Phase II Ex Ante Review Findings

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

IOU	PG&E
Application ID	2K13202231
Application Date	
Program ID	PGE21011
Program Name	Retrocommissioning (RCx)
Program Year	2013
Itron Project ID	X399
IOU Ex Ante Savings Date	Savings are not yet PA-approved
CPUC Staff Measure Name	RCx
Project Description	The customer is completing a retrocommissioning project in an 11-story multi-tenant office building. The five proposed measures include (1) VFD re-automation for the hot and cold deck fans in the building's dual duct air handler, (2) revised hot deck OA reset scheduling, (3) optimum start/stop AHU controls, (4) OA damper repairs to allow airside economizing, and (5) refrigeration compressor head pressure reset control.
Date of CPUC Staff Review	12/16/2013
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 during the post-installation M&V as suggested in this report.

Measure Description

This retrocommissioning project aims primarily to correct deficiencies in the central HVAC systems serving an [redacted] multi-tenant office building in San Francisco. The first three floors of the [redacted] square foot building are primarily unconditioned parking areas; floors [redacted] through [redacted] contain general office space; and floors [redacted] through [redacted] contain radio station tenants with more substantial electronic loads.

A dual-duct, dual-fan air handler with a 50 HP cold deck fan and a 50 HP hot deck fan provides space cooling and heating for the majority of the building; dedicated DX systems provide 24-hour cooling to radio station IT loads on the top floor. The main AHU fans, though equipped with VFDs, are presently operating in a constant volume fashion at an 80% speed set point due to pre-existing building pressurization issues. Three (3) 125 HP, Carrier 5H120 DX reciprocating compressors connected to an evaporative condenser provide mechanical cooling to the AHUs. An Ajax WNG 4000, 2.56 MMBtuh (output), 80% efficient boiler provides hot water to the AHUs. The building HVAC systems are active between 6 AM and 6 PM, Monday through Friday.

In addition to the constant AHU fan speed control problem noted above, the RCx consultant identified the following issues:

- The hot deck set point temperature resets between 150 F (at 40 F outdoor) and 110 F (at 60 F outdoor). This high reset range, coupled with the constant speed fan control strategy causes excessive simultaneous cooling. During the summer months, the facility engineer partially valves off hot water flow to the hot deck specifically because of this issue.
- The building does not use either optimum start or start algorithms. As such, the building may be unnecessarily conditioned in the morning when it is not yet at full occupancy and at the end of the day when thermal inertia would be sufficient.
- The economizer damper actuator has failed. Presently the dampers are set at 10% open. The building therefore does not take advantage of the economizing opportunity afforded by San Francisco's mild climate.
- The head pressure of the R-22 DX compressors is currently fixed at 195 psig (100 F). This high set point causes excessive compressor work in a climate that would allow lower saturated discharge temperatures.

The following RCx measures are proposed to correct the issues identified above:

(1) Enable variable airflow for both the hot deck and cold deck. At minimum, allow airflow to vary between 50% and 80%.

(2) Change the reset temperature range on the hot deck to 75 F (at 60 F outdoor) to 110 F (at 40 F outdoor). Change the reset on the cold deck from between 60F (at 60 F outdoor) and 55 F (at 80 F outdoor) to between 65F (at 60 F outdoor) and 55 F (at 80 F outdoor).

(3) Implement optimum start and stop controls for the building HVAC systems.

(4) Repair the outdoor air damper actuator to allow modulation between 10% and 100% outdoor air. Implement single point temperature based OA economizer control.

(5) Implement a condenser head pressure reset control strategy. The RCx consultant suggests lowering the condensing temperature set point to a minimum set point of 90 F when the ambient dry bulb temperature decreases to 80 F and a maximum of 100 F when the outdoor temperature reaches 90 F.

The table below—the content for which was appropriated directly from the RCx Investigation Report by the RCx agent—summarizes expected energy savings by measure, anticipated measure costs, incentives, and payback periods.

Measure	Projected Electricity Savings (kWh/yr)	Projected Peak Demand Savings (kW/yr)	Projected Natural Gas Savings (therms/year)	Projected Project Cost	Gross Incentive	Simple Payback (Years)
RCx-1: VSD Re-automation	121,740	30.55	10,276	$2,500	$24,287,60	0.04
RCx-2: Optimum Deck Temperature Reset	36,929	0.0	9,191	$2,500	$12,514.61	0.09
RCx-3: Optimum Start/Stop Controls	104,275	0.0	1,398	$2,500	$10,782.75	0.07
RCx-4: Outside Air Damper Repair	67,554	0.0	-887	$12,500	$5,192.86	0.76
RCx-5: Condenser Temperature Reset	9,967	7.59	0	$2,500	$1,656.03	0.55
Totals	340,465	38.14	19,978	$22,500	$11,250.00 **(capped at 50% of total project cost)**	0.16

Summary of Review

The Investor-Owned-Utility (IOU) submitted the following documents on 10/16/2013 in response to the Data Request (DR) for this Phase 1 review:

- RCx Investigation report;
- The eQUEST savings model used to develop initial savings estimates; and

- EMS trend data and screenshots used to support the savings analysis and measure development.

Eligibility Review

A review of the proposed project activities revealed that all measures are eligible per the *Statewide RCx Policy & Procedures Manual.* All measures conform to the RCx measure categories defined in PG&E's *RCx Project Submittal Guidelines*. Although it appears that the measure cost values provided by the RCx agent are merely rough estimates of project costs, the extremely quick overall payback for the project (0.16 years) suggests that even if the project cost comes in considerably higher than expected and the measures do not yield as much savings as proposed, the overall project payback should remain less than one year, which is permitted under RCx program rules in PG&E territory.

Preliminary Savings Estimation Review

To develop savings estimates for each measure, the RCx agent built an eQUEST simulation model of the baseline facility then performed parametric runs for the proposed measures. Baseline conditions were verified and modeled based on 36 days of EMS trending. Additional pre-functional tests beyond trend review and visual verification do not appear to have been performed based on the submitted RCx investigation report.

The baseline model was calibrated using monthly utility billing data to within -7.9% of annual consumption from the most recent year and to within -4% for the most recent two year average. The RCx agent properly utilized a cascading approach to savings estimation wherein the proposed case for one EEM became the base case for the next measure to avoid double-counting measure savings. The following observations were made based on the calculation methods utilized for each measure:

EEM1: VSD Re-automation

In the first parametric run, the analyst adjusted keywords to allow fan modulation and lower the minimum fan speeds on both the cold deck and hot deck AHUs from the fixed 48 Hz used currently to 30 Hz. In our view, no additional adjustments are necessary for this measure.

EEM2: Optimum Deck Temperature Reset

The cold and hot deck temperature reset schedules were adjusted in accordance with the proposed schedules listed in the "Measure Description" Section above. No other adjustments are required for this measure.

EEM3: Optimum Start/Stop Controls

In the fan schedules for the 6 AM to 7 AM and 5 PM to 6 PM hours, the fan ON/OFF value has been assigned a value of -999 in the parametric runs. For the morning hour, this means that if the fans are needed to bring the space up to set point by 7 AM, then they will be activated. Unfortunately, since eQUEST is an hourly simulation tool, it can only determine whether the fans are on or off for the full hour. Simulation of optimum start in this manner is a rough estimation at best, but no other recourse is readily available in eQUEST.

For the evening hour, the -999 value has no actual meaning since eQUEST does not have a methodology in place to simulate optimum stop. Commission Staff does not suggest any modification to account for this issue at present, but suggests that some manipulation of the final 8,760 outputs may be warranted based on M&V data to account for the impacts of optimum stop during the post-installation phase.

EEM4: Outside Air Damper Repair

The maximum outdoor air fraction was adjusted from 10% (the fixed value in the base case) to 100%, allowing for an outside air flow range of 10% to 100% of design flow. In contrast to the RCx Investigation Report, which states that single point outdoor air temperature economizer control will be used, the economizer has been modeled with a single point *enthalpy* control strategy using a high limit outdoor enthalpy of 30 btu/lb. The RCx agent should clarify the intended control strategy and the high limit condition in the RCx report and adjust the model accordingly.

EEM5: Condenser Temperature Reset

The RCx agent was required to make a number of compromises when modeling the installed DX cooling and evaporative condensing HVAC system. eQUEST does not allow any cooling system type other than chilled water for dual duct, dual fan systems. As such, the three DX reciprocating compressors were modeled as reciprocating chillers. Another compromise was then made because central plants in eQUEST with evaporative condensers cannot be modeled with a saturating condensing temperature reset control strategy. The heat rejection equipment was therefore modeled as an open cooling tower/heat exchanger system, which allows definition of an outdoor dry bulb temperature driven condenser water (and hence head pressure) reset strategy.

In our view, there are issues with this measure and the associated analysis strategy that should be considered by the RCx agent. First, the measure proposes to reset head pressure from 100 F SDT at 90 F outdoor air temperature to 90 F SDT at 80 F outdoor air temperature. Considering that the 2.5% design day temperature in San Francisco is 77 F, there are almost no hours when the SDT will raise above its minimum value of 90 F. Additionally, the reset is defined in terms of ambient dry bulb temperature even though the installed heat rejection equipment is an evaporative (not dry coil) condenser. It would be more appropriate to define the head pressure reset in terms of ambient wet bulb temperature.

If the RCx agent chooses to retain the existing definition of the measure, then we suggests implementing one of the two following modifications.

(1) The first option would entail changing the heat rejection equipment in the savings model from an open tower with heat exchanger to an evaporative condenser. As noted above, doing so would not allow implementation of a "head pressure reset" in the model. However, given that the head pressure would almost never reset above its proposed minimum value, this approach would likely better capture the dynamics of what the measure actually achieves—reducing the SDT from a fixed value of 100 F to a nearly fixed value of 90 F—while at the same time more accurately modeling the proper type of heat rejection equipment.

(2) If the RCx agent chooses not to implement the modeling change suggested above, then the following adjustment is suggested at minimum. Currently, the reset schedule is defined in terms of the entering condenser water temperature (i.e. the entering condenser water temperature for the "chillers" varies from a minimum value of 90 F at 80 F ambient to a maximum of 100 F at 90 F ambient). In practice, the SCT of a chiller is typically approximately 3 F higher than the *leaving* condenser water temperature (see: http://www.trane.com/commercial/ library/vol251/v25a1.asp). Assuming that the modeled cooling tower operates with a typical range (LCWT – ECWT) of 5 F (applicable to 50% load conditions), then the modeled condenser water reset schedule would need to utilize 8 F lower ECWT limits (82 F and 92 F) to more accurately model the head pressure conditions seen my the modeled "chillers" under the proposed control strategy. It's worth noting that a similar adjustment should be made to lower the baseline ECWT from the fixed 100 F currently used to 92 F.

Proposed M&V Review

The RCx agent proposes to trend the following parameters in 15 minute intervals for two weeks following project implementation to confirm operation of the proposed control strategies for EEMs 1 through 4:

- Fan speeds
- Hot Deck Temp, Static Pressure, and Damper Position
- Cold Deck Temp, Static Pressure and Damper Position
- OSA Temp and Damper Position
- Return Air Temp.
- Mixed Air Temp.
- Hot Water Valve Position

The RCx agent will additionally verify damper positions to confirm implementation of EEM4. No M&V for EEM5 is proposed beyond checking the implementation of the operating set point

and reset schedule in the EMS since this measure is defined as a "small saver" in the RCx Project Submittal Guidelines. The proposed M&V activities are consistent with the requirements of the RCx program delineated in the aforementioned Submittal Guidelines. However, we believe post-implementation trending should be extended to six to eight weeks to observe operations across a wider range of temperatures. Observing system operations across a broad range of temperatures is particularly critical for this project since three of the EEMs are driven completely off of outside air: the deck temperature resets, the outside air economizer repairs, and the head pressure reset. This suggested M&V modification should incur little to no additional cost since all parameters will be collected using the facility's EMS system.

Review Conclusion

To ensure that the few analysis shortcoming identified during the review had a minor impact on projected savings, we implemented the proposed changes for EEM 4 (changing to single point temperature economizing as claimed in the report) and EEM 5 (using the second approach for EEM 5 above) and found that the model estimated energy savings changed by only -16,793 kWh (or -4.9%) and none for gas. As such, while we requests that the suggested modifications be made at some point, the identified shortcomings are not significant enough to stop project approval at this time.

CPUC Staff conditionally approves this project contingent upon post-M&V true up.

Summary of CPUC Staff Requested Action by the IOU

CPUC Staff requests that the IOU undertake the recommended steps prior to the post-implementation Phase II ex ante review of this project:

1. Modify the savings analysis for EEMs 4 and 5 in accordance with the strategies provided in the "Summary of Review" section.
2. Extend the post-installation M&V trending period from two weeks to six to eight weeks to better characterize system operations over a wide range of ambient conditions.

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: System Optimization
	CPUC Staff Assessment: System Optimization is appropriate. In situ conditions form the appropriate baseline for RCx 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 RCx projects.
	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 the provided RCx Investigation Report.
	CPUC Staff Assessment: The EUL for each of the proposed measures should be identified in the RCx Investigation Report.
	CPUC Staff Recommendation: Per Appendix B in the "RCx Project Submittal Guidelines" document, the EUL of each of the proposed measures is five years.
Savings Assumptions	IOU Proposal: The critical assumption made in the analysis is that the three DX reciprocating compressors providing cooling to the building's central AHU cold duct and their associated evaporative condensers can be reasonably

Reviewed Parameter	Analysis
	accurately modeled as reciprocating chillers attached to cooling towers. The RCx agent also assumed that the eQUEST model could properly account for optimum shutdown.
	CPUC Staff Assessment: Given that eQUEST does not allow DX systems to be connected to dual duct AHUs, the RCx agent had little recourse other than to model the reciprocating DX compressors as chillers. As noted in the review summary above, the RCx agent could have better modeled the head pressure conditions actually seen by the compressors by lowering the fixed entering condenser water temperature used in the baseline model and condenser water temperature reset schedule used in the proposed model. With respect to the inputs used for optimal shutdown, the RCx agent has no recourse because eQUEST does not have a built in algorithm to handle optimum shutdown.
	CPUC Staff Recommendation: Implement the proposed analysis modifications noted in the EEM 5 Analysis Review above. Consider performing post-processing on the eQUEST 8760 outputs during the post-installation M&V phase to account for the optimum shutdown savings.
Calculation Methods/Tool review	IOU Proposal: The IOU's RCx agent utilized a baseline eQUEST model modified with five cascading parametric runs to estimate project savings.
	CPUC Staff Assessment: The overall analysis approach utilized to estimate savings was appropriate. A few minor errors with the savings inputs were identified in the Review Summary section above for EEMs 4 and 5.
	CPUC Staff Recommendation: CPUC staff recommend correcting the minor analysis flaws identified above based on the suggestions provided in the Review Summary section.
Pre- or Post-Installation M&V Plan	IOU Proposal: The RCx agent performed two weeks of baseline data collection to identify present operating conditions. The RCx agent proposes to perform two weeks of additional data collection on the back end of the project to verify measure implementation and operations.
	CPUC Staff Assessment: The proposed M&V is consistent with program requirements.
	CPUC Staff Recommendation: CPUC staff request that the EMS trending period be extended to six to eight weeks post-implementation to guarantee that operations are observed across a range of temperatures. Observing system operations across a range of temperatures is particularly critical for this project since three of the EEMs are driven completely off of outside air: the deck temperature resets, the outside air economizer repairs, and the head pressure reset.
Net-to-Gross Review	IOU Proposal: Net-to-gross issues were not discussed in the provided documentation.

Reviewed Parameter	Analysis
	CPUC Staff Assessment: No assessment is possible at this time.
	CPUC Staff Recommendation: No assessment is possible at this time.

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

Description	IOU Ex Ante Claim	CPUC Staff Recommendations
First Year kWh Savings	340,465	340,465
First Year Peak kW Savings	38.14	38.14
First Year Therms Savings	19,978	19,978
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)	340,465	340,465
Peak kW Savings (RUL thru EUL Period)	38.14	38.14
Therms Savings (RUL thru EUL Period)	19,978	19,978
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)	$22,500	$22,500 (at face value, this amount strikes CPUC staff as low for this project. Consider revising suggested costs upwards or citing the source and/or basis for these estimates).
Project Costs for Baseline #2 (EUL minus RUL period)	N/A	N/A
Project Incentive Amount	$11,250 (capped at 50% of estimated full project cost)	$11,250 (capped at 50% of estimated full project cost)