

## Final Ex Ante Review Findings

**Table 1-1: Project Information**

<b>PA</b>	Pacific Gas and Electric
<b>Application ID</b>	2K12082172
<b>Application Date</b>	2/29/2012
<b>Program ID</b>	PGE21011
<b>Program Name</b>	Non Residential Retrofit Program
<b>Program Year</b>	2012
<b>CPUC Project ID</b>	X103
<b>PA Ex Ante Savings Date</b>	10/01/2012
<b>Measure Name</b>	HVAC & Controls Upgrade
<b>Project Description</b>	<p>This customized retrofit project at an office building includes the following measures:</p> <ol style="list-style-type: none"> <li>1. EEM-1: Replace existing box car units with high efficiency units,</li> <li>2. EEM-2: Replace old pneumatic control system with DDC, which includes static pressure reset, optimum start/stop controls, CO2 based demand control ventilation (DCV), and HHW temperature reset,</li> <li>3. EEM-3: Convert to variable volume HHW flow, and</li> <li>4. EEM-4: Upgrade lighting.</li> </ol>
<b>Date of CPUC Staff Review</b>	09/26/2012 & 08/01/2013 & 12/06/2014
<b>Primary Reviewer / Firm</b>	C.D. Nayak/DNV KEMA; Sue Haselhorst/ERS
<b>Review Supervisor / Firm</b>	Kunal Desai & Joseph Ball/Itron, Keith Rothenberg/Energy Metrics
<b>CPUC Staff Project Manager</b>	[REDACTED]
<b>CPUC Staff Policy Authorization (as needed)</b>	
<b>Type of Review (Desk, On-site, Full M&amp;V, Tool)</b>	Desk review
<b>CPUC Staff Recommendation</b>	<p>Ex ante energy savings are approved with adjustments.</p> <p>The invoice detail did not fully support the PA measure costs. The PA is directed to provide this detail in the final ex ante claim</p>

	for this project and upload all final documents to the CMPA folder for this application
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## **Measure Description**

This project is located at an office building (number 2029), and was documented as part of PG&E's Large Integrated Audit program. The following energy efficiency measures were verified as installed by the PA:

EEM-1: Upgrade to Premium Efficiency Package Units – the equipment installation was verified to have a 10.2 EER efficiency which was documented with photos of the nameplates.

EEM-2: Replaced the old pneumatic control system with DDC, implementing static pressure reset, CO2 based demand control ventilation (DCV), and HHW temperature reset. An optimum start/stop strategy and VSD on the hot water pump proposed earlier were not implemented. Verification of the control operation included:

- Static pressure reset confirmed by two weeks of static pressure trends showing a range in operation and by screen shots of the control strategy implementation in the EMS
- HHW temperature reset by two weeks of hot water supply temperature trends showing a range in operation and by screen shots of the control strategy implementation in the EMS
- DCV operation confirmed by screen shots of the control strategy implementation in the EMS and two week trends of select space temperatures

EEM-3: Hot Water Pump Variable Speed Drives were not installed.

EEM-4: Advanced Lighting Upgrades – Dimmable ballasts and enhanced individual occupancy controls were installed in existing T8 and T5 linear fluorescent fixtures. Equipment was verified through inspection and operation confirmed through trend data produced by the control system.

## **Summary of Review**

This summary recaps each of the previous ex ante reviews and concludes with the CPUC Staff review of the most recent submission.

### *Phase I Ex Ante Review*

The initial submittal for this application proposed a mix of the measures described above installed in six different buildings, all occupied by the same company. In the first review, CPUC staff recommended revising the baseline for all measures from retrofit to normal replacement since no documentation of remaining life was provided. A number of errors were noted in the eQuest models submitted for each building requiring correction. There were also contradictory savings and costs claims. In conclusion, the documentation was insufficient to substantiate savings. CPUC Staff requested the PA to provide additional information describing each

building, correct and calibrate the eQuest models to bills, improve modeling for individual measures, provide additional cost data, and provide the source of EUL.

*Phase II Ex Ante Review*

Only building 2029 was retained as part of this particular application. All other buildings were withdrawn, although there is evidence in the invoices that at least some of the work was completed in these other buildings.

The Project Application Review noted that the SAT reset measure was dropped, since a Title 24 requirement was in effect at the time of building construction and therefore the SAT reset implementation was a re-commissioning measure, not eligible for a CRI incentive.

The eQuest model submitted for Building 2029 was corrected, per the errors identified in the Phase I EAR. The model was calibrated to within a few percent of actual electric bills. The savings were conditionally approved, subject to installation of the measures and post installation M&V.

*Phase III Ex Ante Review*

PA requested permission to shorten the post-installation M&V period from six to four months, and expressed a willingness to provide additional data if four months was not sufficient. CPUC Staff agreed to the four month M&V period and requested the IOU submit the post M&V plan for review prior to the site visit. The CPUC Staff reserved the right to review and potentially reject the post-installed M&V data and analysis.

Subsequent to the Phase III EAR, additional guidance was provided to the PA in an email recommending calculating the lighting measure savings using the standard lighting calculator.

*Final EAR Review*

CPUC Staff reviewed the following documents and information as part of the Final review of this project:

- PGE 2K12082172 X103 Phase III EAR.pdf (previous disposition)
- 2K12082172 Bldg 1 IR Review Form v1.2 (rev3).xls
- 2K12082172 Bldg 1 IR References (rev3).zip (eQuest models with trend data)
- EnergyEfficiencyOIR-Post-2008\_DR\_ED\_262\_EEGA\_2372.pd
- Five months of post-installation electric and natural gas billing data
- Two weeks of static pressure, space temperature, and hot water supply temperature trends and also a trend summary from the EnLighted lighting control system.

This section presents findings for the individual EEMs, followed by an analysis of customer bills, and a summary of the compliance of the PA submittal with the previous EER, concluding with recommendations.

EEM-4 Advanced Lighting Upgrades. The direct energy savings for EEM-4 was calculated using a PG&E's standard calculator. CPUC Staff reviewed the calculator. The lighting inventory is consistent with the building model and the invoice; the lighting hours of operation are consistent with DEER assumptions. A savings rate of 15% was selected for occupancy control (as recommended by CPUC Staff) and 20% for task tuning resulting in a net 23% savings rate.

While the energy savings for this measure was determine using a standard calculator, the EnLighted trend report presents evidence of higher rates of savings therefore, the 23% savings rate assumed in the IR savings is conservative. The PA evidence of actual lighting control savings is presented in a pdf file of an EnLighted trend report showing a 61% reduction in usage over a one month period. The reporting algorithm appears to calculate lighting reductions assuming all lights would be on at all times without the control. While it is unlikely that all lighting ran all the time prior to the installation, the lighting is operating at less than half the load in a building with substantial open office space likely be on during the work day. A rigorous case study of the Enlighted technology was conducted by SMUD, shows similar levels of savings<sup>1</sup>. In addition, this same study found that the Enlighted energy use computations exactly matched independently metered results. The 23% is conservative, based both on the EnLighted trend report and the billing analysis presented later in this review.

This savings estimate would have been improved with pre-installation logging of the lighting profile. This profile would have provided a site specific baseline hours of use, rather than the default hours and it would have likely yielded larger ex ante savings for the PA.

EEM 2 – Replace pneumatic controls with DDC. The savings for this measure was estimated using revisions of the eQuest model originally submitted in Phase II. The baseline model had been calibrated to the electric bills, although not the natural gas bills. The baseline model was subsequently adjusted by the PA Reviewer (referred to as the IR Adjusted Baseline Model), to reflect installed conditions as follows:

- Lighting baseline LPD was changed from 1 watt/sqft to 0.65 watt/sqft based on the control vendor's inventory. The post installed LPD was modeled assuming a 40% reduction in average LPD. These LPD values were used for eQuest building load modeling only and were not used to calculate EEM-4 savings.

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<sup>1</sup> <https://www.smud.org/en/business/save-energy/energy-management-solutions/documents/Intel-Advanced-Lighting-Controls-Project.pdf>

- The occupancy schedule was adjusted based on customer reported schedules, revising the original schedule from 6am to 10pm to 6am to 8pm.
- Equipment loads were reduced by 274 MWh to account for the repurposing of cafeteria space to offices.
- Title 24 compliance, including SAT reset and compliant packaged unit efficiencies.

With the reduction in internal loads and the Title 24 compliance, the IR Adjusted Baseline Model projected electrical usage is now 79% of the actual pre-installed electrical usage.

The eQuest parametric runs were used to estimate the DDC savings by modeling the individual control strategies as follows:

- The static pressure reset was implemented using custom curves representing the VFD baseline controls and static pressure control.
- Hot water reset was implemented using the eQuest reset schedule, with a fixed 180F baseline and a reset schedule between 120F and 160F.
- DDC control was implemented by changing the minimum VAV flow rate from 0.5 to 0.1 ratio. DCV was not modeled, although it was installed in select conference rooms.

The source of the curves used to model VFD control of fans and static pressure reset is not known, although they are plausible (cubic curves). The custom baseline curve results in lower annual baseline than the eQuest default, so it is likely to be conservative. However, the order of the parametric runs did not properly account for baseline conditions – as the lighting measures and HVAC upgrades were added last; reordering the runs reduced the modeled savings by about 9%.

The trends, from the last two weeks of September 2014, confirm that the static pressures and hot water temperatures are varying over time consistent with a reset strategy. The sample of space temperatures shows evidence of setforward during the evenings and weekends and that space conditions are maintained within about a two degree range during occupied periods.

Based on the PA Reviewer’s description of the DDC installation, the pre-installed controls appeared to have worked poorly with simultaneous heating and cooling and likely other undiagnosed failures. During the first post inspection in the fall of 2013, the PA Reviewer and customer engineer concluded that the DDC system installed in the fall of 2012 was not achieving the expected savings and was not providing satisfactory temperature control. The customer replaced the new system in the spring of 2013, at which time, savings, particularly natural gas savings, became evident. It is likely that a variety of undiagnosed problems were resolve with the second system and that these effects were not fully captured by the model.

EEM 1 – Rooftop Packaged Units. The rooftop units were inspected and the efficiency ratings were verified and documented in photos. As proposed by CPUC staff in Phase I, the Title 24 compliant efficiency of a 9.6 EER baseline with an installed efficiency of 10.2 EER modeled as

0.3445. It also noted, however, that the 10.2 EER was the minimum efficiency available for a unit of this type.

The unit installation and rated efficiencies were verified during the post-installation inspection and documented using photographs. The eQuest modeling of the savings is straightforward and appropriate.

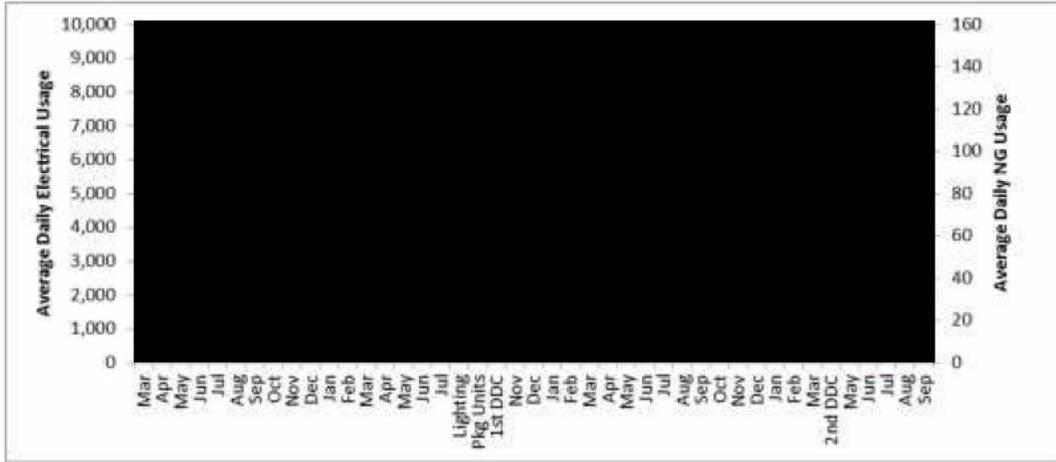
Billing Analysis. The pre and post-installed electric and gas bills were reviewed by CPUC Staff. Given that actual pre-installed lighting and temperature profiles are unavailable for production of a verified baseline and some of the uncertainties noted above, natural gas and electric bills were reviewed as a means of triangulating on the measure savings.

The PA Reviewer was interviewed to gather additional information about building changes and the timing of the changes, since these could impact usage as well. The PA Reviewer reported that the work was completed in late 2012 and included the lighting and HVAC control upgrade and repurposing of about 2,500 square feet of dining space to office space. The dining space included a number of vending machines where were removed, but had not included significant other loads. The facility remained occupied during the renovation with no other notable change to its mission or staffing. The CPUC Staff was unable to reach the customer for corroboration.

The table following summarizes the electric and natural gas bills, the eQuest modeled pre and post usage, and the eQuest estimates of measure impacts. It's apparent that substantial bill reductions occurred from the pre to the post period and also that the model is not fully calibrated to the bills. Note that the modeled electrical savings shown below includes additional lighting, controls, and packaged unit savings that had been excluded from the PA claim for a fair comparison to actual post bills. On this basis, the modeled usage is within 10% of actual usage.

Billing Period	Electrical Annual Use (kWh)			Natural Gas Annual Use (therms)		
	Modeled	Billed	Mod/Bill	Modeled	Billed	Mod/Bill
Pre 7-2011 to 6-2012	2,292,205		79%	28,140		124%
Post 11-2013 to 10-2014	1,414,015		90%	7,351		182%
Total Change	878,190		66%	20,789		112%

A review of the average daily energy usage in the following figure links reductions in usage to the installation events. The change in electric usage also appears linked to the installations, but perhaps a non-EEM event occurred in the spring of 2013 impacting building energy use. The eQuest modeled changes only captures about two-thirds of the total reduction in the bills.



Compliance with Phase III EAR recommendations. The Phase III EAR recommended conditional approval subject to post installation M&V and a savings true up. CPUC staff requested an opportunity to review the M&V plan prior to a site visit.

The PA provided the M&V plan in the document “EnergyEfficiency OIR-Post-2008 DR\_ED\_262\_EEGA\_2372.pdf. The document required the PA to inspect and verify the equipment as specified and collect trend logs, as well. The revised M&V plan stated that the trend and billing data would be used to “help calibrate the post model”. Model calibration was not explicitly done and the analysis above reflects CPUC Staff analysis, not direct outputs of the model.

Measure costs. The CPUC Staff could not verify the PA Reviewer analysis of the measure costs. The invoice submitted for the packaged units did not identify the building or units, but only a total cost, although this value matched the PA Reviewer measure cost analysis. The basis for the DDC measure cost could not be linked to any of the invoices that were included in the project file. The lighting control measure included the full measure cost was appropriate for normal replacement.

**Review Conclusion**

Savings approved with adjustments to account for correct ordering of the parametric runs. The original model had the lighting reduction as the last measure implemented, rather than as the first measure installed which overstated the interactive savings. This correction reduced the savings by 8,163 kWh.

CPUC staff review of the models, trends and billing data substantiates the PA ex ante savings and indicates they are likely conservative. Although the PA did not calibrate the eQuest models with post-installation trend and billing information as was recommended in the Phase III EAR, further attempts to calibrate to post-installation conditions would be a substantial undertaking

and, without better pre-installation information, unlikely to change the savings outcome or increase confidence in the savings estimates.

Current CPUC staff reviewers note that some of the HVAC controls measures documented in this application are mandatory under Title 24 Standards. The Standards also have a clause that significant alterations invoke the requirement to comply with current Standards. PA reviewers and CPUC Staff reviewers overlooked this requirement when reviewing this application. Some of the implemented controls measures that are ineligible for Program participation including static pressure reset.

CPUC Staff will not make any adjustments to the savings analysis for this project for this oversight, however for all future projects, the PA must carefully evaluate when the alteration clause of the Title 24 Standards may require compliance with the Standards in effect at the time of the project implementation and thereby disqualify measures from Program participation.

The lighting controls measure estimate would have benefited from short term pre-installation logging, which could have been done relatively inexpensively and quickly. This data would have provided a basis for site specific hours of operation and would have very likely increase the ex ante savings.

### **Summary of CPUC Staff Required Action by the PA**

For this project:

The CPUC Staff recommends that the PA:

1. Provide additional invoice detail supporting the measure costs for the packaged units and the DDC installation, and upload to this project's folder in the CMPA
2. Upload a document to this project's folder in the CMPA stating this project's Claim ID and the quarter this project is claimed.

For all future projects (submitted after receipt of this review):

1. PA must carefully review project to assess building energy efficiency standard (Title 24) code requirements for the retrofitted systems and equipment. Based on that assessment, ensure that all applicable control measures required by code are listed in the baseline description and included in the baseline building energy simulation model.
2. To avoid possible double-counting of measures, the PA must ensure the baseline model includes any measures estimated externally to the model.
3. For savings estimates generated from multiple energy models, the PA must provide a table that lists and compares each energy model used in the savings estimate. The models

must be clearly labeled to indicate which is the baseline, which measure run it represents, and which model represents the source of final savings. The key input parameters for each model must be listed so that the input changes from model to model are easily identified.

4. For add-on measures to existing lighting systems (e.g., control upgrades), obtain and provide the age of each lighting components to assess the remaining useful life of the system.
5. For HVAC normal replacement measures, the PA must ensure that incremental energy savings are achieved by verifying that the proposed equipment exceeds the minimally-efficient equipment option available for meeting code requirements.

For this project, CPUC Staff have determined that the customer purchased the minimum efficiency unit available from the manufacturer for the 75 ton units documented in this application. Higher efficiency units are available from the same manufacturer but were not purchased by the customer. The PA must design the Program requirements to ensure that customers purchase greater than minimum available efficiency equipment.

6. For lighting control measures, provide a baseline profile of the lighting operation using metering, preferably by logging the amperage or kW usage at the circuit.

**Table 1-2 Review Findings**

Reviewed Parameter	Analysis
<b>Project Baseline Type</b> (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)	PA Proposal: <ul style="list-style-type: none"> <li>• HVAC - normal replacement.</li> <li>• Lighting controls – add-on measure</li> </ul>
	CPUC Staff Assessment: accept
	CPUC Staff Recommendation: none
<b>Project Baseline Technology</b> (in situ equipment, Title 24 (specify year), other code or other efficiency level (specify), industry standard practice - ISP)	PA Proposal: <ul style="list-style-type: none"> <li>• Packaged unit: Title 24 2012</li> <li>• All other measures, in situ.</li> </ul>
	CPUC Staff Assessment: accept
	CPUC Staff Recommendation: none
<b>Project Cost Basis</b> (Full Incremental, or Both. Note: For early retirement	PA Proposal: <ul style="list-style-type: none"> <li>• Incremental: rooftop package unit, DDC controls</li> </ul>

Reviewed Parameter	Analysis
projects, include RUL through EUL cost basis treatment)	<ul style="list-style-type: none"> <li>• Full cost: lighting controls</li> </ul>
	CPUC Staff Assessment: Further invoice detail is required for all measures but the lighting controls.
	CPUC Staff Recommendation: Provide invoice detail delineating measure costs for all measures but the lighting controls.
RUL (required for early retirement projects only, otherwise N/A)	PA Proposal: N/A
	CPUC Staff Assessment: accept
	CPUC Staff Recommendation: none
EUL (for each measure)	PA Proposal: None listed
	CPUC Staff Assessment: <ul style="list-style-type: none"> <li>• 15 years for new commercial AC</li> <li>• 5 years for lighting controls. For an add-on measure, the EUL is limited by the remaining useful life of the existing equipment or system. Lacking any information on the age of the lighting system, the default of 1/3 of the effective useful life (15 years) is used for measure EUL.</li> </ul>
	CPUC Staff Recommendation: accept
Savings Assumptions	PA Proposal: <ul style="list-style-type: none"> <li>• Lighting fixture wattage and baseline hours are compliant. Assumed 15% occupancy and 20% tuning savings rates</li> <li>• eQuest modeling of other measures.</li> </ul>
	CPUC Staff Assessment: accept
	CPUC Staff Recommendation: none
Calculation Methods/Tool review	PA Proposal: <ul style="list-style-type: none"> <li>• PG&amp;E lighting calculator with prescribed control savings rates</li> <li>• eQuest model</li> </ul>
	CPUC Staff Assessment: accept
	CPUC Staff Recommendation: none
Pre- or Post-Installation M&V Plan	PA Proposal: Four months of post-installation billing data and trends.
	CPUC Staff Assessment: accept

<b>Reviewed Parameter</b>	<b>Analysis</b>
	CPUC Staff Recommendation: none
<b>Net-to-Gross Review</b>	PA Proposal: Not addressed
	CPUC Staff Assessment: TBD
	CPUC Staff Recommendation: TBD

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

<b>Description</b>	<b>PA Ex Ante Claim</b>	<b>CPUC Staff Recommendations</b>
<b>First Year kWh Savings</b>	Lighting control: 32,490.6 HVAC measures: 89,301 Total: 121,791.6	Lighting control: 32,490.6 HVAC measures: 81,138 Total: 113,628
<b>First Year Peak kW Savings</b>	Lighting control: 7.86 HVAC measures: 28.83 Total: 36.69	Lighting control: 7.86 HVAC measures: 28.83 Total: 36.69
<b>First Year Therms Savings</b>	9,767.0	9,583
<b>kWh Savings (RUL Period)</b>	N/A	N/A
<b>Peak kW Savings (RUL Period)</b>	N/A	N/A
<b>Therms Impact (RUL Period)</b>	N/A	N/A
<b>kWh Savings (RUL thru EUL Period)</b>	Lighting control: 32,490.6 HVAC measures: 89,301 Total: 121,791.6	Lighting control: 32,490.6 HVAC measures: 81,138 Total: 113,628
<b>Peak kW Savings (RUL thru EUL Period)</b>	Lighting control: 7.86 HVAC measures: 28.83 Total: 36.69	Lighting control: 7.86 HVAC measures: 28.83 Total: 36.69
<b>Therms Savings (RUL thru EUL Period)</b>	9,767.0	9,583
<b>Annual Non-PA Fuel Impact (RUL Period)</b>	N/A	N/A
<b>Annual Non-PA Fuel Impact (RUL thru EUL Period)</b>	N/A	N/A
<b>Project Costs for Baseline #1 (RUL or</b>	Lighting control: 87,229	Provide additional invoice

*Final Ex Ante Review Findings*

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<b>Description</b>	<b>PA Ex Ante Claim</b>	<b>CPUC Staff Recommendations</b>
EUL)	HVAC measures: 89,301 Total: 121,791.6	detail.
<b>Project Costs for Baseline #2</b> (EUL minus RUL period)	Lighting control: \$87,229 HVAC measures: \$66,414.60 Total: \$153,643.60	NA
<b>Project Incentive Amount</b>	\$23,429.90	