Final Phase III Ex Ante Review Findings

Table 1-1: Project Information

IOU	Pacific Gas and Electric Company
Application ID	NC0122507
Application Date	11/16/2012
Program ID	PGE21031
Program Name	Commercial Calculated Incentives (NRNC)
Program Year	2012
Itron Project ID	X241
IOU Ex Ante Savings Date	7/18/2013
ED Measure Name	New Data Center
Project Description	A new data center space is being constructed in an existing building on 6 of the 8 floors. The data center area (Bldg F) is 16,926 ft^2**.** Building G is a 153,969 ft^2 cold shell. This project covers mechanical improvements (a high-efficiency chiller, a waterside economizer, & high temperature differential/variable-speed CRAH units) that will allow this data center to operate while consuming less energy than the standard efficiency baseline data center.
Date of ED Review(s)	1/9/2013, 6/6/2013, 8/27/2013
Primary Reviewer / Firm	Dale Tutaj//DNV KEMA
Review Supervisor / Firm	Doug Maddox / JJ Hirsch & Assoc
ED Project Manager	[redacted]
ED Policy Authorization (as needed)	
Type of Review (Desk, On-site, Full M&V, Tool)	Desk
ED Recommendation	ED approves final savings of 1,722,535 kWh and 155.1 kW, and approves ED-calculated incremental costs of $258,706.

Measure Description

The measures involved with this project are listed below:

High Efficiency Chiller: The chillers used on this project use variable-speed compressors and operate more efficiently than baseline, minimum-efficiency chillers.

Waterside Economizer: A water-to-water heat exchanger allows the chillers to be turned off during periods of low ambient wet bulb temperature. When the economizer is operating, the loads can be met without requiring mechanical cooling.

Efficient CRAH Units: The CRAH units on this project have variable-speed fan motors, allowing the fans to deliver only the amount of air required. Additionally, the air distribution is designed for a high temperature differential across the servers, allowing more cooling work to be done with less air movement.

Summary of Review

This phase III review does not include phase I or II ED summary reviews, but will address new items that arose in the EAR, parallel review process.The parallel review process addressed several additional questions in regards to the post M&V true-up, as follows:

1. Data center load is [redacted] or about [redacted] of design value.

   Response: This is correct. The data center loading is [redacted], much lower than the [redacted] load density for which the facility was designed. This is because the data center is still in the process of being loaded up. The Customer has indicated that they would like to claim their incentive now at the current loading, however, rather than waiting for a larger load to be deployed. Please note that both the actual and proposed systems were modeled with this loading for the savings and incentive analysis. However, the design loading was used for determining the size of the baseline equipment, as the facility does intend to operate at that capacity eventually.

2. CRAH supply/return temperature rise is 12 deg F, which is less than half of the expected value. Thus, even if the data center goes up to the original design load, the fan power savings would be significantly reduced compared to the original estimate.

   Response: That's correct that the air temperature differential across the CRAH units averaged only 12.2 degrees when the data was collected. Since all of the CRAH units are operating despite uneven loading, this is the average throughout the data center. We believe that should the facility be loaded to design conditions, a higher temperature differential would be achievable due to a more even load distribution. That said, for this analysis the fan energy consumption for the proposed system was based on measured data at this temperature differential and we believe it appropriately reflects the operating consumption.

3. In the July trend data, the condenser entering temperature is sometimes lower than the outdoor wet bulb temperature, which is not possible. Some effort should be made to determine the cause of this discrepancy and to formulate a possible workaround to make use of the valid portions of the trend data.

   Response: Looking at the data, this seems to be correct. There are instances when the wet bulb temperature is higher than the condenser water temperature, which physically does not make sense. We have three separate measures of the condenser water temperature (leaving the tower, headered together with the other tower, and entering the chiller) and these measures appear to be consistent with each other within half a degree F. This leads us to believe that the wet bulb sensor used is probably inaccurate.

   A conversation with the building engineer confirmed this suspicion. Apparently the wet bulb temperature sensor gets direct sunlight during morning hours, which causes the temperature to read higher than it should. This can be seen when looking at a chart of the wet bulb temperatures, where every morning there is a spike in the data that clearly deviates from the typical daily pattern you would expect. We have adjusted the calculations accordingly by eliminating the wet bulb data points that appear during this direct sunlight temperature spike. A consequence of removing this questionable data is that the trend relating the cooling tower fan speed with wet bulb temperature is more correlative. This revised trend equation has been used in updated calculations attached to this memo.

4. The “Actual” chiller performance curve is based on a condenser entering temperature of 72 deg F. The analysis should account for the degradation in chiller efficiency at higher condensing temperatures in order to make the peak kW calculation accurate.

   Based on the data that we received, the condenser water set point was a fairly constant 72 degrees F. However, you are correct that at higher wet bulb temperatures, which are expected to occur in a typical meteorological year, it would be impossible to produce that condenser water temperature. Consequently we have adjusted the calculations to have no less than a five degree condenser water approach to the wet bulb temperature. The cooling tower fan and chiller energy consumption have changed to reflect this and both the kWh savings and peak kW reduction are revised accordingly.

5. Outdoor temperature is not shown for the January trend data. There are points in that data set where the transition between economizer and chiller operation appears to occur. If outdoor temperature were known, the transition point assumption of 55 F used in the model could be verified.

   Response: Unfortunately, no outdoor air temperature was trended for the January data we received. Additionally, the temperature never dropped low enough to trigger the economizer operation for the data collected in July. However, please note that the economizer operation is triggered based on the wet bulb temperature rather than dry bulb.

The set point for crossover is 50 degrees F wet bulb (as indicated in cell J48 of the "Actual" calculation tab). While no measured data is available to verify that crossover point, we do have trended data from the July series showing the economizer set point clearly entered at 50 degrees F wet bulb in the Building Management System. We have added this data into columns O and P of the "Free Cooling Data" tab of the trend data analysis.

So, while we do not have concurrent data showing outside air temperature (wet bulb or dry) during economizer operation, we do have some data verifying economizer operation and other data verifying the economizer set point. Consequently, we have modeled the crossover at 50 degrees wet bulb and believe this to be correct.

ED Response:

Response: Weather data from Moffett Naval Air Station was used for the regression. This approach leads to an economizer crossover temperature of 47.3 deg F wet bulb. While the crossover temperature may be programmed into the BMS at 50 deg F wet bulb, there are concerns about the wet bulb sensor location which may be causing the economizer to actually crossover at a temperature a few degrees lower on average.

Additionally, using wet bulb temperature data correlated with cooling tower fan operation in economizer mode, further updates were made. While previously cooling tower fan speed had been estimated from manufacturer's software, now it can be correlated with actual wet bulb temperatures. A regression analysis was done and this change has also been included in the calculations.

6. Incremental cost calculations appear to be reasonable. (See additional comments below at the bottom of Table 1-3).

   Response: No further comment.

Savings estimates were revised from 6,931,637 kWh and 701.3 peak kW to 1,722,535 kWh and 155.1 peak kW. The major cause of the reduction in the final energy savings are due to the lower load observed during the post metering period. The trend data collected during the post installation inspection showed the affected chiller to be operating at a lower load than expected. The post installation M&V activates involved collecting trend data as discussed in Table 1-3.

The following summarizes changes to inputs and assumptions used for initial estimates:

- Chiller load, maximum trend value of 288.8 tons, 1,010 tons assumed for phase 1 EAR savings estimate,
- Cooling tower VFD speed, maximum trend value of 69%, 98% speed assumed for phase 1 EAR savings estimate,

- Chilled water flow rate, trend value ranged from 1,252 gpm to 1,384 gpm, 1,010 tons assumed for phase 1 EAR savings estimate,
- Kitchen MAU supply air temperature setpoint is 65°F versus 68.7°F,
- CRAC fan speed was reduced from 96.8% to 68.5%, and
- CRAC unit quantity was reduced from 17 units to 13.
- Economizer crossover wet-bulb temperature was changed from 50°F to 47.3°F.

Review Conclusion

Final ex ante savings are approved as post-install M&V and savings true-up have been performed.

Summary of ED Requested Action by the IOU

No action required.

Table 1-2 Review Findings

Reviewed Parameter	Analysis
Project Baseline Type (Early Replacement, Normal Replacement, Capacity Expansion, New Construction, System Optimization, Add-on Measures, Major Renovation) Note: For early retirement projects only, include RUL through EUL baseline)	IOU Proposal: New construction
	ED Assessment: The IOU proposed project baseline type is appropriate.
	ED Recommendation: New construction
Project Baseline Technology (in situ equipment, Title 24 (specify year), other code or other efficiency level (specify), industry standard practice - ISP)	IOU Proposal: "Energy Efficiency Baselines for Data Center" document dated November 30,2011 highlight baselines as follows: • Water-cooled chiller, part load-efficiency kW/ton provided in document • CW pumps at 19W/gpm @ design conditions • CW flow rate 3 gpm/ton • CHW pumps at 22W/gpm • CHW flow rate 2.4 gpm/ton • MUA supply air flow rate 0.15 cfm/ft^2at 55°F • Chiller capacity 600 tons, based on design load 1.2 safety factor Minimum number of chillers, and cooling tower pumps n+1 = 2
	ED Assessment: This document provides the appropriate baseline as T24 does not cover data centers. The 12kV connected loads for Building G lab loads are 4,009 kVA, resulting in the large data center category. The baseline cooling system water cooled chilled water plant serving uniformly-sized chilled water CRAHs equipped with constant-speed fans.
	ED Recommendation: Baseline assumptions are valid and the correct document is referenced.
Project Cost Basis (Full Incremental, or Both. Note: For early retirement projects, include RUL through EUL cost basis treatment)	IOU Proposal: Incremental cost
	ED Assessment: The IOU proposed project cost basis is appropriate.
	ED recommendation: Incremental cost
RUL (required for early retirement projects only,	IOU Proposal: N/A
	ED Assessment: N/A

Reviewed Parameter	Analysis
otherwise N/A)	ED recommendation: N/A
EUL (for each measure)	IOU Proposal: Not provided
	ED Assessment: DEER 2008 EUL values should be used. For high efficiency chillers use 20 years, for water side economizer use 15 years, and for high temperature differential/variable-speed CRAH units with VAV box/VSD fan use15 years
	ED Recommendation: DEER 2008 EUL values should be used. For high efficiency chillers use 20 years, for water side economizer use 15 years, and for high temperature differential/variable-speed CRAH units with VAV box/VSD fan use15 years
Savings Assumptions	IOU Proposal: Trend data has replaced the initial assumptions for chiller load, CT fan load, free cooling, and CRAC fan speeds.
	ED Assessment: The assumptions have been replaced by post trend data
	ED Recommendation: None
Calculation Methods/Tool review	IOU Proposal: A simple engineering calculation spreadsheet is used. Chiller baseline performance curve is based on the 2013 Data Center Baseline Report. Chiller, pumps, fans power is summed for each weather hour bin.
	ED Assessment: The majority of the load is not weather dependent for data center loads so a building simulation is not required.
	ED Recommendation: None
Pre- or Post-Installation M&V Plan	IOU Proposal: No M&V plans were provided. However post M&V trend data and savings true-up was completed.
	ED Assessment: The energy savings estimate was revised to reflect system operation as verified by trend data. Trend data was collected for a period of one week with weather conditions ranging from 58°F to 84°F drybulb temperature. Data was collected at 5 minute intervals. As the majority of the load is not weather sensitive for this duration of monitoring and range of conditions is sufficient to revise savings estimates. The following trends were collected: • CRAC fan speed • CHWP speed • CHW flowrate • CH P FLA • CT Fan speed • CWP speed

Reviewed Parameter	Analysis
	• CW flowrate • CW approach temperature • CW supply temperature • CHWS supply and return temperature
	ED Recommendation: None
Net-to-Gross Review	IOU Proposal: Not provided
	ED Assessment: Not assessed
	ED Recommendation: None

Table 1-3 Energy Savings Summary, Project Costs & Incentive

Description	IOU Ex Ante Claim	ED Recommendations
First Year kWh Savings	1,722,535 kWh	Accepted
First Year Peak kW Savings	155.1 kW	Accepted
First Year Therms Savings	-	Accepted
kWh Savings (RUL Period)	N/A	N/A
Peak kW Savings (RUL Period)	N/A	N/A
Therms Impact (RUL Period)	N/A	N/A
kWh Savings (RUL thru EUL Period)	1,722,535 kWh	Accepted
Peak kW Savings (RUL thru EUL Period)	155.1 kW	Accepted
Therms Savings (RUL thru EUL Period)	-	Accepted
Annual Non-IOU Fuel Impact (RUL Period)	N/A	N/A
Annual Non-IOU Fuel Impact (RUL thru EUL Period)	N/A	N/A
Project Costs for Baseline #1 (RUL or EUL)	$299,232	ED adjusted project cost of $258,706 are accepted; after a more detailed review of the incremental project costs it was observed the O&P (overhead & profit) line item

Description	IOU Ex Ante Claim	ED Recommendations
		of $73, 339 included a calculation error. ED used 7.5% of this value to arrive at an O&P line item of $5,500.42.
Project Costs for Baseline #2 (EUL minus RUL period)	N/A	N/A
Project Incentive Amount	$149,616	ED-adjusted incentive of $129,353 is accepted