Work Order 32 Comments and IOU Responses – November 2013

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Comment	Response
Comments from all IOUs	
Participating technicians are required to attend training in which economizer testing, diagnosis and repair is addressed. [In response to "technicians are not properly repairing…economizers."]	The findings apply to trainings observed in 2013, which in most cases were for both the 2010-12 and 2013-14 programs. If there are new training documents we would like to review them.
Topics covered in technician training. [In response to "due to measurement instrument errors, improper field procedures, and economizer or mixed-air damper leakage causing higher superheat or suction temperatures compared to manufacturer specifications."]	Leakage causes higher coil inlet wet-bulb temperatures compared to return air wet-bulb measurements. Our findings are that the details are critical. If the topic of instrumentation is "covered" then it must include details about specific instrumentation and the installation and calibration of those instruments. Example, The lab findings show that some instruments allowed in programs are not accurate enough to perform diagnostics. This issue would be not be known by the programs prior to lab testing.
Program design feature; what changes in program design would mitigate the incentive to RCA while ignoring other possible faults? [In response to "incentives for refrigerant charge adjustments will cause many units to be overcharged."]	Regardless of the incentive structure we have recently discovered that refrigerant charge test and service measures for commercial package systems have many potential pitfalls that can lead to incorrect adjustments and overcharging (outdoor air temperatures, economizer or damper leakage, instrumentation issues, sensor type and placements, presence of other faults, and certain procedures). A charge adjustment may not yield the expected ex ante savings. These issues (pitfalls) need to be addressed before providing incentives for RCA measures. Laboratory tests are evaluating these issues. The preliminary lab findings are that many of the other factors tend to lead diagnostics to show circuits are "under charge" thus leading to "many units will have charge added and will be overcharged". Lab tests and additional research could be used to develop new field procedures for diagnostics and an incentive and savings estimates may have to address multiple refrigerant issues in addition to the amount of charge.
If this unit is representative of the population, wouldn't the delta between rated and measured be the same for standard and high efficiency units? [In response to "8.4 EER which is 24% less efficient than the AHRI rating of 11 EER."]	This was partially addressed in the August 22nd meeting. For replace on burnout it is true that the same issues would apply to both baseline and newly installed units. Additional verification tests by Intertek since drafting the memo indicate the unit is within 95% of AHRI-

	rated EER, IEER, and IPLV per AHRI 340/360 (10.47 EER, 11.03 IPLV, 11.22 IEER). The AHRI rating was achieved by testing unit in horizontal position (off platform), reducing cabinet and duct losses, and optimizing refrigerant charge and airflow. This means that the AHRI ratings were achieved through system adjustments that would not be applicable to field conditions for the unit tested in the laboratory. This requires testing on more units and additional units are planned for testing that may provide additional clarity.
Was the unit defective? [In response to "laboratory tests showed that this setting actually provides 30% outside air and decreases efficiency" and "outdoor airflow is 15% with closed dampers, 20% with 1-finger open, 23% with 2-fingers open, 30% with 3-fingers open, and 62% with dampers fully open."]	No, the unit was not defective. Verification tests performed by Intertek indicate the unit is within 95% of the rated EER and IPLV per AHRI 340/360 (10.47 EER, 11.03 IPLV, 11.22 IEER). Two vertical economizers were tested compliant with AMCA 511-10 (Rev. 8/12) Class 2 (10 cfm/sf) and Class 1A (3 cfm/sf). Results were presented were for the Class 2 (ASHRAE 90.1) model. Economizer leakage includes cabinet leakage. For this unit tests indicate cabinet leakage contributes only 6 to 17% of total leakage while closed dampers contribute 83 to 94% of total leakage. Tests of two horizontal economizers have been completed as part of tests on additional manufacturer units. Field measurements of airflow through economizer dampers indicate similar levels of leakage.
What is the source indicating that this is the prevailing assumption? [In response to "designers, technicians, and program implementers incorrectly assume 2% outdoor airflow with closed dampers and 100% outdoor airflow with fully open dampers."]	Outdoor air leakage of 10 cfm/ft2 is the specification for AMCA 511-10 (Rev. 8/12) Class 2 low-leakage dampers. The tested units leak 15% or more at inlet static pressures ranging from -0.6 to -0.3 inches water gauge.100% outside air with economizers fully open is a common assumption. Program workpapers assume 64% and 70% for fully open based on prior studies. An effort will be made to compare the lab setup and field measurements to the prior studies.
The applicability of this finding is limited to units that do not provide continuous ventilation during occupied hours. If the unit must run the fan continuously regardless of the requirement for heating and cooling the economizer alone should be used as long as it is able to satisfy the load. This brings up another issue that limits the implications of this finding - in most situations the economizer alone would not be able to satisfy a cooling load at outdoor air temperatures higher than	It is true that some units should be providing ventilation continuously. A field finding is that most of the units monitored and tested do not provide continuous ventilation. At the time of writing the memo there was not enough data to report the pervasiveness of this issue. The performance of the unit in the different modes of operation needs to be associated with the run time in each mode. The memo indicates potential savings based on a particular control scenario. The WO32 team is working to develop a clear set of definitions to characterize

65, so the unit would need to cool mechanically. Agree that integration of mechanical and economizer cooling is very important. [In response to "because of the significant damper leakage, tests of economizer change-over settings indicate negative efficiency benefits relative to the baseline closed damper 1st-stage cooling at outdoor conditions of 70°F drybulb and 60°F (70/60°F) wetbulb and 65/57°F" and Figure 3.]	baseline performance based on the laboratory findings. Considerations include: The waste heat from the fan motor is not always considered in calculations of "free cooling", defining baseline for cooling and for ventilation given new discoveries, and developing efficiency metrics for economizers.
Note that DOE-2 does not properly simulate the "alternating integration" that is accomplished by RTUs. DOE-2 simulates full integration that is only possible with modulating capacity, and thus overstates the economizer savings for economizer+1st stage cooling. [In response to "based on DOE-2 simulations of a DEER prototype small office building 82% of economizer energy savings are from 1st-stage cooling indicating the importance of integrating mechanical cooling and economizer control strategies to save energy."]	For the memo, cooling loads were calculated using DOE-2 and then applied to the efficiency data from the Lab tests. The analysis was done to provide estimates of energy savings based on lab performance tests. Field monitoring data that has not yet been presented will show the performance of real units with actual controls. Workpapers are based on the addition of wiring and controls that would produce benefits associated with fully integrated economizer controls for those measures that reset economizer control points. This will be evaluated by WO 32 field tests and passed to workpaper review team members.
Prioritize activities to avoid problem in summary (see comment 3). [In response to "tests indicate that open dampers can have a larger negative impact on EER than improper refrigerant charge and low airflow."]	The EM&V team is currently working on determining the best way to present results where economizer and cabinet leakage are present since the current EER* accounts for both increased load leading to a reduced **system** efficiency as well as the effect of outdoor air (via damper and cabinet leakage) raising the air temperature on the coil exiting (supply) side which reduces the apparent capacity and the apparent **unit** efficiency. Tests indicate cabinet leakage contributes only 6 to 17% of total leakage while closed dampers contribute 83 to 94% of total leakage.
Calibration of faulty equipment. [In response to "Preliminary results indicate some sensors provide readings that will lead to inaccurate fault diagnostics. Tests were conducted with eight sensors on liquid and suction lines. The largest differences are with the suction line measurements where tube temperatures are 25°F to 40°F less than outdoor ambient temperature. The liquid line	These issues were not calibration issues per se since multiple sensors of each type were tested. Some sensor types always provide poor results regardless of calibration and the equipment is not "faulty", they simply do not have good surface contact and thus are closer to air temperature than pipe temperature.

temperature is typically 8°F to 12°F above ambient so there are smaller variations from measured temperatures to actual tube temperatures."]	
Do they mean better diagnoses and repair of the measures or more and different measures? [In response to "programs should be redesigned to provide more effective energy efficiency measures."]	The current measures need specific procedures for both diagnosis and repair. In addition, there are other faults that can confound the current measures. So adding measures and adding procedures for existing measures, or other changes to the program design, would be needed to address all possible faults needed to bring units to their performance baseline.
Volume 1 indicated that Technicians are performing services as they have always done them, despite the training on protocols and proper use of calibrated tools. [In response to "programs should be redesigned to provide… training, tools, protocols."]	These findings are based on a combination of observations in the field and follow up interviews.
Isn't this already the focus of the training? [In response to "technicians will require specific training on energy saving repairs."]	The CQM and the non-statewide trainings we have attended and training materials we have reviewed do not provide step by step instructions or procedures. Current training does not address the additional faults which confound those faults included in ex-ante savings estimates and provide service companies compensation.
While these topics are covered, this statement makes it seem like this is all that's covered. Training is focused on maintenance protocols and proper tools. [In response to "the programs provide training to contractors, technicians on how to market the program and enter data into the online program database system."]	To clarify the items in the checklist and a list of tools are provided. In the trainings observed directly the tools and procedures were not covered. In additional videos and materials from trainings provided to the WO32 team after the memo was released, these topics are covered and we have identified more specific issues with the information provided. Some of the specific issues are the fundamental industry issues that are just starting to be uncovered.
AirCare Plus? [In response to "local commercial HVAC tune-up programs differ from the CQM program in that they do not require three-year maintenance agreements and are not based on the ACCA 180 Standard."]	There are two non-statewide CQM programs. PG&E AirCare Plus and the SDG&E local program.
How is this known? [In response to "RCA protocol does not identify severe non-condensable and	The programs do not provide training on RCA protocols to differentiate non-condensable or restriction faults from refrigerant charge faults. Master

restriction faults in 17.8% of cases with faults."]	technicians performed acid tests and reviewed refrigerant pressures and temperatures. The WO32 team developed a more detailed response to this issue with a table/figure that can be presented as a separate document showing the different conditions and which refrigerant side faults they indicate.
Note that the CEC RCA protocol is not the prevailing protocol in use in the programs. The PG&E "Local Program" (AirCare Plus) utilizes a proprietary FDD algorithm that is software-based and directly integrated with hardware. The SCE CQM program specifies the metrics that must be considered in diagnostics and provides default targets for those metrics when manufacturer data is not available, but the diagnosis is ultimately left up to the technician. The metrics specified by SCE CQM are more comprehensive than the metrics required for the CEC RCA protocol, and thus have the potential to inform a more comprehensive diagnosis (given a reliable FDD protocol). This reviewer is not aware of the protocols specified by other programs. [In response to "Are technicians correctly following a poor protocol or are errors compounding due to incorrectly implementing a poor protocol? The evaluation found problems with both issues in addition to lack of awareness and training regarding manufacturer protocols provided in installation manuals (Carrier 2005). The current CEC RCA protocol is based on at least three manufacturers' SH, SC, and proper airflow protocols which have been available for decades (Carrier 1986, Carrier 1998, Trane 1996, York 1991)."]	We agree that AirCare plus follows the FDSI method and not the CEC protocol. Limiting this to statewide CQM. ▪ The past programs used the CEC protocol and technicians are familiar with it. ▪ The statewide CQM program does not exclude the CEC protocol from being used. ▪ We have observed technicians in the field using the CEC protocol and using other "rules of thumb". ▪ Laboratory tests are being conducted of manufacturer protocols, CEC protocols, and FDSI protocols. Economizer damper position and airflow impact FDD. At this time we are uncertain of the protocol in which charge can be optimized for efficiency. The field observations can characterize the frequency that each method is being used, but additional laboratory testing will be required to determine the impacts of the various methods. Manufacturer protocols and factory charge have been tested so far and the other methods still need to be tested.
Are all systems overrated? If so, wouldn't the delta between standard and high efficiency units be approximately the same? [In response to table 1.]	We believe that all systems are overrated based on differences between AHRI test conditions and field conditions. But the delta between standard and high efficiency cannot be fully determined at this time. The delta for a standard and high efficiency unit will greatly depend on minimum outdoor air (MOA) damper position, fan system efficiency, and the sensitivity of the laboratory measured efficiencies to field conditions. This issue was partially addressed in the

	August 22nd meeting. For replace on burnout units with the same MOA damper position, it is true that the same issues would apply to both baseline and newly installed units. Additional testing since drafting the memo has been able to reproduce the AHRI rated efficiency for the test unit. As noted above, The AHRI rating was achieved by modifying the unit in ways that would not occur in field applications, (e.g. changing from a down-flow to horizontal flow arrangement, reducing cabinet and duct losses, and optimizing refrigerant charge and airflow). This finding applies more to the definition of the optimal efficiency of existing units, not the savings of installing new high efficiency units.
I believe AHRI 210/240 allows down to 0.25"WC. Testing at the absolute minimum would theoretically improve efficiency, but only marginally. In the field total static may approach 2"WC. Higher pressures increase the fan power required to deliver the same volume of air, and may shift the optimal EER to lower airflow rates. Testing should be conducted to evaluate impact of realistic static pressures in the field. [In response to "0.25 inches water column (inWC) total static pressure to reduce blower fan power and achieve maximum EER per AHRI test protocols" and section titled "Economizer Impacts with Low Airflow."]	AHRI 340/360 (Table 5) allows minimum total external static pressure of 0.25 inches of water column for units with rated cooling capacities ranging from 71 to 105 thousand Btu per hour. The 0.25" WC is only used for verifying the AHRI ratings as is commonly done by manufacturers. WO32 is directing Intertek to test units at realistic total external static pressures ranging from 0.8 to 1.6 inches of water column. Field measurements indicate that some units have total external static pressure of up to 3.4 inches of water column. WO32 master technicians are collecting inlet and total static pressure data on units in the field. This data is being used to establish realistic static pressure for Intertek tests to evaluate the impact of higher static pressures on airflow and EER.
For commercial systems that provide outside air the CEC RCA protocol *may* perform better if the evaporator inlet wet bulb temperature is used to establish a superheat target rather than the return air wetbulb temperature as specified in the protocol. The RCA protocol was originally conceived for residential units, and additional considerations are required when applying it to commercial units. [In response to "CEC RCA protocol (CEC 2008)."]	The WO32 team will review whether any field technicians use the CEC protocol as stated or use the evaporator inlet wet bulb as stated in this comment. Observations indicate that technicians attempt to measure return air wet-bulb temperatures in different locations leading to measurements that actually represent mixed air (outdoor and return air). Although we recognize that accurate entering evaporator coil wet-bulb is crucial in the RCA protocol, in the background discussion we do not include our recommendations for changes to the CEC protocol. We primarily needed to reference any methods currently available and being used by technicians. Master technicians have previously provided comments to the CEC about these issues that have not been adopted.

	Lab tests have indicated that outside air flow is highly non-uniform across evaporators, even with the outside air dampers closed. Obtaining the "correct" coil entering wet-bulb temperature for use with the CEC protocol would be difficult, if not impossible
The definition of EER as it is being used in this report needs additional clarification. Where are the measurement points for calculating capacity? Is the inlet condition the return/indoor air or the air entering the evaporator? ? A diagram may be of some help. Introduction of ventilation air changes the properties of the air entering the evaporator, and should be expected to reduce performance as outside air temperature increases, so the results are not unexpected. Comparing the results to factory testing, which does not include any ventilation, is not really comparing apples to apples. [In response to "These tests show that even optimally adjusted systems with an economizer don't perform anywhere close to their rated efficiency… The test results demonstrate that reducing minimum damper position can be a more reliable measure to improve cooling efficiency."]	The WO32 laboratory tests are performed per AHRI standards to verify that the unit meets the AHRI 340/360 tolerances within 95% of the rated EER, IEER, IPLV, and cooling capacity. The report generally provides application EER* which is defined as the delivered cooling capacity divided by total power for the application tested (i.e., non-standard fault conditions). The measurement points do not change from test to test and air-side cooling capacity measurements are used to report the EER*. A schematic diagram is being prepared to illustrate the test setup and measurement points. Laboratory test results include cooling capacity impacts associated with economizer outdoor airflow. The RTU plus economizer cooling capacity is defined as the supply air mass flow rate (lbm/hr) times the enthalpy difference between return and supply air (Btu/lbm). Supply air enthalpy includes direct-expansion cooling plus economizer cooling. The RTU and economizer are defined as an integral cooling system rather than as separate parts. This definition includes the importance of optimal minimum damper position and economizer functionality to system efficiency. The trend of performance diminishing as outside air temperature increases is expected as the comment notes. However, it was not expected that the capacity delivered under conditions commonly known as "free cooling" are so low and that leakage through the cabinet and dampers in closed position would as high as they were during the tests.
Is this representative of all units in this category? Design flaw? Poor assembly? [In response to "462 cfm or seven times greater than the 67.1 cfm rated leakage."]	The economizer is a new 10 cfm/ft2 (AMCA Class 2) unit without design flaws or poor assembly. Tests of a new vertical economizer rated at 3 cfm/ft2 (AMCA Class 1A) economizer and tests of a horizontal

	economizer rated at 10 cfm/ft2 (AMCA Class 2) produced similar results. Inlet static pressure is -0.08 to -0.6 inches of water column (-20 to -150 Pa) when dampers are closed. Damper leakage and cracks around gears, and motor actuator assembly cause outdoor air leakage to be seven times greater than the rated leakage. The memo does not assume the tests are representative of all units. However, additional tests of new horizontal economizers produce similar results. The preliminary results justify the need for more testing to produce a distribution of actual leakage rates to expect in the field. The master technicians are returning to sites to measure economizer flow rates in open and closed positions to provide data for existing units.
To add to this, how do the tests perform compare to ANSI/AMCA 500-D-12? What is the static pressure difference used to rate the dampers? What is the difference in this testing? [In response to "462 cfm or seven times greater than the 67.1 cfm rated leakage."]	Laboratory tests of new economizers compliant with Class 2 (10 cfm/sf) or Class 1A (3 cfm/sf) indicate closed damper outdoor air leakage of 15% or more at inlet static pressures ranging from -0.6 to -0.3 inches water gauge. This is 2 to 4 times lower than the 1 in w.g. static pressure test standard per AMCA 511-10 (Rev. 8/12). Field installations typically have closed-damper inlet static pressure ranging from -0.6 to -0.3 inches of water. The laboratory test conditions are based on field measurements. A summary of field data used to establish laboratory conditions will be provided. Inlet static ranges from -0.08" (fully open) to -0.6 inches of water column (fully closed) depending on damper position.
The economizer provides a benefit when OA temperature is less than return air temperatures, which differ from indoor temperatures in the field. Also, humidity plays a role, but temperature should remain the primary focus for testing that applies to CA. [In response to "the economizer plus 1st stage cooling is more efficient and provides more cooling capacity when outdoor temperatures are less than indoor temperatures."]	The important finding is that "free cooling" is generally assumed and not measured. When considering the fan power and low capacity delivered when in economizer operation the stage 1 operation is more efficient. We agree in a more humid climate that stage 1 operation is often needed at lower outdoor temperatures to meet latent loads. The fan motor heats air from the economizer with 3.412 Btu/Watt of power. This reduces economizer available "free cooling" by 59% at 70°F and 27% at 65°F. At 70°F and 65°F outdoor conditions insufficient cooling is available for the "economizer-fan-only" to be more efficient than the "economizer plus 1st-stage-cooling." We are currently investigating the effect of economizer leakage increasing load and reducing

	system efficiency versus cabinet leakage that may lower supply temperature and thus appears as reduced EER.* Tests indicate cabinet leakage contributes only 6 to 17% of total leakage while closed dampers contribute 83 to 94% of total leakage.
This seems reasonable. [In response to "With the 10°F dead band, the dampers won't open again until OAT is less than 45°F. Control setting "D" yields very little economizing. Installing new sensors with +/- 1°F dead band set at 68°F to 70°F will save energy if the minimum damper position is closed and the economizer is working properly."]	Laboratory tests of the 10°F dead band and economizer sensor accuracy are currently in the laboratory test plan. However, field technicians have reported that these types of controllers are almost impossible to find as replacement or repair parts. While these controllers are relevant, they appear to be less so than was anticipated when the lab test proposal was developed.
True for all training programs? Did they observe each utility's training? [In response to "programs do not provide training."]	At the time of writing the memo the master technicians had observed some, but not all trainings. Since the draft memo was published two PG&E statewide CQM training classes have been observed and one PG&E CIP train-the-trainer classes have been observed (September 2013). All IOUs had some form of training on the program rules and/or program data entry. The statement refers to technical training on the procedures, tools, and diagnostics to determine faults and the procedures to repair the faults.
Persistence with maintenance programs are problematic; regular, periodic maintenance is a must, hence the requirement for a 3 year CSA. [In response to "in another program, 11 out of 16 economizers at one site were reported as repaired, but only 5 are still working one year later and 11 are not working."]	We strongly agree with this statement about persistence being problematic. Especially for economizers. In one local program most non-working economizers were either incorrectly repaired or failed shortly after repairs were made. However we were not evaluating persistence as the expectation was repaired economizers should be working within a year of repair to achieve first year savings. . Observations indicate economizer operation is not tested in the CQM program, and economizers are not repaired, replaced or maintained. The programs need to differentiate energy efficiency tasks from regular maintenance tasks. Most regular maintenance does not appear to have any energy efficiency savings benefits. See answer below. This statement refers to a third-party/local program. For the CQM, when observing quarterly/annual maintenance the economizer functionality is not tested.

Is this observation for a CQM with 3 year agreement or local tune-up only program? [In response to "in another program, 11 out of 16 economizers at one site were reported as repaired, but only 5 are still working one year later and 11 are not working."]	This statement refers to a third-party/local program. Statewide program data indicate that a majority of units did not receive economizer repairs. However field observations have discovered issues that could be repaired or entire economizers could be replaced
This seems reasonable. [In response to "these finding indicate that there are significant economizer savings available."]	No response
Even those with regular, periodic maintenance? [In response to "new economizers reported 64% failures after 2 to 3 years of operation."]	This was a citation from another report. The citation was provided to help interpret the current findings. In the cited report we do not know if the economizers received regular periodic maintenance. Separate from the study we cited, we have not seen technicians performing economizer functional tests at quarterly or annual follow-ups for CQM. Therefore, the high failure rate for economizers cited might continue unless functional tests are added to regular periodic maintenance.
2003 economizers were still analog with no OBD, so these "new" economizers are actually "old" economizers by today's standards. [In response to "(CEC 2003)."]	We agree that the study is dated. However, these findings should be relevant to CQM since most existing units also do not have digital controls or OBD.
Were any of these make-up air units intended to provide 100% OA? [In response to "the EM&V study found fully-open economizer and mixed air dampers on six units at three sites representing 9% of the sample."]	These units were installed on office buildings and the design intent is unknown. . This is an important issue to explore in order to achieve an objective of optimizing efficiency while meeting health and comfort requirements. The observed technicians are unaware of the design OA and how units should be setup to achieve the design or recommended OA. The field flow measurements through economizers will be analyzed to determine how much outside air is provided through the fully open economizers and dampers.
Is the 15% OA with fully closed dampers is a typical characteristic of all units in the category[?] [In response to "laboratory tests indicate that	Results are provided for a new vertical economizer rated at 10 cfm/ft2 (per ASHRAE 90.1). The tested units did not have noticeable design flaws or poor assembly. Tests of a new vertical economizer rated at

closed damper leakage will provide sufficient outdoor air to meet code ventilation requirements for many building occupancies even with the damper fully closed."]	3 cfm/ft2 economizer and tests of a horizontal economizer rated at 10 cfm/ft2 produced similar results. The memo does not assume tests are representative of all units. However the preliminary results should justify the need for more testing to produce a distribution of actual leakage rates to expect in the field. The laboratory test conditions were based on field measurements of return chamber pressures. A summary of the field data used to set the laboratory condition can be provided.
While instrument accuracy is pertinent and interesting, there is also a need for overcoming physical challenges to these measurements encountered in the field. The need to perform measurements away from the fan, fittings, and other causes of turbulence make measuring these parameters on vertical-discharge units difficult or impossible. The testing would be even more useful if those challenges could be examined as well. [In response to "digital instruments to measure airflow static pressure."]	We agree there is a persistent need to test both tools and procedures and placement of tools and sensors. The EM&V team will develop of list of instrumentation tests we were not able to complete that should be tested in 2013-14.
Recommend referencing Title 24 instead of 62.1 since it's the applicable standard in CA (or reference both). [In response to "minimum outdoor air requirements for most building occupancies per ASHRAE 62.1."]	Agreed. The WO32 report will reference Title 24 and show where Title 24 refers back to ASHRAE 62.1
EER as it is being used needs additional explanation. This is misleading. Open dampers increase the heating and cooling load unnecessarily, but likely have a negligible effect on EER if the basis for comparison is the evaporator inlet condition rather than the indoor air condition. [In response to "open dampers can have a larger negative impact on EER."]	The memo uses EER when testing is performed per AHRI standards and EER* when deviations are introduced. The measurement points are not changing in air-side measurements used in reporting EER*. Additional discussion on nomenclature and definition of EER* versus some other terminology (e.g. system efficiency, EER* + load increases, etc.) is warranted. The primary goal is to show the relative effects of faults and damper position on energy efficiency. Unnecessary loads and faults will increase energy consumption. For the purpose of interpreting the memo consider the following since EER* as reported combines fault and outside air effects: Open dampers have a significant impact on cooling

	and heating efficiency as viewed from the building occupant. The AHRI 340/360 test procedure code testers are located in conditioned space which is the reference point for building occupants. It would be misleading to reference EER with respect to coil inlet conditions (i.e., mixed air) since this is not the condition of building occupants. Supply air conditions are measured in conditioned space consistent with building occupants. Note the evaporator inlet condition is dramatically affected by the economizer given the close proximity. The return air and outside air do not mix well and there is always a significant temperature gradient on the coil entering side. Again the terminology will be discussed further prior to the final report.
Per volume 1, it doesn't seem to matter how much training, if the technicians continue to perform these tasks as they've always done them. [In response to "Current programs do not provide sufficient training on proper fault detection diagnostics (FDD) and repair…Laboratory tests indicate challenges associated with relying on refrigerant charge adjustments to improve efficiency."	Detailed training focused on the measures eligible for incentives is recommended, but additionally new laboratory findings suggest additional testing is needed to develop procedures for refrigerant charge adjustment for units with economizers and other ventilation openings, which includes most commercial units. Pre-measurement maintenance procedures (cleaning coils, installing new air filters, belt tension/alignment) and checking temperature split should be required before measuring refrigerant temperatures and pressures. Measurement equipment accuracy and installation specifications and time required for units to reach equilibrium are also important.
Reduce cooling energy, not necessarily improve cooling efficiency. [In response to "that reducing minimum damper position might be a reliable measure to improve cooling efficiency."]	The EM&V team is currently working on determining the best way to present results where economizer and cabinet leakage are present since the current EER* accounts for both increased load leading to a reduced **system** efficiency as well as the effect of cabinet leakage raising the air temperature on the coil exiting (supply) side which reduces the apparent capacity and the apparent **unit** efficiency. Cabinet losses account for 6 to 17%, and closed damper outdoor air leakage accounts for 83 to 94%. At 95F DB/75F WB outdoor conditions and 75FDB/62F WB indoor conditions the impact of economizer closed damper leakage by itself on cooling efficiency is 18%. Adding cabinet leakage increases the impact to 21%.

Diagnostic requires measurement of supply air volume, measurement of % outside air, and determination of design ventilation requirements for the space. This is very difficult to perform in the field. If it can be determined that closing all dampers, dampers on certain occupancies, or certain types of dampers that are known to have high leakage then it could be an easy measure. [In response to "i.e., easier to diagnose and repair."]	As discussed in the 8/23/13 PCG meeting, economizers can be difficult to repair (many configurations exist) and often overlooked. One solution would be to replace the whole economizer with a new one. PG&E is currently recommending an economizer replacement measure in their statewide program. However, this is an industry wide problem and is not specific to CA programs. The WO32 team has additional ideas for economizer manufacturers and will work with the CPUC and IOUs to explore potential options.
Prioritization of the best measures with the highest energy savings need emphasis, not necessarily more effective measures. [In response to "programs should be redesigned to provide more effective energy-efficiency measures."]	As stated later in the memo, "incentives should be provided for measures with the highest probable applicability, FDD repair rate, and savings." Measures should be targeted based on more than just their energy saving potential for a single installation: we need to consider the frequency of measures, probability of successful repair and cost of repair as well.
Comments from the IOUs	
It is inevitable in rolling out such a challenging/complex program, that the program teams encounter program design issues and implementation and that necessitate adjustments, corrections and revision. However, a distinction must be made between the need to drive 'focused, ongoing program refinement' from 'program re-design'. This stage of the program's evolution is still relatively immature and warrants time and effort to continue the development rather than a complete overhaul of the program. The IOUs are committed to the long-term development of the program to fully develop its energy savings potential leading to transformation of the HVAC maintenance market (see Appendices 3, 4 and 5 for specific changes – implemented and planned – to the statewide CQM program since launch by the IOUs).	Our statement meant to convey there are multiple interrelated issues as opposed to specific items. "Re-design" is recommended since the current CQM programs focus too much on check lists of "what to do" without providing instructions on "how to do" maintenance tasks that will improve energy efficiency. We generally recommend more focus on the energy saving measures and the specific procedures to diagnose and repair faults to achieve those measures. More important than the terms redesign or refinement, something needs to be done to address issues observed in the field. Decision makers need to examine short- and long-term damage to the market done by several change strategies and pick the one that does the least damage or produces the most improvement. The current programs assume the same energy savings whether or not measures are performed or installed properly. The lack of connection and accountability between assumed savings and interventions that actually achieve measureable savings is the primary reason that the current CQM programs need to be re-designed.
There is a need for program design improvements and revisions leading to	We agree that these items were observed program short-comings, but cannot, at this point, confirm that

improved program performance essential to achieving the energy savings potential and the MT objectives. This is especially true as it relates to HVAC technicians preforming CQM tasks. Field observation of technicians participating in the program has revealed serious gaps in in many areas including: a. Skills and competency. b. Failure to follow established protocols for HVAC service c. Failure to detect, properly diagnose and repair faults d. Failure to use calibrated tools for measuring existing condition. e. Improper use of tools and equipment f. Introducing air and other contaminants into systems	their corrections will provide the benefits anticipated in current workpapers, savings potential or MT objectives.
Because of these failures, there were two notable areas where technicians failed to correct systems deficiencies and failed to follow basic procedures for HVAC maintenance. In many cases, technicians did not: a. Correctly diagnose and repair damper related problems associated with economizers leading to significant energy lost; b. Correctly evacuate hoses prior to connecting to the system, introducing air and other contaminants leading to system inefficiency and, possibly, mechanical failures if left uncorrected.	We agree that these items were observed program short-comings, but cannot, at this point, confirm that their corrections will provide the benefits anticipated in current workpapers, savings potential or MT objectives.
The findings from the technician field observations, as well as technician responses to survey questions indicate point to the need for additional technical training for HVAC service technicians and a. Observation of Technician performance in the field reveals significant differences between program expectations and actual services delivered. Additional Technician technical training is needed to assure that: i. Services delivered through the program adhere to ACCA/ASHRAE protocols in detecting, diagnosing and	No comment, we cannot assess all of the recommendations based on WO32 findings.

repairing system faults; ii. Technicians not only know "what" should be checked according to the stands, but "how to" perform each task correctly iii. Appropriate and properly calibrated test equipment is used for fault detection and diagnosis; and iv. Appropriate tools are used correctly to make adjustments and repair system faults. b. While ratepayers have an interest in energy savings resulting from quality maintenance, the burden for technician training does not depend solely and entirely on ratepayer involvement through the PGC. i. Improved technician training requires involvement from all HVAC industry stakeholders, local government, and utilities. ii. Manufacturers, distributors, vendors – equipment specific service requirements and maintenance procedures iii. Local government jurisdictions –code requirements, codes enforcement iv. Utilities – specific energy efficiency aspects of HVAC CQM leading to optimized energy performance v. CSLB – C-20 licensing rigor needs to be re-examined c. Need for reliable FDD protocol to support HVAC maintenance practices d. Data collection protocols need to be streamlined with a focus on those protocols and procedures that deliver energy savings.	
Research design: The IOUs appreciate that the study design makes distinctions between three program elements in their evaluation of CQM: a. Program design (versus potential) b. Contractor adherence to program protocols, and c. Program implementation (versus program design).	No comment, WO32 is striving to separate these elements, but we also may not be able to separate issues. The most difficult element is "potential". Based on our ongoing rate of laboratory discoveries we assume there are still unknowns regarding the potential savings associated with maintenance of commercial HVAC.

These are relevant and important distinctions that should be highlighted in the discussion and recommendations. In the current version, however, one must read carefully to understand these distinctions. For example, these distinctions are lost in the statement: "Overall, field observations indicate that technicians participating in the statewide and local CQM programs lack the tools, training, and procedures to correctly identify faults and perform repairs to achieve the maximum energy savings……. data collection. (Executive Summary p. 2)" In the final report, it will be important to highlight which findings and recommendations apply to program design, standards adherence, or program implementation.	The WO32 team appreciates this request for additional distinction between the three issues above. We will strive to separate the issues in the report and also reference where we believe the issue is more fundamental to the industry as opposed to any of the programs. Conversely it is also quite challenging to separate interrelated issues. Since the programs within the scope of the WO32 evaluation have many "degrees of freedom" there are challenges to evaluate the discrete issues. For example, The statewide programs generally assume the same energy savings per unit (kWh/ton, kW/ton, therms/ton) whether or not measures are installed or are installed correctly. The SCE CQM work paper assumes "expected value savings" based on "composite measures being implemented at the discretion of the contractor." SCE doesn't require contractors to perform specific energy efficiency measures unless technicians believe measures are necessary. SCE believes technicians need to determine if coils need to be cleaned prior to evaluating refrigerant charge faults. SCE indicated that thermodynamic analysis of the condenser and evaporator coils is required prior to cleaning coils. SCE personnel indicated that this is what ACCA 180 "embraces." This is a fundamental program design issue. If contractors are not required to follow specific manufacturer installation and maintenance protocols, then it is unlikely that they will achieve the ACCA 180 performance baseline defined by the manufacturer (i.e., AHRI-rated performance). For some measures, even if contractors follow manufacturer specifications it is unlikely that the AHRI-rated performance will be achieved (i.e., minimum economizer damper position, refrigerant charge, fan-belt-drive pulley turns, etc.). Therefore a possible outcome is that distinguishing the causes becomes indeterminable or is not necessarily relevant to a particular service item. At this stage we do not know exactly where separating the issues is possible or practical.
The following comments are in response to "Volume 1 – Field Observations of Technicians"	
It seems premature to recommend wholesale redesign of the program when most of the issues identified in the findings point to in-field technician behavior and performance. There	We believe that the detailed procedures are critical as stated below. A more general wording than "redesign" would be that the programs should provide more effective energy efficiency measures, training,

remains considerable confidence that the energy savings potential from the CQM program can be realized, so more emphasis will be placed on three elements of technician training: a. Industry maintenance standards and best practices b. "How-to" procedures for FDD c. The proper use of calibrated tools.	tools, protocols, and data collection focused on energy efficiency measures. Incentives should be provided for measures with the highest probable applicability, repair rate, and savings. To address the issues identified, future programs will need to focus on repairs that maximize unit performance and technicians will require specific training on energy saving repairs. The program should not assume that there are well-established procedures to improve unit efficiency. This means that procedure development may need to precede training on those procedures. Achieving overall market transformation goals will require additional efforts outside the programs. The HVAC industry, state licensing boards, and USDOE can help by supporting improved equipment-efficiency ratings, technician-competency standards, FDD protocols, and field measurement instrument standards. However WO32 is limited in scope and cannot address all of these general recommendations.
There are many distinctions not only between CQM programs and Local Programs, but between the programs as they are implemented in each utility territory. Will there be any differentiation between SW CQM programs and Local Programs findings?	As noted in the 8/23/13 PCG meeting, the intent of the final report will be to provide program level results that differentiate between local and statewide programs. It is likely there will be common issues that cross programs. A distinction will be made between program level findings and findings that crosscut programs and affect the whole industry.
The report is not clear about the sample sizes for the field observations for each of the programs operating in the various service territories. It will be important that the final report disaggregates the data by service territory and by core CQM programs and local. Without this differentiation and disaggregation, it will be very difficult to determine which finding applies to which program, and then to make meaningful corrections and adjustment. For example, regarding economizers not being fixed, it is unclear which IOU service territory and which program for which this finding applies.	The final report will provide program level information. In general findings apply across programs unless noted in the memo. "One of the programs…" The economizer repair issue was observed in two statewide and one of the local programs.
If the 44 sites include participants from the 3 utility core CQM programs as well as results from the 3 local programs implemented by third-party contractors, the overall sample population may not be statistically significant.	Pre-maintenance observations were conducted of 44 units and 75 circuits. Ride-along observations were conducted of 74 units and 122 circuits. Post-maintenance observations were conducted of 31 units and 55 circuits. Non-participant observations have

Extrapolation of the results to the entire population of core CQM program participants for all IOUs may not be appropriate.	been conducted on 19 units and 22 circuits. Additional observations will be performed on more units in 2013 to meet the WO32 research plan objectives. Results in the memo have not been extrapolated to program populations. The IOU program implementers were informed of the WO32 EM&V research plan in 2012, and had ample time and opportunities to motivate and encourage contractors and customers to participate in the sample. The study attempted to recruit contractors who received the largest share of incentives. A smaller program recruited contractors for data logging who performed 100% of work. A larger program recruited contractors for data logging who received less than 6% of total incentives. In order to overcome sample and referral bias, the EM&V study recruited additional contractors from the larger program who received 67% of total incentives for field observations of maintenance on non-data logger units. The WO32 team has attempted to establish proper samples and to work cooperatively with program personnel to mitigate bias sources. However, an additional source of bias has been caused by program implementers or trainers intervening with service work being performed by participating technicians during EM&V observations. Program trainers in one service area intervened nine times at five sites to assist technicians with program data collection during EM&V observations conducted in 2012 and 2013. During another observation in the same service area, program personnel intervened to stop observations of a technician who was in the middle of repairing a 10-ton heat pump unit with data loggers installed. This in itself caused significant bias of our sample since we were unable to monitor energy performance after anticipated repairs were performed. In addition, several sites included in the pre/post monitoring effort were later dropped from the program. Those sites were provided by program representatives as appropriate for the M&V evaluation effort. This is beyond the control of the WO32 staff and could affect sample size related issues. The WO32 team have attempted to work cooperatively with program personnel to mitigate bias.
Sample distributions are needed to be able to	A distribution of the sample at the time of writing the

effectively understand the study findings as they relate to the entire population of CQM program participants and to each IOU's program. Please provide a discussion of how well the sample used represent the populations to which they apply for both non-participant and participant units, and make a statement regarding the degree to which the conclusions reached are representative of the entire population of participants.	memo and current will be provided to the PCG. The memo was not written to provide statistically significant program specific findings. Those results will be included in the final report. The goal of the memo was to summarize findings to date with preliminary recommendations where issues were pervasive across programs and contractors.
Are the technicians that are included in the sample representative of participating contractors as a whole? IOU specific issues are listed below: i. SDG&E: One contractor performed most of the work in 2010-2012, with estimated gross annual energy savings of 8.8 million kWh. The observed contractors represented 2.80 million kWh, 2.4 million kWh, and 0 kWh, respectively, of the total claimed savings. Without evaluating the largest participant (who has not been active in the program since 2012), it is difficult to estimate the overall energy savings effects. Moreover, with the small sample sizes, there is a strong likelihood that the findings are not representative of the larger population of contractors and technicians. This applies especially to the evaluation of the one contractor that had not participated in the 2010-2012 program: the technician was new to the program in 2013 and did not have the required tools. The evaluators should exercise caution in extrapolating the observations of one technician or a small pool of sites to generalizations about the skills, training or tools of participating contractors. ii. SCE: One of the largest subscribers to the CQM program was a customer who's own employees performed maintenance services on HVAC units providing heating and cooling for the company's facilities. Evaluators observed these technicians as	In general no savings are reported and thus the findings have not been extrapolated to program populations. The memo provides as much technical information as available based on initial findings. SDG&E – Since writing the memo the largest contractor has been observed. SCE – Observations of the other top 5 contractors were conducted in addition to a large property management company that owns units at commercial buildings that are leased or rented to tenants. It is our understanding that this service contractor does not have a C-20 license. They primarily enrolled large units greater than 60 tons that already have on-board diagnostics and when surveyed they reported no difference in how they maintain units that received rebates. These findings for this contractor are only extrapolated to the units serviced by this firm and not to the program in general. PGE – Correct. AirCare Plus has been observed but not PGE Statewide. In 2010-12 there were primarily two statewide firms one of which refused EM&V and the other left the program. Since the memo the EM&V team has worked with PG&E to observe training and the team will perform field observations prior to writing the final report. One observation of maintenance services was observed at the PG&E Applied Technology Services laboratory (noted above). SCG – No observations have been performed of heating system testing or repair. Economizer issues will impact gas savings, but no tests have been observed of heating components within packaged units.

they serviced the owner's units. iii. Do these employees have equivalent background and training as those working for a C-20 contractor? iv. Is it appropriate to extrapolate this performance to the entire population of participants? v. PG&E: It is not clear that any participants in PG&E's CQM program were visited by evaluators. There are indications, however, that evaluators have observed technicians providing service as part of the *AirCare Plus* program – a third-party program distinct from PG&E's core CQM program (see Appendix 1 for a comparison of the programs). Because these programs are completely different, comments about technician behavior in the *AirCare Plus* program should not be used as the basis for evaluation of the PG&E core program. While CQM is a statewide program with all utilities, each utility trains technicians separately using different approaches and curriculum. It doesn't appear that evaluators observed any PG&E technician training session. Any conclusions stated in the interim findings may not be valid for technicians serving PG&E's participants (see Appendix 2 for PG&E technician raining outline). vi. SoCalGas: Were there any field observations of technicians servicing the heating system? If so, what are the findings? If not, are such observations planned?	
The evaluators were notably cautious about reporting the findings when discussing the statistical significance of the t-test comparing the samples of participants versus non-participants (which was not significant). The evaluators, however, did not elaborate on the statistical significance of other key findings such as tools, training, fault detection diagnostics. The IOUs expect [statistical significance] will be more fully developed in	The study was not designed to report interim findings and thus coverage by IOU and by program is uneven. The EM&V team has now observed training from each program, but field observations continue.

the final report.	
The concept of best available data needs to be reinforced in some of the discussion. The report uses some of the lab findings, or findings from the field, to highlight some of the problems encountered during the field observations. While there may be questions about the data outlined in the memo, the IOUs may ultimately agree with the logic of evaluators' analysis. Once the questions regarding the data are resolved, the results may be applied more broadly.	Since both the laboratory and field measurements are incomplete, all available information was brought together. Ultimately the laboratory data helps to define detailed performance and field observations help to characterize the methods and conditions in the real world. In the final report additional field measured performance will also be included as well as additional lab tests recreating faults and conditions encountered in the field.
The locking caps discussion does not seem to have any clear link to energy efficiency. In the report it is unclear what the locking caps discussion is intended to achieve. On the conference call there was a discussion around a contractor removing the locking caps from a school which was interesting but further detail would be necessary for the programs to act upon the issue. Is there a recommendation, based on findings, that the program should consider these?	The energy efficiency impact is when machine fit caps are over tightened with the potential to cause leaks and introduce non-condensables to systems. In addition, many of the ACCA 180 items do not address energy efficiency. Some of the items address health and safety issues which are just as important as energy savings given the market transformation goals of the programs.. The inclusion of this issue was to say that AirCare plus provided an incentive for installing a non-locking cap and has removed locking caps from sites. The PG&E statewide CQM program requires similar brass machine-fit caps. Statewide and local CQM programs outside PG&E do not provide guidance on caps. All programs should consider the recommendation that locking caps prevent theft of refrigerant for illegal use or resale and that they ensure persistence of refrigerant charge measure. The rationale for PG&E programs requiring brass machine-fit caps needs to be evaluated.
Evaluators observed that most of the units in the sample had economizers, and that no action was taken on them. What was the condition of these economizers? Did these economizers need to be repaired or replaced? Were these observations for technicians providing CQM services or for local programs?	The primary point of the statement in the memo is that during direct observations program technicians did not perform functional tests or repairs and in follow-up tests economizers failed the functional test. Direct observations were of SCE and SDG&E statewide CQM program, the PG&E AirCarePlus Program, and the SDG&E local CQM program. Since "condition" is subjective, master technicians testing of economizers are performed using a cold spray on sensors to determine if cooling sensors cause dampers to functionally open. Note that one of the largest manufacturers of economizer sensors and

	controls uses similar cold spray to test economizer functionality in the laboratory. Economizers that were not repaired were in need of repair in most cases based on cold spray functional tests. The decision to repair or replace depends on additional factors, especially availability of replacement parts.
The report should clarify and fully describe the methodology used by evaluators during the field observations. The IOUs assume that this will be detailed in the final report.	The methodology will be described in the final report and the WO32 team has also developed the following summary. Industry and manufacturer installation and maintenance specifications are available to evaluate the criteria used to define performance issues. The WO32 EM&V study is performing laboratory tests of performance issues and faults to evaluate the criteria used by manufacturers and industry to define performance issues. Procedures outside of manufacturer specifications or specific FDD tools are grouped under "rules of thumb." The report will include all criteria. Examples include: • Metrics and criteria for FDD and repair include evaluation of compliance with ASHRAE 180 standards to achieve manufacturer performance baseline based on published manufacturer installation and maintenance specifications for the specific unit being serviced. Manufacturers provide instructions, specifications, and protocols for coil cleaning, airflow adjustment (belt tension/alignment, fan-belt-drive pulley turns, CFM, static pressure), refrigerant charge (protocols, tools, specifications, targets), recovery and evacuation methods, liquid line driers, and economizer setup and operation (filters, wiring, sensors, controls, dampers, operation). Additional metrics and criteria include ASHRAE 62.1 minimum outdoor air standards and minimum outdoor air damper position based on measurements of return, economizer inlet, and mixed-air temperatures. • Criteria include EPA 608 requirements for low-loss fittings on refrigerant hoses and de minimis purging hoses of air and water vapor prior to attaching to Schrader valves. None of these issues were addressed in program training classes. This will

	create a performance issue of introducing non-condensables into the system. • Industry and manufacturer requirements for installing new properly-sized liquid line driers when repairing leaks, reversing valves, thermostatic expansion valves (TXV), or compressor to prevent refrigerant restrictions. If water vapor is left in the system, it can combine with oil and refrigerant to form corrosive acid and sludge and produce refrigerant restrictions at the expansion device or filter drier (if present). • Master technicians perform an acid test as an indicator of moisture and acid in the system. Moisture in the system may produce a partial orifice freeze-up or improper TXV tracking. Other restrictions that may occur during improper installation or as a result of non-condensables in the system may include a plugged inlet screen, foreign material in orifice, filter drier restrictions, kinked or restricted liquid or suction lines, oil logged refrigerant flooding the compressor, or wax buildup in expansion valve from wrong oil in system. If the restriction is at the metering device, then frost or ice will develop at this location. If the restriction is at the liquid line or filter drier, then the liquid line temperature will be colder than ambient at this location. All lead to a reduction in cooling efficiency and may reduce equipment life. • Criteria of whether technicians test economizer operation to identify non-functional economizers. Master Technicians perform a cold spray test and test the signal from the controller back to the economizer sensor. Manufacturer economizer installation instructions recommend cold spray to test sensor functionality. Cold spray does not damage sensors. • . • Criteria of whether technicians check total static pressure, fan-belt-drive pulley RPM and turns, and belt tension/alignment to evaluate proper airflow to optimize efficiency. • Criteria of whether technicians properly diagnose refrigerant system faults. The same criteria are used across all observations to ensure the results are based on facts and not opinions.

The report needs to differentiate evaluators' observations of technicians servicing CQM program participants, and observations of other non-core HVAC maintenance programs delivered by others. Technician behavior based on these other programs should not be used to characterize technician behavior at CQM sites.	The report will separate findings by program. It should be noted that while the program designs and incentives have major differences the actual list of incented maintenance actions in statewide CQM and the energy efficiency measures in the local/third-party programs are quite similar and the information and tools available to technicians apply across program designs. FDD applies to all programs and tools and training for FDD and repairs cut across programs. Looking for the common items reduces some of the complexity of addressing pervasive issues.
This study needs to include a review of technician FDD procedures for the furnace of the HVAC system.	We have not observed training or use of FDD by technicians for heating systems and it has not been included in WO32 since it does not appear to be part of the observations or program documentation.
Observation Criteria: During the technician observations, evaluators indicated tasks were done incorrectly (e.g. no economizers were fixed). What is not stated is the stage of the protocol the technician was executing. Is it possible that this was observed during the equipment inventory where the fault was noted, but not repaired at that point? Please clarify.	None of the observations were of the equipment inventory. The EM&V team stressed observations need to be of CSA tasks. In some cases CSA tasks were not completed during the first observation. Often the contractor did not notify the team when they returned for quarterly maintenance or additional tasks. To follow up master technicians returned to sites after all CSA tasks were indicated as completed in order to evaluate claimed repairs. These return visits were not all completed in time for the memo.
What criteria was used the Master Technician decide that the technician servicing the equipment was complete the tasks incorrectly? Is there an object standard that the Master Technician is using to evaluate performance, or were these findings the Master Technician's opinion regarding how the tasks should be performed?	See above for examples. Where possible the master technician refers to manufacturer specification. For the data logger sample the analysis will look at actual efficiency changes from repairs to support the observation. The same criteria are used across all observations to ensure the results are not based on opinion.
From a research perspective, when researchers go in the field to make observations, they usually have observation protocols that specifically state actions the technicians should take to complete the service steps. Without these objective observation protocols, it may not be possible	This will be included in the final report. See above for specific criteria for refrigerant charge and economizer measures.

to determine whether the observed technician is performing the steps correctly.	
Using the IOU's protocols (e.g., SCE's) may not be appropriate because ACCA 180 is not a performance standard. ACCA 180 is list of tasks to be performed with recommended frequencies for performing those tasks. It is a merely a checklist providing only what is to be done, and not how to do them. Interim Findings are stating that the tasks are being done incorrectly. The study does not provide the criteria are for judging that a task is done incorrectly.	Agreed ACCA 180 does not provide sufficient criteria to determine if maintenance was done correctly. The criteria will be provided in the final report. See above for specific criteria for refrigerant charge and economizer measures. While not a specific response, but rather a comment on this comment, this is this seems to raise a more fundamental issue. How can program verification determine if tasks are performed correctly leading to energy savings? Does the program OSV include performance criteria? What assumptions were used in workpapers regarding the performance baseline? How do programs achieve the performance baseline? What criteria are defined by the programs for participating technicians to achieve the performance baseline and save energy?
In the final report, please provide the observation criteria used by the Master Technician to observe and judge technician behavior.	This will be included in the final report. See above for specific criteria for refrigerant charge and economizer measures.
The following comments are in response to Volume 2 – Laboratory Testing of a 7.5 ton RTU	
While this testing provides a better understanding of the issues a technician might encounter in the field with a new RTU being installed, it might not be appropriate to generalize the results from one HVAC unit from one manufacturer as characteristic of all units of this type.	The results are not applied to program populations. The early results do justify a need for additional testing.
If the "out-of-the-box" laboratory results are representative of other high efficiency units (actual performance is less that rated performance), wouldn't we expect the same sort of lower than rated performance of standard HVAC units similarly situated? If that is the case, wouldn't the difference between the high efficiency and standard efficiency unit remain approximately the same?	This was partially addressed in the August 22nd meeting. At this time, there is insufficient data to confirm or deny that difference would be the same. There are technical reasons that indicate they may not, especially if higher efficiency is provided by a more efficient supply air fan. Additional testing is planned.

PG&E, with support from the ED, is conducting similar testing of a commercial packaged HVAC unit at its San Ramon Research facility. The testing is being conducted with a used HVAC unit (approximately 20 years old) that may be representative of the units a technician might encounter.	This testing has been reviewed by our team and we will continue to share our laboratory experiences to inform the testing. However the unit model number for the 20-year-old is much less frequent across all IOU programs than the initial WO32 test unit. It will be equally true that the 20-year-old unit is not representative of the program populations. The 20-year-old unit has an older economizer with screw actuator that is not representative of economizers found on units in the program population.
Since the lab was not able to get the unit to perform to manufacturer specifications (baseline), does the unit function properly at any point?	Additional verification tests by Intertek since drafting the memo indicate the unit is within 95% of AHRI-rated EER, IEER, and IPLV per AHRI 340/360 (10.47 EER, 11.03 IPLV, 11.22 IEER). The AHRI rating was achieved by testing unit in horizontal position (off platform), reducing cabinet and duct losses, and optimizing refrigerant charge and airflow. Test modifications to the unit required to yield AHRI-rated capacity and efficiency values would never be used in a field installation.
The report switches between "lab optimized" and "out of the box" refrigerant levels. This makes it difficult to compare the results to manufacturer specifications.	Additional explanation may be required because there are two manufacturer specifications – factory amount of charge (weighed in ounces) and manufacturer charging chart specification which provide diagnostic targets (based on measured temperatures and pressures). The later requires a measurement of return air temperature which is affected by economizers or fixed outside air dampers. This is important because the manufacturer charge chart specifications were not met by the unit out-of-the-box and laboratory optimal is also outside manufacturer charge chart specifications. Essentially the manufacturer charging chart specifications will result in the unit being diagnosed as undercharged with an economizer and closed damper. Thus a key finding is that units tested in the field (many of which have economizers with closed or partially open dampers) following manufacturer charge chart specifications will not achieve factory charge levels. In fact, most field units similar to the lab test unit will be diagnosed as undercharged. Laboratory tests for the unit tested indicate adding charge to units with similar expansion devices and factory charge will not improve efficiency.
ANSI/AHRI 210/240 requires indoor conditions of 80°F (db), but researchers use 72°F when	Tests are performed at multiple indoor conditions: AHRI indoor conditions of 80F DB/67F WB and indoor

testing the economizer outdoor air damper at various settings. This introduces a bias against economizer effectiveness.	conditions of 75F DB/62F WB, more typical of field conditions. The 75F DB/67F WB conditions are based on field measured data in 2006-08 and in 2010-12. Thus it is more true that rating economizers at an assumed 80°F return temperature provides misleading effectiveness values for typical California applications.
Is Figure 1 the way that the contractors in the field identify the appropriate charge level? If not, then this should not have been used, and the contractors' actual methods should have been used.	Contractors in the field use a variety of methods. After quantifying efficiency changes from specific charge adjustments and performing the instrumentation tests for multiple tools then each procedure can be evaluated. Researchers commonly use the methodology of defining performance changes first, then applying various tools or algorithms to the performance data..
The ST and SH values for each test should be shown and compared to the "target" ones given to the contractors.	Additional information and will be provided in the final report.
Table 5 is not clear on the baseline.	The Table 5 baseline is the "no economizer closed dampers 1st-stage cooling." This baseline provides the largest potential savings for the economizer. If instead, the baseline is 1-finger or 3-fingers open with 1st-stage cooling, the economizer savings would be much lower and possibly negative. The WO32 team is working to develop a clear set of definitions to characterize baseline performance based on the laboratory findings. Performance in different modes has been characterized and field units will operate in multiple modes. The run time in each mode and performance in each mode will be defined for a baseline case and then savings from other scenarios can be better defined.
Test technicians need to describe the DOE-2 modeling used in more detail. We look forward to seeing this in the final report.	For the memo an extensive modeling effort was not undertaken. The existing DEER models were used to establish some values for runtime in cooling mode for different outside conditions. The lab findings for performance at the different conditions were applied to the runtime of the model.
The legends for Figure 6 through Figure 13 are not clear. I can't tell what is being compared based on Table 8.	The figures show the difference between the field instrument measurement and the laboratory measurement.. The text accompanying the figure will be revised for clarity in the final report. For Figure 6 the type-K pipe clamp measurement is

	compared to the laboratory measurement next to it on the same tube at the same time. For field instrument manufacturer A (A1-A8), A3 is compared to S1 (Suction 1) or A1 is compared to L1 (Liquid 1). For Figure 12, manufacturer L (L1-L8) instruments are compared to laboratory measurements S1 though S8 and L1 through L8. The figure shows the difference between these two measurements. Perfect field measurements would line up on the axis of zero difference
The interim findings memo does not mention the heating system of the new unit. Will there be an assessment of the heating system performance in the lab test (actual performance versus AFUE rating)? This study needs to include a review of the "out-of-the-box" baseline for typical heating equipment encountered by technicians in the CQM program.	The current schedule of lab tests does not include heating. The EM&V team will discuss potential tests in 2014 with ED and the IOUs through the HVAC PCG.
New findings since the memo and comments – Observation of testing at PG&E Laboratory	A recent demonstration of program services performed by participating technicians on a 24-year old RTU at the PG&E Applied Technology Services laboratory is relevant. Two technicians spent approximately 3 hours replacing an old economizer with a new economizer. No refrigerant system or airflow repairs were performed. The minimum outdoor air (MOA) damper position on the new economizer was set to 14% open (1 finger). The old economizer MOA damper position was closed. The technicians did not measure outdoor air leakage for either economizer. The new economizer damper position (14% open) will reduce cooling and heating efficiency relative to the old damper position (closed). Economizer damper position is a key driver of savings, but the programs currently provide no instructions or guidance to technicians on how to measure outdoor air leakage or how to optimize damper position to improve energy efficiency