Phase 1 Ex Ante Review Findings

Table 1-1: Project Information

IOU	Pacific Gas & Electric
Application ID	a0b70000008HMx1P1
Application Date	Not provided
Program ID	PGE21011
Program Name	Lodging Savers (NRR-DR)
Program Year	2013
Itron Project ID	X363
IOU Ex Ante Savings Date	Not Provided
ED Measure Name	Seven (7) HVAC & Guest room controls measures
Project Description	HVAC retrofit project for a luxury hotel
Date of ED Review(s)	June 21, 2013
Primary Reviewer / Firm	Chris Williams / DNV KEMA
Review Supervisor / Firm	Joseph Ball / Itron
ED Project Manager	[redacted] / California Public Utilities Commission, Energy Division
ED Policy Authorization (as needed)	
Type of Review (Desk, On-site, Full M&V, Tool)	Desk
ED Recommendation	The ex ante savings are conditionally approved pending completion of action items in the *Summary of ED Requested Actions by the IOU* section.

Measure Description

The following measures have been proposed to be implemented as part of the retrofit project:

1. EEM01 – Install Guestroom Controls to Operate Fan Coil Units (Guestroom Energy Management System, or GREMS) – There are currently (802) guestrooms in the hotel, each served by 4-pipe fan coil units (FCU) and controlled by thermostats located in the guestrooms. The existing thermostat set point is maintained by the guestroom occupant, and does not have an automated set back schedule. The proposed measure will implement occupancy-based thermostat controls that will place the guestroom FCU thermostat in to a set-back temperature when the room is left unoccupied for a given period of time (typically 15-30 minutes).
2. EEM02 – Install VFDs on Chilled Water Pumps (CHWPs) – Two (2) 50 HP single speed chilled water pumps are proposed to be retrofitted with VFD controls. The VFD controls will allow the pumps to modulate flow based on load. The pumps are sequenced to run in a lead-lag configuration on the same chilled water loop. The chilled water loop is continuously running and provides chilled water to all the cooling coils in the hotel.
3. EEM03 – Install VFDs on Hot Water Pumps (HWPs) – Two (2) 50 HP single speed heating hot water pumps are proposed to be retrofitted with VFD controls. The VFD controls will allow the pumps to modulate flow based on load. The pumps are sequenced to run in a lead-lag configuration on the same heating hot water loop. The loop is continuously running and provides hot water to all the heating coils in the hotel.
4. EEM04 – Install VFDs on Condenser Water Pumps (CWPs) – Two (2) 50 HP single speed condenser water pumps are proposed to be retrofitted with VFD controls. The VFD controls will allow the pumps to modulate flow based on load. These pumps are connected to two (2) cooling towers, both with VFD-controlled fans programmed to maintain a condenser water temperature of 75 °F. The condenser water pumps are each dedicated to an individual chiller.
5. EEM05 – Install VFDs on Domestic Water Pumps (DWPs) – Two (2) domestic water booster pumps (DWPs), rated at 5 HP and 15 HP respectively, are proposed to be retrofitted with VFD controls. The VFD controls will allow the pumps to modulate flow based on load. Both pumps currently operate continuously (24/7) and at full speed regardless of the water pressure needed at the top floor (furthest location in loop). The VFDs will allow the pumps to operate at a relatively constant but lower than full speed, to provide adequate water pressure to the worst-case locations (top floors).
6. EEM06 – Install VFDs on Ballroom Units – Four (4) air handler units (AHUs), two (2) with one 10 HP supply fan motor each and two (2) with one 3 HP supply fan motor each, are proposed to be retrofitted with VFD controls to modulate the supply fan air flow

based on load. The four AHU supply fan motors currently run continuously (24/7) at full speed, regardless of zone demand. The AHUs are constant volume systems.

7. EEM07 – Install VFDs on AHUs above 15 HP – Ten (10) AHUs' supply fan motors that serve the hotel atrium and other common areas are proposed to be retrofitted with VFD controls in order to modulate supply air flow based on load. Nine (9) of these AHU supply fan motors are 15 HP in size while the tenth is 30 HP. The AHUs are constant volume systems, and the AHU supply fan motors currently run continuously (24/7) at full speed, regardless of zone demand.

Based on the third party investigation report submitted by Ecology Action, project savings are estimated to be 784,375 kWh, 92.61 kW, and 39,200 Therms. The total estimated incentive is $119,055 based on incentive rates of $0.09 / kWh, $100 / kW, and $1 / Therm. The net payback period is estimated to be 6.5 years, based on pre-incentive project cost of $981,985.

Summary of Review

The Investor Owned Utility (IOU) submitted the following documents for Data Request (DR) ED_423 (EEGA 6824) on June 6, 2013for this Phase 1 review:

- Transmittal Memorandum for DR ED_423;
- Third party Project Investigation Report submitted by Ecology Action, dated June 21, 2013;
- Spreadsheet containing one year of monthly electric and gas utility data;
- Spreadsheet containing energy savings analysis and calculations for the EEMs; and
- Baseline and "Measure Case" eQuest model; used solely for EEM01 savings.

The project review will discuss any issues with the savings methodology, M&V plan, or other areas, categorized by EEM below, with general issues discussed in Table 1-2.

EEM01
Note that during the ex ante parallel review, discrepancies in the FCU schedules were discovered while reviewing the eQuest model. On June 21, 2013, those discrepancies were addressed and changes were reflected in the eQuest model, the calculations & savings workbook, and the Investigative Report.

The savings approach currently used to estimate the guestroom (EEM01) savings utilizes the "CASE" (*Guestroom Occupancy Controls*, written by the California Utilities Statewide codes and Standards Team in 2011) study's savings approach that is referenced in the investigation report. While the CASE study uses Title 24 schedules, the project uses default baseline DEER heating and cooling schedules (which happened to also be the site-observed schedules) and the CASE occupancy schedule and formulas are applied to the DEER schedules in order to develop

the measure case heating and cooling schedules. This heating and cooling schedule change is the modeled impact of EEM01.

The current eQuest model does not use any type of site-specific approximation to take baseline vacancy and occupancy patterns in to account, so the model essentially simulates the hotel as being completely booked (no vacancy), with all guestroom FCU fans operating intermittently to satisfy the room's load for all 8,760 hours. This likely over-estimates guestroom FCU fan usage because pre-existing cleaning staff procedures may involve turning off or setting the FCU temperature back from the default 72/70 °F cooling/heating set point. Ecology Action has noted, however, that vacancy (and possibly occupancy data, depending on the GREMS installed by the customer) information is planned to be collected as part of the post-installation M&V effort, and the eQuest model will be revised to take into account average vacancy and room occupancy. ED recommends that the revisions should adjust the model's FCU fan schedule by developing several vacancy and occupancy categories and applying these categories to new FCU schedules that reflect the average vacancy and occupancy for those respective schedules. So for example, if the post-installation data determines that the hotel is on average 25% vacant, and those vacant guestrooms typically had their FCU turned off or set back by the hotel staff in the pre-existing case, then 25% of the thermal zones that represent guestrooms in the baseline model should have their FCU fan and/or temperature schedules adjusted accordingly.

During the parallel review Ecology Action proposed to collect several guestroom parameters during; the post-install phase, depending on the vendor and GREMS model selected by the customer. Vacancy data was also proposed to be collected by the hotel as part of the post-M&V data collection. The guestroom parameters (room occupancy, room temperature, FCU status e.g., fan, heating, cooling modes, and possibly thermostat set point) and the ability to override the occupancy control of the proposed guestroom thermostat & EMS will allow the post-M&V plan to collect pre-existing baseline and installed conditions that can be used to adjust the eQuest model with baseline and post-install occupancy, vacancy, and FCU schedule (fan, heating, and cooling) conditions.

EEM02, EEM03, and EEM04

The savings methodology for EEM02, EEM03, and EEM04, essentially using a duty cycle approximation to estimate the post-implemented drive speed profile, was considered to be a reasonable approach for the pre-M&V phase for these measures. Savings parameters, such as hours of operation, load factor, motor efficiency, affinity exponent, and proposed duty cycle are also reasonable for the pre-implementation ex ante approximations; however, the post-M&V plans should incorporate a method to verify the hours of operation and full speed motor load factors, in order to develop a relationship between drive speed and motor load (kW), and to describe & document the VFD control algorithm chosen (e.g., VFD feedback from discharge pressure sensor and fixed set points based on outside air temperature or some other independent

parameter). The post-install M&V plan and subsequent savings calculations should also attempt to measure and account for average VFD efficiency losses (typically 2-5%); and as already discussed in the Investigation Report, the 2 weeks of VFD trending from a representative sample of the affected motors should be utilized to both verify and modify the duty cycles estimated in the pre-implementation ex ante savings calculations. To support the post-installation duty cycle distribution, collect outside air temperature data (EMS trend data, portable logger, or regional weather station) and perform a temperature-bin analysis to compare measured duty cycles over the two weeks and the duty cycles as extrapolated over the entire year.

EEM05

The savings methodology for EEM05, essentially using a duty cycle approximation to estimate the post-implemented drive speed profile, was considered to be reasonable for this measure. Savings parameters, such as hours of operation, load factor, affinity exponent, motor efficiency, and proposed duty cycle are also reasonable for the pre-implementation ex ante approximations; however, the post-M&V plans should incorporate a method to verify the hours of operation, full speed motor load factors, develop a relationship between drive speed and motor load (kW), and to describe & document the VFD control algorithm chosen (e.g., VFD feedback from discharge pressure sensor and fixed set points based on worst-case pressure differential or some other independent parameter). The post-M&V plan and subsequent savings calculations should also attempt to measure and account for average VFD efficiency losses (typically 2-5%).

EEM06 and EEM07

The savings methodology for EEM06 and EEM07, essentially using a duty cycle approximation to estimate the post-implemented drive speed profile, was considered to be reasonable for these measures as a pre-implementation ex ante estimate. Savings parameters, such as hours of operation, load factor, affinity exponent, motor efficiency, and proposed duty cycle are also reasonable for the pre-implementation ex ante approximations; however, the post-M&V plans should incorporate a method to verify the hours of operation, full speed motor load factors, develop a relationship between drive speed and motor load (kW), and to describe & document the VFD control algorithm chosen (e.g., VFD feedback from discharge pressure sensor and fixed set points based on outside air temperature or some other independent parameter). The post-M&V plan and subsequent savings calculations should also attempt to measure and account for average VFD efficiency losses (typically 2-5%); and as already discussed in the Investigation Report, the 2 weeks of VFD trending from a representative sample of the affected motors should be utilized to both verify and modify the duty cycles estimated in the pre-implementation ex ante savings calculations. The power factor parameter (of 0.90) that is currently being used to calculate estimated fan motor load and energy consumption is typically not used when the rated nameplate horsepower is known. The use of the power factor parameter conservatively under-estimates the baseline and proposed motor load; the post-M&V plan will collect actual motor

power measurements so that the parameter may be ignored. To support the post-installation duty cycle distribution, collect outside air temperature data (EMS trend data, portable logger, or regional weather station) and perform a temperature-bin analysis to compare measured duty cycles over the two weeks and the duty cycles as extrapolated over the entire year.

Review Conclusion

The ex ante savings are conditionally approved pending acceptance of the ED Requested Actions listed below.

Summary of ED Requested Actions by the IOU

ED requests that the IOU undertake the recommended steps and submit the following information:

1. Incorporate recommendations for the post-M&V plan (for all measures) as discussed in the **Summary of Review** section and the **Pre- or Post- Installation M&V Plan ED Recommendation** (in Table 1-2) section.
2. Inform ED of the installed capabilities of the guestroom EMS system when the customer chooses the GREMS equipment. During the parallel review, Ecology Action had noted that the following parameters will be potentially available for trending: room occupancy, room temperature, FCU status (e.g., fan, heating, cooling mode), and possibly the thermostat set point. ED recommendations regarding the post-install eQuest model true-up will depend on the availability of these data; and
3. Upon project completion, submit project cost documentation in the form of vendor invoices, or cost estimates broken down by labor and materials, categorized by individual measure.

Table 1-2 Review Findings

Reviewed Parameter	Analysis
Project Baseline Type (Early Replacement, Normal Replacement, Capacity Expansion, New Construction, System Optimization, Add-on Measures) Note: For early retirement projects only, include RUL through EUL baseline)	IOU Proposal: Add-on Measure
	ED Assessment: All measures (EEM01 – EEM07) are VFDs or thermostat retrofits
	ED Recommendation: None
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
	ED Assessment: All measures (EEM01 – EEM07) are VFDs or thermostat retrofits thus the VFD measures (EEM02 – EEM07) have the fan and pump motors as in situ baseline equipment, and EEM01 has the pre-existing FCU thermostat as the in situ baseline
	ED Recommendation: None
Project Cost Basis (Full Incremental, or Both. Note: For early retirement projects, include RUL through EUL cost basis treatment)	IOU Proposal: Full
	ED Assessment: Since the measures proposed in this project are retrofit measures, full measure cost basis is appropriate
	ED recommendation: None
RUL (required for early retirement projects only, otherwise N/A)	IOU Proposal: N/A
	ED Assessment: N/A
	ED recommendation: N/A
EUL (for each measure)	IOU Proposal: All EEMs – 15 years
	ED Assessment: EEM01 - To stay consistent across projects that implement this measure, use ED recommendation of 11 years. Other VFD EEMs – 15 years is the default DEER value for VFD measures
	ED Recommendation: Change EEM01 EUL to 11 years
Savings Assumptions	IOU Proposal: EEM01: eQuest assumptions include the following – (1) All guestrooms effectively rented and occupied; (2) all guestroom FCUs have identical baseline & proposed fan, heating, and cooling schedules, which are the default DEER hotel schedules; (3) guestroom FCU fan statuses set to "Intermittent" (fan only runs during part of the hour to meet guestroom load);

Reviewed Parameter	Analysis
	(4) proposed guestroom FCU heating and cooling schedules based on measure-case schedules derived from the Guestroom Controls CASE study. EEM02 & EEM03: Hours of operation = 5,110 hours; load factor = 0.70; affinity law exponent = 2.4; proposed duty cycle = 10% of time @ 90% speed; 75% of time @ 70% speed; 15% of time @ 55% speed EEM04: Hours of operation = 4,380 hours; load factor = 0.70; affinity law exponent = 2.4; proposed duty cycle = 10% of time @ 90% speed; 75% of time @ 80% speed; 15% of time @ 70% speed EEM05: Hours of operation = 8,760 hours; load factor = 0.70; affinity law exponent = 1; proposed duty cycle = 10% of time @ 90% speed; 80% of time @ 75% speed; 10% of time @ 55% speed EEM06: Hours of operation = 3,600 hours; load factor = 0.70; affinity law exponent = 2.4; power factor = 0.90; VFD efficiency = 98%; proposed duty cycle = 40% of time @ 100% speed; 55% of time @ 80% speed; 5% of time @ 70% speed EEM07: Hours of operation = 8,760 hours; load factor = 0.70; affinity law exponent = 2.4; power factor = 0.90; VFD efficiency = 98%; proposed duty cycle = 40% of time @ 100% speed; 55% of time @ 80% speed; 5% of time @ 70% speed
	ED Assessment: EEM01: The assumptions regarding hotel vacancy and occupancy may over-estimate guestroom FCU fan usage and energy consumption. While baseline occupancy/vacancy data is not available for the pre-implementation savings estimate, the post-installation M&V plan proposes to collect these data. EEM02 & EEM03: Hours of operation are based on site engineer's explanation of pump run times (the two pumps alternate running 10 months out of the year, or 5 months each pump; and run simultaneously during the remaining two months when increased load is present – ~July/August for CHW pumps; ~December/January for HW pumps). This estimate is reasonable for pre-implementation calculations but must be measured during the post-M&V period. Similarly, the proposed duty cycle is a reasonable estimate for the pre-implementation phase EEM04: Hours of operation are based on site engineer's explanation of pump run times (the two pumps alternate running during the entire year, or 4,380 hours each pump). This estimate is reasonable for pre-implementation calculations but must be measured during the post-M&V period. Similarly, the proposed duty cycle is a reasonable estimate for the pre-implementation phase. EEM05: Hours of operation are based on site engineer's explanation of pump run times (all pumps run continuously, year round). This estimate is reasonable for pre-implementation calculations but must be measured during the post-M&V period. Similarly, the proposed duty cycle is a reasonable estimate for the pre-implementation phase but needs to be trued up in the

Reviewed Parameter	Analysis
	post-implementation phase. Load factor and affinity law exponent used are also reasonable for pre-implementation. EEM06 & EEM07: Assumptions are reasonable for pre-implementation calculations.
	ED Recommendation: EEM01: See ED Requested Actions, and the Summary of Review for ED recommendations EEM02 through EEM07: Proposed duty cycle will need to be verified and modified using the 2 weeks of drive speed trend data that is proposed to be collected in the post-implementation phase. The load factor and affinity exponent can be dropped in the post-implementation phase because spot power measurements will be taken so actual motor loads may be used to calculate energy savings
Calculation Methods/Tool review	IOU Proposal: EEM01 uses a custom eQuest model to generate baseline and measure-case energy consumption. The difference between the baseline and measure-case models' energy (electric and gas) usage is the measure's savings. EEM01 is modeled in eQuest as a change in the baseline guestroom FCU heating and cooling schedules. The change to the baseline schedules is dictated by the average hourly occupancy schedule sourced from the Guestroom Controls CASE study and an assumed 5 °F set-back / set-up. EEM02 through EEM07 use spreadsheet calculations and proposed annual drive speed duty cycle profiles to estimate annual measure savings
	ED Assessment: EEM01: This method is appropriate for this type of measure. Since this measure's savings are very schedule- and behavior-dependent, this method can be expanded in to multiple occupancy and rented-room categories on the post-M&V side EEM02 through EEM07: Using this method (using duty cycle profiles) as opposed to temperature bin analysis can have a loss in resolution as the ultimate number of "bins" with potentially different drive speeds is usually less than the temperature bin analysis method. However, the duty cycle profile can readily be interpreted as a modified temperature-bin analysis, and the post-M&V plan may be revised to include additional data collection in order to correlate drive speed to some independent variable (outdoor air temperature, building schedule or respective HVAC static pressure set point) in order to annualize the proposed 2 weeks of collected drive speed trend data. However, based on discussion with the implementer and from anecdotal observations from other high-rise hotel projects, typical base plant load is internally driven as opposed to having strong dependence on weather, especially in climate zone 3; so the proposed post-M&V plan will revise the current duty cycle profile by expanding the number of bins if the trend data hints at larger variation in drive speeds.

Reviewed Parameter	Analysis
	ED Recommendation: Recommendations for modifying calculation methods for EEM01 through EEM07 are given in the *Pre- or Post-Installation M&V Plan* section and the *Summary of Review* section
Pre- or Post-Installation M&V Plan	IOU Proposal: EEM01: Pre-M&V plan included developing the custom eQuest model which used a digital CAD drawing to draw the as-built building shell and zones. It appears that some of the main mechanical schedules (set points, capacities, & quantities for main plant equipment, cooling tower, pumps, and air handlers) and specifications were then input in to the model and the model was "calibrated" to annual utility electric and gas data (Utility data shows 9,424,683 kWh and 404,923 Therms for May 2012 through April 2013; modeled energy usage reports 9,530,000 kWh and 392,100 Therms). The post-M&V data collection plans includes "two weeks of trend data collected after the units are installed". EEM02 through EEM07: The pre-M&V data collection for these measures included taking pictures of all pump and fan motor nameplates to collect nameplate HP and efficiency. Hours of operation for these measures could not be collected from the existing EMS system so estimates were obtained from the site's building engineers. Post-M&V plans for these measures included "2 weeks of VFD trending from a representative sample of [pump & fan motors]" that will be used to "verify post-installation duty cycles".
	ED Assessment: EEM01: The guestrooms are currently modeled as being completely rented with no variation in guestroom FCU schedules (fan, heating, and cooling). Therefore, the current model is likely over-estimating guestroom load and subsequent savings; however, without hotel vacancy data and guestroom occupancy & FCU data that are proposed to be collected in the post-M&V phase, the savings over-estimation presumption cannot be substantiated. EEM02 through EEM07: Pre-M&V data collection is sufficient; savings parameters including load factor, power factor (EEM06 and EEM07), affinity law exponent, and VFD efficiency can all be excluded if ED Requested Actions are performed for the post-M&V data collection phase
	ED Recommendation: EEM01: See the ED Requested Actions for guestroom data points and hotel vacancy data that are proposed to be collected in the post-installation phase. EEM02 through EEM04: In addition to the proposed post-M&V plan: (1) Perform spot power measurements (most importantly, true power and power factor) on all sampled pumps for various drive speeds (e.g., 30 Hz – 60 Hz, in 10 Hz increments), and with the VFD in override mode (i.e., baseline), in order to develop a relationship between drive speed and measured motor load (kW). This will allow actual power measurements to be used in place of the pre-M&V estimated baseline and proposed motor loads that utilize assumed load factors, affinity law exponents, and VFD efficiencies; (2) Hours of operation will be an inherent data point that is collected when the two weeks

Reviewed Parameter	Analysis
	of VFD trend data is collected for the selected sample of pumps, which is likely to be one of the two pumps (for each measure); (3) Additionally, collect outside air temperature data (using portable logger, weather station, or facility trend data) and perform temperature-bin analyses using the collected VFD drive speed and temperature data. Compare the measured duty cycle results to the temperature bin analyses, for the two- week period and the extrapolated annual period, as a means to support the post-installation duty cycle distribution. EEM05: In addition to the proposed post-M&V plan: (1) Perform spot power measurements (most importantly, true power and power factor) on all sampled pumps for various drive speeds (e.g., 30 Hz – 60 Hz, in 10 Hz increments), and with the VFD in override mode (i.e., baseline), in order to develop a relationship between drive speed and measured motor load (kW). This will allow actual power measurements to be used in place of the pre-M&V estimated baseline and proposed motor loads that utilize assumed load factors, affinity law exponents, and VFD efficiencies. EEM06 and EEM07: In addition to the proposed post-M&V plan: (1) Perform spot power measurements (most importantly, true power and power factor) on all sampled fan motors for various drive speeds (e.g., 30 Hz – 60 Hz, in 10 Hz increments), and with the VFD in override mode (i.e., baseline), in order to develop a relationship between drive speed and measured motor load (kW). This will allow actual power measurements to be used in place of the pre-M&V estimated baseline and proposed motor loads that utilize assumed load factors, power factors, affinity law exponents, and VFD efficiencies. EEM06 should have one AHU of each size measured (i.e., one of the two "Grand Ballroom SF" AHU fans and one of the two "Ballroom A/B/C" AHU fans), while EEM07 should have one AHU of each service zone and distinct size measured (i.e., AHUs labeled "MME 09", "MME 12", "SFM 2", and "MME 31"); (2) use the two weeks of VFD trend data proposed to be collected as a means to verify hours of operation. Collect any additional information to account for potential seasonal variations in the service zone schedules as a means to revise pre-M&V estimated hours of operation.; (3) Additionally, collect outside air temperature data (using portable logger, weather station, or facility trend data) and perform temperature-bin analyses using the collected VFD drive speed and temperature data. Compare the measured duty cycle results to the temperature bin analyses, for the two- week period and the extrapolated annual period, as a means to support the post-installation duty cycle distribution.
Net-to-Gross Review	IOU Proposal: Not provided
	ED Assessment: TBD
	ED Recommendation: A NTG review may be recommended at a later time

Table 1-3 Energy Savings Summary

Description	IOU Ex Ante Claim	ED Recommendations
First Year kWh Savings	784,375	TBD
First Year Peak kW Savings	92.61	TBD
First Year Therms Savings	39,200	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	N/A
Peak kW Savings (RUL thru EUL Period)	N/A	N/A
Therms Savings (RUL thru EUL Period)	N/A	N/A
Annual Non-IOU Fuel Impact (RUL Period)	N/A	N/A
Annual Non-IOU Fuel Impact (RUL thru EUL Period)	N/A	N/A