Phase I Ex Ante Review Findings

Table Error! No text of specified style in document.**-1: Project Information**

IOU	Pacific Gas & Electric
Application ID	2K13216098
Application Date	8/28/2013
Program ID	PGE21011
Program Name	Outside Air Damper
Program Year	2013
Itron Project ID	X450
IOU Ex Ante Savings Date	Savings are not yet PA-approved
CPUC Staff Measure Name	HVAC Upgrades
Project Description	The customer is retrofitting three existing 100% outside air handlers in a [redacted] square foot office building to allow recirculated airflow during periods of heating (the building will still use 100% OA during cooling periods). The affected AHUs, which deliver 164,800, 171,200, and 58,000 CFM at design conditions, are the primary airside systems in the facility. The retrofit involves installing OA dampers on outdoor air intakes; commissioning return fans that were installed at the time of building construction (1960) but never enabled; installing VFDs on those same return fans; and updating DDC controls to allow operation of the new equipment.
Date of CPUC Staff Review	11/20/2013
Primary Reviewer / Firm	Brandon Gill/DNV KEMA
Review Supervisor / Firm	Amit Kanungo/DNV KEMA
CPUC Staff Project Manager	[redacted] / California Public Utilities Commission, Energy Division
CPUC Staff Policy Authorization (as needed)	
Type of Review (Desk, On-site, Full M&V, Tool)	Desk Review
CPUC Staff Recommendation	The ex-ante savings are conditionally approved and will be verified and revised during the post-installation M&V as suggested in this report.

Measure Description

The project consists of a single measure at a large commercial office building: Retrofitting three AHUs to allow operation with less than 100% outside air. This is not an economizer measure per se. Under the proposed operating strategy, the building will still use 100% outdoor air whenever the AHUs are predominantly providing cooling; when the AHUs are primarily providing heating, the dampers will actuate to provide the code minimum outside air. Currently, the building's three air handlers - which are all variable volume and sized at 164,800, 171,200, and 58,000 CFM - deliver 100% outside air under all conditions. Supply airflow is varied in order to maintain a constant static pressure set point; variable speed exhaust fans expel air from the building in order to maintain a constant building pressure level.

The customer proposes to alter their existing AHU configuration to allow recirculation air during heating operation. In order to implement this strategy, outside air dampers will be installed on the OA inlets. Additionally, the return fans associated with each air handler — which were installed at the time of building construction in the 1960s but never commissioned due to a mid-construction design change — will be commissioned to allow recirculation air. The return fans will additionally be outfit with variable speed drives. DDC controls will be updated to allow operation with the proposed control strategy. The project is anticipated to save 60,955.2 therms per year and cost $137,204.00 to implement. The utility is offering a $60,955.20 incentive for this project paid at a rate of $1.00 per therm saved. The chosen incentive rate is consistent with Customized Retrofit Program policies.

Summary of Review

The Investor-Owned-Utility (IOU) submitted the following documents on 11/03/2013 in response to a Data Request (DR) for this Phase I review:

- Project Application (PA) Review Form
- A project description document including a statement of influence
- Preliminary savings calculations
- Cost quotes for equipment and labor
- Conversation records between program staff and the customer
- Select equipment cut sheets

Eligibility & Baseline

The IOU characterizes the proposed measure as a Retrofit Add-On since the building does not currently have AHU OA dampers. During the initial review of this project it appeared that installing OA dampers would trigger Title 24 requirements for ventilation systems under clauses pertaining to alterations. However, a thorough review of code revealed that economizer/OA system prescriptive requirements are not triggered even if installing OA dampers is an alteration.

As such, the project is eligible and rightly characterized as a Retrofit Add-On. Because the measure is a Retrofit Add-on, the IOU is correct in utilizing the pre-existing condition as the project baseline.

Preliminary Savings Estimate Review

Savings were estimated utilizing a dry-bulb temperature bin spreadsheet analysis. The analysis only accounted for the gas savings resulting from reducing the amount of outdoor air brought into the building during heating operation. Cooling energy savings were not estimated because the facility will still use 100% outside air during cooling operation. The analysis did not account for the impact that activating the previously un-commissioned return fans would have on fan energy consumption. The IOU PA reviewer argued that because the combined airflow through the return and exhaust fans is not expected to change following measure implementation, the change in fan energy use should be negligible. This contention will be addressed below.

Gas savings were accounted for using a simplified psychometric analysis. For each 2-degree temperature bin below 58 °F — the change-point temperature at which the building is assumed to switch from heating to cooling, and therefore from minimum OA to 100% OA in the proposed case — the difference between the baseline and post-retrofit gas consumption was effectively calculated as follows:

$$\Delta Therms_{bin-i} = \frac{Hours_{bin-i} * 1.08 * CFM_{Design} * \left(\frac{Hz_{heating}}{60}\right)\left(MAT_{post} - OAT_{pre}\right)}{\eta_{boiler}}$$

Where,

$$MAT_{post} = OAT * Min_{OA_{frac}} + RAT * (1 - Min_{OA_{frac}})$$

A few clarifications are warranted for the above equations.

- The design CFM specified is the gross design CFM for all three air handlers combined.
- All three air handlers are assumed to operate at 40 Hz in heating mode based on 1) an observation made at the time of the site visit, and 2) subsequent discussions with the building engineer.
- The return air temperature utilized in the mixed air calculation is assumed to be 75 °F.
- The post-installation minimum outdoor air fraction is assumed to be 45.6% based on the Title 24 ventilation requirement of 0.15 CFM/square foot for the [redacted] square feet of affected office space. This corresponds to a requirement of 119,700 CFM of ventilation air during building operations.
- The boilers are assumed to operate at their high fire rated combustion efficiency of 82%.

The CPUC's review staff believes the preliminary *gas savings* analysis, as currently constituted, is sufficient for the PA stage. CPUC staff however rejects the contention that the measure's

impact on fan energy use will be negligible. Activating the return fans and adjusting the control strategy to maintain the desired OA flow may sufficiently affect the dynamics of the fan systems, and therefore, the fan energy use associated with the project should be considered. Understandably, the net impacts are as yet unclear; the total static pressure (TSP) that the supply fans (SFs) are operating against will change, the exhaust fans (EFs) will operate at lower speeds, and the return fans (RFs) will operate at an unknown speed with an indeterminate TSP. The energy use associated with the current fan operations, however, should be documented so that post-installation fan energy use may be reasonably compared with pre-retrofit conditions. According to PA documentation, the SFs currently operate in a very small frequency range (SF: 40-45 Hz in heating, 50 Hz in cooling); the RFs should, therefore, be expected to operate in a small frequency range as well. Facility or IOU staff should, at minimum, take a spot power and speed reading of each fan (SF and EF) in the pre-retrofit condition during both cooling and heating operation. These readings will provide a datum for comparison purposes during the post-implementation IR review.

CPUC is not requesting a verification of either the gas or electric consumption of the in situ equipment operation at this time. CPUC staff believes that the gas savings calculations are reasonably robust given the limited available data pre-retrofit. However, since the net impact of the fan component of this project is highly uncertain, specific fan savings estimates are requested for the post-installation inspection IR savings true-up.

The IOU is currently proposing no M&V beyond post-installation verification. While this project will almost assuredly save a considerably amount of energy, CPUC staff requests that a low rigor level post-installation M&V (as described in the Summary of CPUC Staff Requested Action by the IOU section below) be conducted in order to true-up the PA savings estimate.

Review Conclusion

The ex ante savings are conditionally approved contingent upon post-M&V true up and inclusion of a fan savings/penalty calculation.

Summary of CPUC Staff Requested Action by the IOU

CPUC Staff requests that the IOU undertake the following proposed low-rigor, short-term metering and spot measurement activities during the post-install energy savings true-up period:

<u>Proposed low-rigor M&V Protocols</u>

- Presumably, following measure implementation, the supply, return, and exhaust fans will still operate at stable speeds in a narrow range. To verify take spot power and speed readings from all affected fans while they are operating in the narrow speed ranges

corresponding to heating and cooling operation. These data will support inclusion of the aforementioned fan savings (or penalty) estimates in the savings analysis.

- Conduct two (2) weeks of fan speed (Hz or % speed for SFs, EFs, and RFs) EMS trends are additionally requested to identify the building's airflow and fan power requirements in response to changing ambient conditions and time of day. If fan speed trending is not capable with the current EMS, then amperage logging of the fans is requested. These data will be useful in calibrating the "change-point" temperature used in the savings calculations to actual operations since the building's transition from cooling to heating should be marked with a decrease in fan speed.
- Trend AHU SAT and OA damper positions for two (2) weeks following measure implementation. These data will assist in more accurately defining a building "change-point" temperature estimate. Additionally, these data will add clarity to how the proposed strategy (i.e. running 100% OA during "mostly cooling mode" and minimum OA during "mostly heating mode") is actually implemented.
- Also trend the actual building return air temperatures for two (2) weeks to true-up the return air temperature value utilized in the mixed air temperature portion of the calculation.
- Collect the testing, adjustment, and balancing (TAB) report following project implementation to determine the OA volumetric flow rate through the new OA dampers during heating operation post-retrofit. These data will allow a true up of the outdoor air fraction utilized in the analysis, and may allow an overall adjustment of the design airflow assumptions taken from the building's original mechanical schedule (assuming supply flow data are included in the TAB report).
- Perform several boiler combustion tests to confirm the boiler efficiencies utilized in the analysis. Additionally a 1% or 2% deduction in boiler efficiency should be included in the analysis to account for the difference between combustion and thermal efficiency.

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: Retrofit Add-on
	CPUC Staff Assessment: Retrofit Add-on is the appropriate baseline. In situ conditions form the appropriate baseline for Retrofit Add-on projects.
	CPUC Staff Recommendation: No recommendation at this time.
Project Baseline Technology (in situ equipment, Title 24 (specify year), other code or other efficiency level (specify), industry standard practice - ISP)	IOU Proposal: In situ equipment
	CPUC Staff Assessment: In situ equipment is appropriate.
	CPUC Staff Recommendation: No recommendation at this time.
Project Cost Basis (Full Incremental, or Both. Note: For early retirement projects, include RUL through EUL cost basis treatment)	IOU Proposal: Full cost.
	CPUC Staff Assessment: Full cost is the appropriate basis for Retrofit Add-on projections.
	CPUC Staff Recommendation: No recommendation at this time.
RUL (required for early retirement projects only, otherwise N/A)	IOU Proposal: N/A
	CPUC Staff Assessment: N/A
	CPUC Staff Recommendation: N/A
EUL (for each measure)	IOU Proposal: EUL is not discussed in any of the provided IOU documents.
	CPUC Staff Assessment: The EUL for the proposed project should be documented in the submitted IOU paperwork.
	CPUC Staff Recommendation: The closest measure in DEER to the proposed EEM is the "Add Economizer" measures, which has a 10 year EUL per DEER 2008. 10 years is appropriate for this project.
Savings Assumptions	IOU Proposal: The IOU analysis relies on the following critical assumptions: 1) The building heating/cooling "change-point" is 58 °F.

Reviewed Parameter	Analysis
	2) The post–retrofit AHUs will utilize 119,700 CFM of OA (code minimum) during heating operation. 3) Building return air is 75 °F during heating operation. 4) Airflow varies linearly with supply air temperature. 5) Boiler efficiency is equal to the installed boilers' rated combustion efficiency in high fire mode. 6) The proposed measure will have a negligible impact on fan power.
	CPUC Staff Assessment: In order, CPUC staff's view of the above assumptions is as follows: 1) The chosen change point is reasonably conservative (low) and sufficient for the PA phase. This value should be updated based on post-installation M&V. 2) The chosen value is consistent with the measure's design intent: limit OA flow during cooling operation. This value should be trued up during the post-installation phase based on M&V. 3) The assumed return air temperature is reasonable, but should be adjusted based on M&V conducted following project implementation. 4) The airflow assumption is reasonable and cannot likely be adjusted without the luxury of airflow stations permanently installed in the affected AHUs. 5) Boiler efficiency should be updated based on combustion tests performed during post-installation M&V. An additional 1% or 2% deduction in boiler efficiency should be made to account for shell losses in addition to combustion losses. 6) This assumption may not be valid and should be assessed with M&V data collected before and after measure implementation.
	CPUC Staff Recommendation: CPUC recommends that each of the above assumptions, with the exception of #4, be verified using data collected during the post-implementation M&V process. See the "Proposed M&V Review" subsection in the "Summary of Review" section for details regarding suggested M&V activities.
Calculation Methods/Tool review	IOU Proposal: The IOU performed the savings analysis with a spreadsheet implemented dry-bulb temperature bin analysis.
	CPUC Staff Assessment: The proposed analysis is appropriate for the claimed measure. However, as mentioned before, the analysis neglects to consider the impact of the proposed EEM on the facility's fan systems.

Reviewed Parameter	Analysis
	CPUC Staff Recommendation: Fan power spot measurements should be performed prior to measure implementation. These measurements, in addition to information collected during post-installation M&V should be utilized to include a fan savings/penalty calculation to the existing analysis during IR true up.
Pre- or Post-Installation M&V Plan	IOU Proposal: The IOU is only proposing a post-installation verification site visit for this project.
	CPUC Staff Assessment: Given the magnitude of the claimed savings and the uncertainty associated with many of the key savings assumptions, CPUC staff believes that the proposed activities are insufficient to reduce the uncertainty associated with the claimed savings.
	CPUC Staff Recommendation: A two week post-installation trending interval should be sufficient to true-up many of the critical assumptions in the existing savings analysis. See the "Proposed M&V Review" discussion above for further detail regarding the requested M&V.
Net-to-Gross Review	IOU Proposal: Net-to-gross issues were not discussed in the provided documentation.
	CPUC Staff Assessment: No assessment is possible at this time.
	CPUC Staff Recommendation: None

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

Description	IOU Ex Ante Claim	CPUC Staff Recommendations
First Year kWh Savings	N/A	Include a fan savings/penalty calculation in the analysis following measure implementation.
First Year Peak kW Savings	N/A	Include a fan savings/penalty calculation in the analysis following measure implementation.
First Year Therms Savings	60,955.2	TBD
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)	N/A	Include a fan savings/penalty calculation in the analysis following measure implementation.
Peak kW Savings (RUL thru EUL Period)	N/A	Include a fan savings/penalty calculation in the analysis following measure implementation.
Therms Savings (RUL thru EUL Period)	60,955.2	TBD
Annual Non-IOU Fuel Impact (RUL Period)	N/A	TBD
Annual Non-IOU Fuel Impact (RUL thru EUL Period)	N/A	TBD
Project Costs for Baseline #1 (RUL or EUL period)	$137,204.00	TBD
Project Costs for Baseline #2 (EUL minus RUL period)	N/A	N/A
Project Incentive Amount	$60,955.20	TBD