assumption development. We anticipate program elements that may affect the forecast assumptions to include, but is not limited to:

- Updated assumptions on the shape of the impacts across the 5-hour RA window based on historical events called for longer durations for each IOU and program.
- Ex-post analysis findings on realization rates, i.e., delivery performance rate.
- Program changes such as product offerings, event durations, dispatch windows, resource requirements, event triggers, event notification procedures, etc.
- Aggregator feedback to IOU program managers on forecasted participant recruitment and deliveries.

We will utilize findings and results from each IOU to develop forecast assumptions as needed and as applicable. For example, in PY2021, PG&E residential CBP will be in its second year of active participation. Any observations, experiences, and statistical findings can be valuable in developing forecast assumptions as SCE and SDG&E anticipate, including residential participation in coming years.

Step 2. Utilize Ex-Post Regression Models

We will use the ex-post hourly regression models to apply developed forecast assumptions and predict weather-adjusted impacts for each weather scenario. This will produce a set of impacts under each of the different weather scenarios required by the CPUC LIP, typical event day, and monthly peak for both IOU and CAISO 1-in-2 and 1-in-10 weather years. To do this, we will carry out the following steps:

- Apply Assumptions and Weather-Adjust Impacts. We will assemble an input dataset that includes the appropriate forecast assumptions and required weather scenarios for each non-residential participant with a customer-specific model and each combination of residential reporting subgroups required in the CPUC LIP.
- Generate Per-Customer Ex-Ante Load Impacts. Using the final ex-post hourly regression models, we will predict two scenarios of an average customer load for each participant and subgroup: (1) Reference Load – assuming a non-event day; and (2) Predicted Load – assuming a CBP event day. We will then calculate the ex-ante load impact for each participant and subgroup by subtracting the weather-adjusted predicted load from the weather-adjusted reference load.
- Assess Uncertainty and Produce Confidence Intervals. Similar to the ex-post analysis, it is vital to establish a confidence interval around the estimates resulting in the uncertainty-adjusted load impacts required by the CPUC LIP. We will utilize a statistical package to output the standard errors of the point estimates. The standard errors can then be used to calculate a confidence interval at various levels (e.g., 50%, 70%, 90%, etc.) for each subgroup and participant.

Step 3. Create 11-Year Annual Forecast

Non-residential participant ex-ante load impacts can be grouped together to produce per-customer average impacts for each combination of non-residential reporting subgroups required in the CPUC LIP. Both residential and non-residential per-customer estimates can be multiplied to program enrollment counts to create an annual forecast of load impacts over the next 11 years. For PG&E and SDG&E, we will include a "back-cast," which consists of weather-adjusted ex-post estimates of the current program year. Each IOU will provide an 11-year enrollment forecast, while the "back-cast" will utilize actual program year enrollment counts.

Step 4. Aggregate Load Impacts to Reporting Subgroups

Once ex-ante load impact forecasts have been predicted for each combination of reporting subgroups, for each of the desired weather scenarios, it becomes a relatively simple exercise to aggregate the load impacts and generate per-customer average impacts for each of the CPUC LIP required reporting subgroups.

To estimate statistical uncertainty for each reporting subgroup, we can assume that the estimates are independent across participants, and consequently, estimates are independent across subgroups. Thus, the variance of the sum is the sum of the variances. We can follow this approach to obtain the confidence intervals for each reporting subgroup and each IOU service territory.

AEG recognizes that there will also be an error in the enrollment forecast. Assuming that each IOU can provide the necessary uncertainty information from the enrollment models, we will incorporate the enrollment error into the estimated confidence intervals for the ex-ante forecasts.

Task 6: Reporting & Database

- AEG will deliver a project database that includes all the data collected or developed during the evaluation. The database will be delivered to each of the three IOUs under the appropriate confidentiality protections and prepared in each of the three IOUs' requested file formats. The database will also include complete documentation regarding estimation techniques and models used in the ex-post and ex-ante impact analyses.
- AEG will conduct presentations with each IOU in Mid-February 2024 to go over the ex-post and ex-ante findings for PY2023.

The final reporting for PY2023 will include two components:

- The report documenting all methodology and results of the load impact evaluation; and
- Table generator workbooks for ex-post and ex-ante impact estimates.

We will first update the load impact table generators for both ex-post and ex-ante analyses to be filed with the report using the standardized input selection fields presented in the RFP. We will work with the Project Managers and review the appropriate tariff requirements, program specifications, regulatory decisions, and any additional material necessary to determine the appropriate options to include in each field.

Next, we will create and deliver a draft report that describes the results of the ex-post and ex-ante load impact estimation. AEG will virtually present the draft results to each IOU. We will incorporate any comments received during the presentation or directly in the draft report into a Project Final Report. We understand that the draft-review process may require more than one iteration.

We anticipate that the final report will include, at a minimum, the following sections:

- An Executive Summary presenting an overview of the findings.
- An Introduction summarizing the objective of the project and giving an overview of the CBP program.
- A Methodology section presenting the analysis techniques employed in the evaluation.
- A Key Findings and Recommendations section summarizing our findings and recommendations for each IOU.
- IOU Specific Results sections including:
- An Ex-post Results section presenting the program-level load impacts for each CBP event, and average impacts over the entire summer. We will present the load impacts by the more granular subgroups specified in the RFP including but not limited to customer size, LCA, and subLAP.

- An Ex-ante Results section will include the 11-year annual load impact forecast for both a 1-in-2 weather year and a 1-in-10 weather year for both CAISO and IOU-specific weather scenarios.
- A Validity section discussing the methods employed to ensure robust and unbiased estimates from the regression models. We will also present graphs that compare the estimated load with actual load for similar event-like days in each evaluation year.
- A Comparisons section discussing the ex-post and ex-ante results relative to the previous program year's results.

Task 7: Load Impact Workshop

Each year, AEG will prepare the draft and final versions of a presentation summarizing the results of the evaluation. We will then attend the annual DRMEC load impact workshop and present the ex-post and ex-ante analysis results.

Task 8: Supplemental Analysis for Long Term Procurement Plan (LTPP)

For PG&E, SCE and SDG&E, AEG will satisfy any additional deliverables required to fulfill LTPP staff requested supplements to annual IOU load impact reports for DR programs for each program year evaluation. AEG is experienced with the analysis required for the LTPP Supplemental Analysis. We have fulfilled the Part B and C requirements for SCE since 2016 and SDG&E since PY2017. The LTPP requirements are described in the subsections below.

- Part B. Report portfolio aggregate ex-ante load impact (MW), by program, for 1-in-2 weather year August system peak day, for each year of the entire 11-year forecast period, disaggregated by WECC transmission level busbar, in plain Excel format. The WECC transmission level busbar shall be identified by two columns (fields) in the Excel file: (1) WECC busbar number as used in CAISO power flow models and (2) substation identifier/name. This applies to all dispatchable DR programs. The methods and assumptions for disaggregating DR impacts by WECC transmission level busbar shall be standard and uniform across each IOU and documented in a supplemental report.
- PG&E PY2023 Part B LTPP Support. For PG&E only, AEG will provide analysis support to fulfill portfolio-wide requirement Part B of the LTPP. This supporting task will produce PY2023 impacts at the Busbar-level for the following programs: BIP, CBP, PDP, SmartRate, and SmartAC.

Task 9: Regulatory Support

At the PG&E Project Manager's and/or the DRMEC's request, AEG will provide additional regulatory and analytical support as a follow-up analysis on the evaluation findings.

(Optional) Filing Update

As mentioned in the RFP, the IOUs have the opportunity to update the existing qualifying capacity (QC) values for market integrated DR resources (July 1st of each evaluation year). The update is needed when:

- The current capacity of the load-serving entity's (LSE) DR resource portfolio increases above the threshold of 20% or 10 MW greater than the assigned QC value, and
- The IOU has no plans to increase the RA allocation assigned to the DR resources in the current year.

As requested by each IOU, AEG will fulfill this task and produce any updates to the ex-ante load impact deliverables.

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DELIVERABLES SCHEDULE AND DUE DATES

The table below highlights the months wherein each task is expected to be performed.

AEG Project Schedule

Task	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Task 1: Project Initiation Meeting	Agenda, Memo								
Task 2: Evaluation Plan		Draft/Final Plan							
Task 3: Data Collection & Validation		Data Request							
IOU Deliverables			Majority of Data	Oct Event Settlement	Ex-Ante Enrollment Forecast				
Task 4: Ex-Post Analysis				Draft Ex-Post	Pre-Final Ex-Post	Final Tables			
Task 5: Ex-Ante Analysis					Draft Ex-Ante	Pre-Final Ex-Ante	Final Tables		
Task 6: Reporting, Database & Documentation						Draft Reports	Final Reports, SDG&E Database	PG&E & SCE Database	
Task 7: LI Workshop									TBD
Task 8: Supplemental Analysis for LTPP							SDG&E Tables		SCE Tables
Task 9 (Optional): Regulatory Support									TBD
Power BI Dashboard			Data Validation		Add Ex-Post	Add Ex-Ante	Final		

The table below outlines the associated deliverables for each task and the approximate or specified due date specified in the RFP and discussed during the kickoff meeting.

AEG Deliverables Schedule

Deliverable	Due Date
Task 1: Project Kickoff Meeting	
Agenda & Slides	September 15, 2023 (Completed)
Kickoff Meeting	September 18, 2023 (Completed)
Meeting Memo	September 22, 2023 (Completed)
Task 2: Evaluation Plan	
1st Draft Evaluation Plan	October 2, 2023 (Completed)
2nd Draft Evaluation Plan	5 business days after receipt of 1st draft comments
Final Evaluation Plan	5 business days after receipt of 2nd draft comments
Task 3: Data Collection & Validation	
Data Request	October 2, 2023 (Completed)
IOU Data Delivery	*Settlement Data for Oct. Events by Dec. 4, 2023* ***All Other Data by Nov. 24, 2023***
Task 4: Ex-Post Impact Analysis	
Draft Ex-Post Estimates (Table Generator)	December 11, 2023
Final Ex-Post Estimates (Table Generator)	January 10, 2024
Task 5: Ex-Ante Impact Analysis	
2023-2033 Draft Ex-Ante Estimates (Table Generator)	January 31, 2024
2023-2033 Final Ex-Ante Estimates (Table Generator)	February 22, 2024
Final Reporting	
Ex-Post Results Presentation by IOU	Mid February 2024
Draft Evaluation Report (Ex-Post Results)	February 9, 2024
Ex-Ante Results Presentation by IOU	Mid February 2024
Draft Evaluation Report (Ex-Ante Results)	February 23, 2024
SDG&E Ex-Post and Ex-Ante Datasets	March 1, 2024
Final Evaluation Report	March 8, 2024
Report Public Posting Comment Period	March 10–22, 2024
Technical Abstract for CALMAC	April 10, 2024
Task 6: Database Documentation	
Final Database Documentation	April 28, 2024
Task 7: Load Impact Workshop	
Load Impact Workshop	TBD
Task 8: LTPP Supplemental Analysis	
SDG&E Supplemental Analysis	April 3, 2024
SCE Supplemental Analysis	June 30, 2024
PG&E Supplemental Analysis	June 30, 2024
Task 9. Regulatory Support	
Ex-Ante Update (TBD)	July 1, 2024

The following items are the deliverables specific to each IOU:

PG&E Deliverables

- DR Impact Tables (ex-ante load impacts)
- Return of Load
- PY2023 LTPP Part B requirement (All PG&E programs)

SCE Deliverables

- DR MV Forecasting templates
- LTPP Part B requirement
- DR Executive Summary (DSA templates)

SDG&E Deliverables

- Executive Summary tables
- Slice-of-Day Estimates Tab (Table Generator add-on)
- Hourly Ex-post and Ex-ante database
- LTPP Part B requirement
- Impact Estimates based on nominated customers vs. dispatched customers (awarded customers)

6

QUALITY CONTROL MECHANISMS AND PROCESSES

AEG ensures the quality of our work by close teamwork and monitoring. The Analysis Leads, Project Manager, and Project Director will review all deliverables with careful attention to data analysis and reporting quality. We will also communicate regularly with the PG&E Project Manager, as well as with the IOUs as needed, to make sure any questions or issues that come up through the course of the project are thoroughly addressed in a timely manner.

Data Analysis

One way we will ensure quality data analysis is by using the quality assurance (QA) checklist provided by the PG&E Project Manager and revised by AEG during the previous evaluations. The checklist was developed specifically for load impact analysis of CBP programs and addresses five key areas: 1) data request and delivery; 2) ex-post impacts; 3) ex-ante impacts; 4) crosscutting checks, and 5) confidentiality. Appendix C contains the revised Load Impact QA Checklist in the form of an embedded link.

AEG's evaluation team also has internal quality control procedures developed for data analysis in evaluation work. Our analysts are accustomed to following the guidelines, which begin with a clear understanding of the project and analysis objectives and address data diagnostics, data accounting, code conventions, code libraries, use of comments, version control, and review by analysis leads.

Reporting

Our standard review process focuses on reporting content and quality. It ensures the methods and results are clearly, accurately, and consistently presented and that recommendations are appropriate, realistic, and actionable. It also ensures writing style, grammar, and formatting are consistent and professional. We have an internal checklist that assists in this process.

For this evaluation, it will also be important to develop confidential and public versions of reports and summary tables. Therefore, our reporting quality control process will include steps to check that we clearly identify confidential data in confidential reports by using grey highlighting and that we redact confidential data from public versions of the reports.

We will use all of the quality control tools and checklists mentioned here to ensure that tables, figures, values, and input and output data are internally consistent and accurate in all of our final deliverables.

A

DATA REQUEST

CBP Data Request

B

ANNUAL PLANNING MEETING DELIVERABLES

Meeting Agenda and Slide Deck

CBP PI Meeting Slides

Meeting Memorandum

CBP PI Meeting Memo

C

QUALITY ASSURANCE CHECKLIST

Load Impact QA
Checklist (Nov 2017)

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