RTR Appendix

Southern California Edison, Pacific Gas and Electric, Southern California Gas, and San Diego Gas and Electric ("Joint Utilities" or "Joint IOUs") developed Responses to Recommendations (RTR) contained in the evaluation studies of the 2013-2015 Energy Efficiency Program Cycle. This Appendix contains the Responses to Recommendations in the report:

RTR for the Study of Deemed HVAC Measures Uncertainty Year 3 Report (HVAC4)
(DNV GL, Calmac ID #CPU0145.04, ED WO #ED_D_HVAC_4)

The RTR reports demonstrate the Joint Utilities' plans and activities to incorporate EM&V evaluation recommendations into programs to improve performance and operations, where applicable. The Joint IOUs' approach is consistent with the 2013-2016 Energy Division-Investor Owned Utility Energy Efficiency Evaluation, Measurement and Verification (EM&V) Plan[1] and CPUC Decision (D.) 07-09-043[2].

Individual RTR reports consist of a spreadsheet for each evaluation study. Recommendations were copied verbatim from each evaluation's "Recommendations" section.[3] In cases where reports do not contain a section for recommendations, the Joint IOUs attempted to identify recommendations contained within the evaluation. Responses to the recommendations were made on a statewide basis when possible, and when that was not appropriate (e.g., due to utility-specific recommendations), the Joint IOUs responded individually and clearly indicated the authorship of the response.

The Joint IOUs are proud of this opportunity to publicly demonstrate how programs are taking advantage of evaluation recommendations, while providing transparency to stakeholders on the "positive feedback loop" between program design, implementation, and evaluation. This feedback loop can also provide guidance to the evaluation community on the types and structure of recommendations that are most relevant and helpful to program managers. The Joint IOUs believe this feedback will help improve both programs and future evaluation reports.

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1 Page 336, "Within 60 days of public release of a final report, the program administrators will respond in writing to the final report findings and recommendations indicating what action, if any, will be taken as a result of study findings. The IOU responses will be posted on the public document website." The Plan is available at http://www.energydataweb.com/cpuc.

2 Attachment 7, page 4, "Within 60 days of public release, program administrators will respond in writing to the final report findings and recommendations indicating what action, if any, will be taken as a result of study findings as they relate to potential changes to the programs. Energy Division can choose to extend the 60 day limit if the administrator presents a compelling case that more time is needed and the delay will not cause any problems in the implementation schedule, and may shorten the time on a case-by-case basis if necessary to avoid delays in the schedule."

3 Recommendations may have also been made to the CPUC, the CEC, and evaluators. Responses to these recommendations will be made by Energy Division at a later time and posted separately.

Response to Recommendations (RTR) in Impact, Process, and Market Assessment Studies

Study Title: Study of Deemed HVAC Measures Uncertainty Year 3 Report (HVAC4)
Program: HVAC
Author: DNV GL
Calmac ID: CPU0145.04
ED WO: ED_D_HVAC_4
Link to Report: http://calmac.org/publications/HVAC4_Year_3_Report_2017-12-29.pdf

Item #	Findings	Best Practice / Recommendations (Verbatim from Final Report)	Recommendation Recipient	Disposition	Disposition Notes
			If incorrect, please indicate and redirect in notes.	Choose: Accepted, Rejected, or Other	Examples: Describe specific program change, give reason for rejection, or indicate that it's under further review.
1	**Nonresidential Upstream HVAC Distributor Rebate Program**: • For Tier-2 unitary systems under 55 kBtu/h, the mean annual savings in CZ08 for the small office building prototype were 218.2 kWh/ton, with a standard deviation of ± 29.4 kWh/ton (compared to 2015 DEER savings of 327.8 kWh/ton). The savings uncertainty was most sensitive to whether systems have 1- or 2-speed fans, the fan power index, and the cooling setpoint. • For Tier-2 unitary systems under 55 kBtu/h, the mean annual savings in CZ12 for the small office building prototype were 178.0 kWh/ton, with a standard deviation of ± 29.2 kWh/ton (compared to 2015 DEER savings of 322.2 kWh/ton). The savings uncertainty was most sensitive to whether systems have 1- or 2-speed fans, whether systems have an economizer, the fan power index (W/cfm), and the cooling-sizing ratio. • For Tier-2 air-cooled chillers, the mean annual savings in CZ03 for the large office building prototype were 35.6 kWh/ton, with a standard deviation of ± 21.6 kWh/ton (compared to 2014 DEER savings of 84.4 kWh/ton). The savings uncertainty was most sensitive to the full-load cooling efficiency, the cooling temperature schedule, and the minimum condenser temperature. • For Tier-2 air-cooled chillers, the mean annual savings in CZ08 for the small office building prototype were 36.8 kWh/ton, with a standard deviation of ±	Assumptions used to estimate DEER savings should be reviewed. Additional data collection for factors contributing to savings uncertainty is warranted.	IOUs and ED	Other	Agree that assumptions used to estimate DEER savings should be reviewed and that additional data collection is warranted. Collected data should be limited to that necessary to attribute and claim savings. While large quantities of data are valuable, a balance must be stricken between data capture and performance of program duties. Gathering additional data, especially site installation data is outside of the reach of an upstream program. Air-Cooled Chiller - CZ03 is a poor climate zone selection for evaluating chiller equipment including that at full-load conditions. Not clear on reasoning for selecting CZ03 with such low CDDs. Per latest policies and T24, part 6, minimum efficiency requirements, chiller equipment are to be evaluated at both part-load and full-load operation. It looks like 2008 T24 already requires both full- and part-load efficiencies to be met. Evaluation of chiller equipment operation at only full-load operation is not the correct approach. Also, the average equipment operation will not occur at full-load operation. Measurements at part-load conditions will be needed to better understand equipment performance and benefits of the offering. Not clear what was the approach for evaluating the minimum condensing water temperature (CWT). Was the chiller equipment operation additionally evaluated as a function of CW flow? Was the chiller evaluation only at constant flow operating conditions even when serving the 175,000 sq ft DEER Large Office? Given that chiller equipment was evaluated with the 175,000 sq ft Large Office, the evaluation needed to include both constant and variable speed flow chiller equipment. Also, the incorrect DEER (Large Office) model was selected for the evaluation of the air-cooled chiller, which is defaulted to water-cooled chiller equipment. Additionally, information from HVAC1 on the presence of fans that have more than two-speeds is not included in this analysis and should be considered in the additional data collection for factors contributing to uncertainty. It is also unclear whether economizer setpoint limits, which are set by climate zone according to Title 24, collected in HVAC3 were delineated by climate zone and how the distribution of these points would change according to each climate zone model. Lastly, there was a large discrepancy in W/CFM of the equipment found in HVAC1

	23.4 kWh/ton (compared to 2014 DEER savings of 176.7 kWh/ton). The savings uncertainty was most sensitive to the full-load cooling efficiency, the cooling-temperature schedule, and the minimum condenser temperature.				2013-2014 vs. HVAC1 2015, and the size category for the W/CFM do not seem to be captured. Additional data should discover if there are trends in W/CFM by size categories or fan types (single, two-speed, and variable speed). The data on cooling setpoints for air cooled chillers based on engineering judgement does not seem to align with setpoints used for package units. HVAC3 showed setpoints for package equipment were <76F for 90% of equipment, whereas air-cooled chillers show 80% of the units using cooling setpoints ≥76F. Therefore, it's unclear how these engineering judgements were made and reiterates the need to collect additional data that can be used to update each model. The air-cooled chiller analysis shows high uncertainty based on the EIR of the model. The EIR is usually dictated by the DEER measures, and therefore additional data on EIR may not need to be collected to update DEER assumptions. Additionally, the analysis does not consider the large range of IPLVs that were submitted to the program and the units that had high IPLVs with relatively low full-load requirements. Manufacturers design equipment to support higher IPLVs with very little full-load improvements, but these units are not properly represented through this uncertainty analysis. Analysis of the measure needs to properly account for the equipment with high part-load values submitted through the Program.
2	**Nonresidential Upstream HVAC Distributor Rebate Program**: • For Tier-2 unitary systems between 65 and 134 kBtu/h, the mean annual savings in CZ08 for the small office building prototype were 69.8 kWh/ton, with a standard deviation of ± 12.7 kWh/ton (compared to 2015 DEER savings of 61.3 kWh/ton). The savings uncertainty was most sensitive to the cooling-sizing ratio, the cooling setpoint, and the fan power index. • For Tier-2 unitary systems between 65 and 134 kBtu/h, the mean annual savings in CZ12 for the small office building prototype were 59.8 kWh/ton, with a standard deviation of ± 10.1 kWh/ton (compared to 2015 DEER savings of 53.0 kWh/ton). The savings uncertainty was most sensitive to the cooling-sizing ratio, the cooling setpoint, and the fan power index.	Additional data collection for factors contributing to savings uncertainty is warranted.	IOUs and ED	Other	Agree that assumptions used to estimate DEER savings should be reviewed and that additional data collection is warranted. Collected data should be limited to that necessary to attribute and claim savings. While large quantities of data are valuable, a balance must be stricken between data capture and performance of program duties. Gathering additional data, especially site installation data is out-side of the reach of an upstream program. The "Best Practice/Recommendations" made in item number 1 states: "The Assumptions used to estimate DEER savings should be reviewed." It is unclear why this recommendation is included for units <55 kBtu/h and air-cooled chillers, but not unitary large equipment (as it is applicable). Additionally, information from HVAC1 on the presence of fans that have more than two-speeds is not included in this analysis and should be considered in the additional data collection for factors contributing to uncertainty. It is also unclear whether economizer setpoint limits, which are set by climate zone according to Title 24, collected in HVAC3 were delineated by climate zone and how the distribution of these points would change according to each climate zone model. Lastly, there was a large discrepancy in W/CFM of the equipment found in HVAC1 2013-2014 vs. HVAC1 2015, and the size category for the W/CFM do not seem to be captured. Additional data should discover if there are trends in W/CFM by size categories or fan types (single, two-speed, and variable speed). Unitary Equipment - Part-load performance (IEER) on baseline equipment is unknown. Equipment with cooling capacities greater than 65 kBtu/h should have been evaluated against both EER and IEER. The baseline assumption for Unitary Equipment is incorrect. The baseline equipment should have been weighted between "1-speed" and "2-speed" fans leveraging latest related saturation studies and contingent that 2-speed fan is a prescriptive and not a mandatory T24, Part 6, requirement. It appears that temperature setpoints were assumed based on Engineering Judgment opposed to latest applicable saturation studies which is the incorrect approach. Sample rate per unitary equipment system type and capacity range should be documented.

					How the selected building vintage aligns with building types and vintages generally supported by program is not clear.
3	**Nonresidential Upstream HVAC Distributor Rebate Program**: • The part-load efficiency (IPLV) qualification pathway results in some qualifying air-cooled chillers with full-load efficiency that is below the Title-24 code requirement; this results in negative savings during full-load periods of operation. Since eQUEST does not support efficiency performance curves that deviate significantly from the default curve, exaggerated mean annual savings are predicted.	Full- and part-load efficiency metrics (EER and IPLV) should be gathered and recorded in the program tracking data.	IOUs and ED	Accepted	Full- and part-load efficiency metrics are gathered and recorded by the SCE and PGE programs. The program IPLV is also referenced in section 5.2.3.1. SDGE is considering offering air-cooled chillers as part of Upstream/Midstream programs.
4	**Nonresidential Upstream HVAC Distributor Rebate Program**: • Given the influence of the cooling temperature schedule and the minimum condenser temperature on the annual savings uncertainty for air-cooled chillers, a retro-commissioning measure opportunity exists.	Consider establishing a retro-commissioning measure for air-cooled chillers to influence the practices of building equipment managers.	IOUs	Accepted	Retro-commissioning measures currently exist in other programs.
5	**Nonresidential Upstream HVAC Distributor Rebate Program**: • The part-load efficiency (IPLV) qualification pathway for air-cooled chillers results in some qualifying chillers with full-load efficiencies that are below the Title-24 code requirement; this results in negative savings during full-load periods of operation.	Consider adding the full-load efficiency rating (EER) and the part-load efficiency rating (IPLV) to list of required fields in the tracking data for air-cooled chillers.	IOUs	Accepted	Full- and part-load efficiency metrics are gathered and recorded by the SCE and PGE programs. The program IPLV is also referenced in section 5.2.3.1. SDGE is considering offering air-cooled chillers as part of Upstream/Midstream programs.
6	**Nonresidential HVAC Quality Maintenance Rebate Program**: • For both system types studied—single-stage without TXV and multi-stage with TXV—results suggest that, even with other faults present, correctly diagnosing and addressing undercharged refrigeration circuits will nearly always have positive performance impacts. This is particularly true for highly undercharged units.	Continue to offer the RCA measure where refrigerant charge is very low.	IOUs and ED	Other	Agree that refrigerant charge adjustment should continue to be offered for “significant” instances, but establishing the definition of significant as exceeding 20%-deviation-from-nominal-charge basis is problematic. There are no diagnostics methods that can readily make this distinction in the field. Technicians will not be able to easily determine whether any given field unit exceeds the 20% charge threshold. This approach also misses out on one aspect of preventative maintenance, where an HVAC unit avoids ever reaching “significant” low charge fault levels. It only reacts to adjusting faults when they become obvious problems and have accrued penalties for running inefficiently.
7	**Nonresidential HVAC Quality Maintenance Rebate Program**: • For multi-stage units with TXV, results suggest that, on average, correctly diagnosing and addressing overcharged refrigeration circuits diminishes system performance.	Consider discontinuing correcting the refrigerant charge for systems that are typically overcharged.	IOUs and ED	Other	Agree that refrigerant charge adjustment should continue to be offered for “significant” instances, but establishing the definition of significant as exceeding 20%-deviation-from-nominal-charge basis is problematic. There are no diagnostics methods that can readily make this distinction in the field. Technicians will not be able to easily determine whether any given field unit exceeds the 20% charge threshold. Agree that conceptually there is a tolerable margin of overcharge that may not benefit from adjustment. Since refrigerant will only ever leak out from a system, overcharge will never get worse, it can only leak until it becomes undercharged. However, this type of approach also does not consider any impacts to HVAC reliability that may occur due to liquid slugging of

					compressors at lower ambient conditions, or increased compressor discharge temperatures at high ambient, possibly leading to oil breakdown. Findings should be updated to leverage an expanded lab dataset in addition to HVAC5. The Purdue FDD Evaluator Grey Box Model leverages perhaps the most comprehensive lab dataset to predict performance impacts of faults under thousands of different scenarios.
8	**Nonresidential HVAC Quality Maintenance Rebate Program**: • For single-stage units without TXV, results suggest that correctly diagnosing and addressing typically overcharged units will result in diminished performance. On the other hand, treating highly overcharged units results in improved system performance.	Continue correcting the refrigerant charge for systems that are highly overcharged	IOUs and ED	Other	Agree that refrigerant charge adjustment should continue to be offered for "significant" instances, but establishing the definition of significant as exceeding 20%-deviation-from-nominal-charge basis is problematic. There are no diagnostics methods that can readily make this distinction in the field. Technicians will not be able to easily determine whether any given field unit exceeds the 20% charge threshold. Findings should be updated to leverage an expanded lab dataset in addition to HVAC5. The Purdue FDD Evaluator Grey Box Model leverages perhaps the most comprehensive lab dataset to predict performance impacts of faults under thousands of different scenarios.
9	**Nonresidential HVAC Quality Maintenance Rebate Program**: • The performance-metrics effects on multi-stage units with TXV due to non-RCA treatments are smaller than (and in some cases, negative) those for single-stage units without TXV.	Consider expanding services to repair refrigerant lines or targeting replacement of units that have an established track record of low refrigerant charge.	IOUs and ED	Other	The steps to address refrigerant leaks are already part of Quality Maintenance practices. More research is needed on cost/benefit valuation of refrigerant circuit repair methods, such as tracing with "soap bubbles" or other leak detection devices and sealing, or sealant products meant for injection directly into the circuit. It's also unclear that this can be its own measure, or as a best practice that serves to enhance the realization of charge adjustment savings. More guidance is needed on what constitutes an "established track record" of low charge. Findings should be updated to leverage an expanded lab dataset in addition to HVAC5. The Purdue FDD Evaluator Grey Box Model leverages perhaps the most comprehensive lab dataset to predict performance impacts of faults under thousands of different scenarios.
10	**Nonresidential HVAC Quality Maintenance Rebate Program**: • For units where non-RCA faults are treated first, undercharged units experience greater performance improvements from RCA-treatments than overcharged units. • HVAC4 results corroborated the HVAC3 finding that greater performance benefits are realized by non-RCA fault treatments than the RCA treatments, themselves. This is especially true for multi-stage units with TXV.	With the exception of very low refrigerant charge levels, consider focusing efforts on addressing non-RCA faults before refrigerant offsets.	IOUs and ED	Accepted	Agree there should be consideration for adjusting non-refrigerant-charge faults upfront, except for extreme cases. This is in alignment with best practices. Ultimately, field-measured-performance approach should be considered for incorporation into the long-term vision for enhancing program implementation. Guidance exists from ASHRAE SPC221 standard and WHPA CQI Committee work products. The draft SPC221 standard should be released for public review and comment in Q1-Q2 of 2018. Findings should be updated to leverage an expanded lab dataset in addition to HVAC5. The Purdue FDD Evaluator Grey Box Model leverages perhaps the most comprehensive lab dataset to predict performance impacts of faults under thousands of different scenarios.
11	**Nonresidential HVAC Quality Maintenance Rebate Program**: • Economizer malfunctioning impacts continue to be a large source of savings uncertainty.	Continued investigation and training regarding economizer functionality, reasons for failure, and unintentional operation is warranted.	IOUs and ED	Other	Agree that economizer malfunctions can adversely impact energy efficiency and with need for further investigation and training for economizers. A variety of outside air economizer failure modes have been observed in field studies, with differing rates of prevalence and degree of impact on energy efficiency, e.g. Free Cooling: At What Cost? Kristin Heinemeier, 2014 Summer Study of Energy Efficiency in Buildings. Modeling the impact of economizer failure on EE will need to take this diversity of faults and prevalence into account to provide the greatest insight on EE impact. It is also noted that while Title 24 prescriptively requires outside air economizers to be installed on package HVAC equipment above 55,000 Btu/h (section 140.4 (e) 1, this is not a mandatory requirement. Building upgrades following the performance compliance approach

					do not automatically trigger economizer requirements. The Itron Commercial Saturation Survey Table 9-22, for example, shows very low distribution of economizers for small and medium size single zone air conditioners below 240,000 Btu/h. This is despite the fact that outside air economizers can offset higher energy use resulting from other architectural choices, such as increased levels of fenestration. Further research appears warranted to determine the actual percentage of outside air economizers installed on commercial package HVAC units.
12	**P4 Database**: • To leverage the HVAC4 findings, relative standard deviation better characterizes the annual savings uncertainty than relative precision.	Consider creating an "All Things Simulated (ATS)" table—modeled after the "All Things Reported (ATR)" tables—to leverage the HVAC4 findings.	ED		
13	**P4 Database**: • HVAC4 simulations of mean annual savings and associated standard deviations are best determined for each climate zone and for each building type of the available DEER prototypes.	Consider expanding the resolution of the P4 database to include building types and climate zones.	ED		