Provided by Nils Strindberg, CPUC

Comment	Response
The static pressure difference between the return duct and the outdoor air has a significant impact on the amount of leakage through the economizer. The standard AHRI ratings tests only define the pressure difference between the supply and return of the unit, leaving this value undefined. Can you please document this pressure difference?	Test pressure conditions were established based on median values obtained from field observations of units in the program. Field installations typically had closed-damper inlet static pressure ranging from -0.6 to -0.3 inches of water across units. A summary of the field data used to establish the laboratory condition will be provided. Preliminary field data report inlet static ranges from -0.08" (fully open) to -0.6 inches of water column (fully closed) depending on damper position and unit tested. Laboratory tests of new economizers compliant with ACMA 511-10 Class 2 (10 cfm/sf) or Class 1A (3 cfm/sf) had closed damper outdoor air leakage of 15% or more at inlet static pressures ranging from -0.6 to -0.3 inches water gauge (in w.g.). This is 2 to 4 times lower than the 1 in w.g. static pressure test standard per AMCA 511-10 (Rev. 8/12).
General comment regarding the results in Table 4. It appears from the numbers in the table that the author is defining cooling capacity as the supply airflow rate multiplied by the enthalpy difference between the return air and supply air. This definition neglects any cooling supplied to the outdoor air entering via the economizer. This is a fair definition if the outdoor air entering through the economizer is unintentional. However, in most cases building codes require 10-30% outdoor air to meet IAQ requirement. In this case, the unit is capacity should be defined as the return airflow rate multiplied by the enthalpy difference between the return and supply air PLUS the outdoor airflow rate multiplied by the enthalpy difference between the outdoor air and the supply air.	Table 4 includes the cooling capacity impacts associated with economizer outdoor airflow. The RTU plus economizer cooling capacity in Table 4 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 correctly includes the importance of optimal minimum damper position and economizer functionality to system efficiency. The definition accounts for reduced baseline cooling and heating energy use to maximize economizer savings as a percentage of total cooling energy use. The cooling capacity definition proposed by the comment would increase cooling capacity and efficiency as dampers are opened in spite of the fact that delivered cooling capacity decreases and total power increases. With dampers open the unit would operate longer and consume more power compared to dampers closed. For the sample of RTUs observed by WO32 master technicians, units have minimum damper positions set higher than necessary, based on findings of leakage through

	closed and open dampers, which increases baseline cooling and heating energy use and reduces economizer savings as a percentage of total cooling energy. Table 4 properly calculates cooling capacity and efficiency from the perspective of building owners/tenants who pay utility bills and ratepayers who fund energy efficiency programs.
Were these systems permitted and inspected by local building departments? They most likely were so the training needs to start with WE&T not the committee the last line of defense... the inspectors in the field. As an inspector I know inspectors for the most part do not know what they are looking at. Try looking for the oxygen sensor for the integrated economizer at final when the first inspector missed it at rough inspections and telling the contractor they can't open their business on time with a grand opening set up. City council gets involved and you may be looking for a new job. Yes I'm not kidding. How many times do ALL of you think a residential t-stat is installed and missed by the inspector? Oh gee no outside air.....people get sick and hospitalized I have seen this happen. Audit the building departments and require at least a CEPE on staff for energy, plan check and final C of O.	Permitting and inspection only applies to installations of new units. This evaluation was of maintenance on existing units.
After reading some of the results however I question some of the data. Certainly DNV KEMA is a quality firm, but we should make sure that all the information has been verified, reviewed and is correct. I understand this is interim and not final.	For the field and laboratory there is more detailed data for all of the interim summary results. We would also like to provide metered data results to support the direct observations.

The first thing this report screams is training is needed!

- Training on standard 180
- Training on basic HVAC troubleshooting and repair
- Training on use of instruments and tools
- Training from the factory on equipment and controls
- Education of cause and effect. It is hard for a technician to imagine that his manifold hose can cause significant energy loss or contamination of the system without providing clear data and documentation showing it is true. It is only a 3 foot 1/8 inch hose they would think, how can it hurt? How can vacuum pump oil effect the condition of the RTU DX system?

Yes, we believe that more and better training is required. Contaminated vacuum pump oil can become an issue. The oil will react with refrigerants and produce hydrofluoric and hydrochloric acids. Over time these acids will corrode and damage internal surfaces of the pump making it impossible to achieve the required vacuum. Without the proper vacuum and duration the evacuation process may not remove all contaminants and non-condensables as intended. Manufacturers recommend vacuum pump maintenance after each evacuation.[1] Oil-less evacuation systems also require maintenance. The evaluation team does not have data on the saturation of types of vacuum pumps or frequency of maintenance and consider it a future research question.

It would appear that no technician should participate in a CQM program unless they have spent time in IOU training program that encompasses both written and functional "hands-on" testing, which should be underwritten by a national training organization. Perhaps provide the recognized certification so they want to participate.

We agree with the importance of "hands-on" training.

[1] JB Industries. Deep Vacuum: Its Principle and Application. 2007. JB Industries, PO Box 1180, Aurora, IL 60507-1180, www.jbind.com. Tomczyk, J. 1995. Troubleshooting and Servicing Modern Air Conditioning and Refrigeration Systems. ESCO Press. Mt. Prospect, Ill.: Educational Standards Corporation.

The second thing this report indicates is manufacturers and industry organizations have to step up. There appears to be a disconnect between what individuals such as myself are trying to achieve in development of standards and what is produced and used in practice. • We need to incorporate economizers into testing. It is looked as an energy saving device, but we have no industry standards for its construction, testing, and no certification and rating. • Although ASHRAE 90.1 has leakage requirements in accordance with AMCA 500, no packaged RTU Economizer dampers to my knowledge have previously been tested or constructed to this standard. Only recently with changes in 90.1 and Title 24 2013 are manufactures constructing and testing dampers to be “low leak.” • There are other improvements that could be made to construction of equipment, but right now 60% of the market is cooled by equipment driven by competitive first cost whether it be in factory or what the customer expects. Very few are buying better made and more efficient equipment. Maybe we can help change that.	We agree, economizer testing and rating is a good idea.
The third thing this report indicates is an opportunity to improve the CQM program beyond the aforementioned training. If the data is correct, then there are opportunities for improvement. • In conjunction with training, specify acceptable instruments allowed to be used. Many technicians are responsible for purchasing their own tools and instruments, so this has to be considered. • Require Demand Control Ventilation – this will make up for too much minimum air by having the minimum air dictated by the space needs. The Energy Trust of Oregon requires this in their program. • Another opportunity is incorporation of occupancy sensors that allow the damper to go to zero. ASHRAE 62 has recently	Agreed about training and acceptable instrumentation. There are several good considerations on new ideas for CQM programs, but WO32 is not evaluating all of these potential ideas and technologies, therefore we cannot provide new data to support or deny any opinions our team has on these ideas and technologies.

published an addendum (attached [to email dated 8/28/13]) that allows specific spaces to go to zero when the space is not occupied under normally occupied periods.

- Consider incorporating VFD[s] in conjunction with economizer[s] in the program to reduce fan airflow for low cooling operating times. As the power reduction is theoretically a cube of the speed. This requirement is now in 90.1 and Title 24-2013.
- Consider incorporating airflow monitoring to better dial in ventilation settings or require that airflow measurement is performed when setting economizers. These are both challenges as various arrangements and constructions make this a difficult and I do not believe there is a standard accurate instrument solution. This is something the manufactures of equipment and instruments need to solve, but if there is no call to require it, a solution may not be developed. Mixed airstream temperature calculations have been used, but there are industry studies that indicate that this is far from accurate. The best place to start is to require manufactures to provide curves or tables that can provide airflow per percent open at given static. At least this is better than "1 finger/2 finger".
- Consider replacement of entire economizer assembly rather than repair of an existing one. Although this will provide a new and functioning assembly that is better than the existing product in the field, it will unlikely be an efficiency improvement with respect to performance or leakage. This is because the economizer manufacturers are making new "low leak" assemblies for newer units and not for older models. Unless that is they are challenged to do so. There would be push back due to engineering time and product cost tooling investment for what they would consider a low volume item. Perhaps public investment can help offset this. Of course we are still without an industry standard.
- Consider providing greater incentives for

replacement of entire RTU if the RTU was certified to the previous baseline DOE EER requirements pre 2010 effective date.

Now regarding the laboratory data, there has to be a mistake with respect to the calculated EER values or the test setup when tested with an economizer. To say that an economizer operating at 70F outdoors with an indoor temperature of 75F is less efficient than running in integrated cooling "economizer with a compressor" is like saying a hybrid car is more efficient when running the gasoline engine as opposed to just the batteries. It could be that KEMA is using the ARHI standard test setup and calculations and they do not account for economizers. It could be just a mathematical mistake, or it could be a problem with the older economizer being used. I believe however it is one of the first two. Perhaps it is because the calculation is expecting 100% airflow and it is only getting 62%, but even so, it cannot be that a compressor and fan is more efficient than fan alone. So please review this.	The WO32 team is working to develop a clear set of definitions to characterize baseline performance for the laboratory findings. Waste heat from fan motor is not included in calculations of "free cooling." Efficiency metrics for economizers need to be defined including the baseline for cooling, ventilation, and heating. For these laboratory tests, the "economizer-fan-only" mode is less efficient than "economizer plus 1st-stage-cooling" at 70°F and 65°F outdoor conditions. The fan motor heats air from the economizer with 3.412 Btu/Watt of power. This reduces economizer cooling by 5289 Btuh at 70°F and 5186 Btuh at 65°F and reduces economizer efficiency 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 "economizer plus 1st-stage-cooling." The AHRI test setup and calculations properly calculate cooling capacity and efficiency for the economizer from the perspective of the building owners/tenants who pay utility bills and ratepayers who fund energy efficiency programs.
Other things to note is the older economizers, in addition to having sensor deadband issues, also didn't provide full open damper integrated cooling. As the vapor compression cycle drove down the discharge air temperature, the damper compensated by closing the economizer damper bringing more 75F indoor air than cooler outdoor air.	Due to lack of available parts and degraded performance, it is more cost effective to install new economizers with built-in FDD than to replace old economizers. However, the ASHRAE 62.1 minimum outdoor air damper position should be established based on measurements of return, economizer inlet, and mixed-air temperatures. This process would require additional development and then training of technicians who retrofit economizers.

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I know that the purpose of this study was to understand effectiveness of the existing programs, and that these programs used older economizer controls, however it would be useful going forward to have our product as well as other new digital economizer solutions tested in the same manner in order to predict the improvements so that there is a baseline to start with the new programs.	Agreed. Current laboratory tests are being performed on newer economizers.
Just because a damper is tested at AMCA conditions 1 in w.g., and the classification of the damper is supposed to be a class 2, and results show it leaked 7 times what it should, it doesn't mean that the damper will leak that much airflow in the field. Yes the damper fails to meet the requirement and improvements should be made, but the performance is going be dependent of operating system pressures. It is also assumed that whenever the building is occupied, the damper should be at a minimum position. In that case closed damper leakage doesn't matter so much unless there is uncontrolled leakage (e.g. leaking in areas other than open damper blades), which would actually bring in more air than intended or expected. It can also be assumed that when the building is unoccupied, the fan is off and the damper is closed. In this case leakage is a factor of wind and stack effect. My point is that the concern should be more focused on over ventilating and ventilating when it should not than leakage. This can be mitigated by DCV as noted [in previous comment]. If an economizer is not using an occupied contact to position the damper to minimum position, than the damper goes to minimum position any time the fan is on. That means an unoccupied building may require heating or cooling during off hours and it brings in outside air. This is likely to be more wasted air needed to be reheated or cooled than damper leakage would require. So in plain language, require thermostatic controls with occupancy contacts.	While it's true that thermostatic controls with occupancy sensors would allow better ventilation control, the problem of excessive damper leakage still exists. Damper leakage will vary depending on return static pressure. Laboratory tests of AMCA class 2 and class 1A dampers indicate outdoor airflow of 15% or more with dampers closed. The laboratory inlet static pressure was -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. These findings indicate that technicians should not rely on "rules of thumb" to establish minimum damper positions (i.e., 1 finger equals 15% outdoor air). Instead technicians need to be trained on how to optimize energy efficiency and meet ASHRAE 62.1 based on measurements of return, economizer inlet, and mixed-air temperatures.
This report reinforces my belief that in addition to comprehensive up front training, rigorous verification and mentoring must follow. Most	Agreed.

technicians will not fully comprehend these measures right from the beginning and unless follow up is consistent until technicians are fully proficient, work quality will soon degrade. Incentives should be provided for tools to technicians that demonstrate the willingness to go the extra mile so results will improve over time. Mentoring should be available during site verifications so technicians can see where they had problems or failed to meet program specifications.	
Yes, training is very important but what really happens out in the field is that some contractors do not allow enough time on the job to check things out like the economizers. For example, on a brand new unit on startup, the tech may only have 15 minutes to start a new unit up and not having enough time to check the economizers, superheat or proper airflow etc. Some contractors may cut corners and no one is monitoring the new startup to see if it is done correctly.	Agreed, time pressure is an issue. Optimal setup for new units and new economizers are also issues.
On commercial HVAC, there should be a maintenance program for all units for 3 to 5 years, the reason for that length of time is that it will take time to show the effects of a good maintenance program and get a good average of energy savings. (Climate conditions varies from season to season.)	
The key to energy savings factors around many different items. We must start with the four basic components in a air conditioning unit (excluding aborsortion units), compressor, evaporator, condenser, and a metering device. All four components MUST be running at its optimal performance under different heat load and ambient conditions. For example, the compressor must have all of its internal parts working correctly along with good lubrication. The evaporator must be clean in order to get proper heat transfer and air flow is important. The condenser also must be clean to allow proper heat transfer, also its needs to have good ambient air flow to the condenser. The metering device needs to have the proper refrigerant charge in order to work correctly,	Agreed, all components must be maintained in good condition for correct diagnoses and repairs of faults to achieve optimal performance. Attempting to diagnose refrigerant charge faults on units with low ambient conditions, open economizer dampers, heat exchanger faults, restrictions, or non condensables can lead to misdetection, misdiagnosis or false alarms of a refrigerant charge faults when faults do not exist.

sometimes the ambient temperature can play an factor in this operation. Sometimes, this is where the economizer plays a important factor in saving energy.	
Another important factor is training and education for the service technician. We are not the "back yard mechanic" that some people think we are. We are in the technical and science field and we need to follow the current and new items coming out in the field. This is where constant training is important to the technician.	Agreed, training is important.
Another important factor is educating the consumer that a proper maintenance program is important for the air conditioning unit, and not go with the lowest price all the time. The consumer should go by the work being performed and the energy savings and little or no breakdown of units.	Agreed, customer education on the importance of maintenance is important.
Industry-wide HVAC Issues • Isn't part of the problem also associated with the industry-wide HVAC issues? • Given that only 10% of contractors/technicians can correctly address HVAC faults in the field, the burden of improving technicians HVAC capabilities should not fall solely on the IOUs, especially when the HVAC industry is fraught with issues. • WO32 personnel responded to questions that … "many of the issues found to date with CQM is an industry problem that cannot be controlled simply by providing money to the contractors. It is not the implementers or program problem per se. There are too many industry issues that are difficult to deal with." These issues are extremely relevant and must be highlighted in the CQM discussion, along with recommendations/possible solutions.	Industry-wide issues cannot be addressed by assuming the same energy savings per unit whether or not measures 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. Technicians are not trained to diagnose and repair faults to optimize energy efficiency. The programs need to prioritize energy efficiency tasks and avoid paying incentives for maintenance tasks that do not save energy.
The programs should begin exploring program design changes to improve training, tools, protocols, and data collection. This seems odd. If technicians lack training, procedures and tools, it would seem that the focus would be on	Agreed, the programs need to define new energy efficiency measures that contractors have not previously performed. Training needs to be provided on how to perform new measures and incentives should not be paid unless new

contractor certification to perform the services they are said to have. Doesn't the C-20 license require that staff perform to some standard, that technicians have the requisite skills, and that they perform to that level of skill, using the appropriate tools needed to measure existing system performance? While the utilities offer training, and though that training can be improved, it should be supplemental – focused exclusively on energy efficiency measures – to the training technicians receive to perform their basic duties. It should not replace the training technician are to receive in order for the contractor to maintain their license. The onus should be on the contractor to ensure that its staff is properly trained, skilled and equipped to perform service on HVAC units (see footnote 1, page 4 below).

measures are documented as being properly installed. Contractors performing "business-as-usual" measures (i.e., rinsing coils with water, changing airfilters, not repairing obvious faults, etc.) do not bring a unit to the manufacturer performance baseline and should not require incentives. The ASHRAE standard 180 check list items needs to be simplified so technicians are able to perform the check list without incentives. The C-20 license does not currently include technical requirements regarding contractor or technician skills.

When interpreting the evaluator preliminary recommendations, it is therefore critical to distinguish between the need to drive focused, ongoing program refinement from "program re-design." The former is consistent with the intent of the IOUs implementation teams; the latter would represent a significant step backwards in program evolution, industry outreach, and most importantly, an erosion of market transformations effects.

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. 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. 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 ASHRAE 180 performance baseline defined by the manufacturer (i.e., AHRI-rated performance). Participating contractors reported to program evaluators that they are performing maintenance measures the same way they did previously without the program. The programs could define new energy efficiency maintenance measures and improve existing efforts that contractors are required to perform that are different from "business-as-usual" maintenance. The market transformation goals could occur in the larger industry after program participants achieve and demonstrate savings. 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. The current programs assume the same energy savings whether or not measures are performed or installed properly. While WO32 has not yet developed savings estimates, the lack of connection between assumed savings and interventions that actually achieve measureable savings is the primary reason that the current CQM programs need to be re-designed.
Need overall context. Even though this is an interim report, overall context of the program must be provided to enable the reader to put the findings in perspective. See IOUs 'Clarification Issues and Questions' document – General Observations section (first two paragraphs). It is the IOUs hope that overall context will be provided in the final report.	The context will be provided in the final report.
For the Core CQM program, ASHRAE/ACCA/ANSI 180 Standard is to be used by participating technicians. As such the Core CQM program is differentiated from other local programs by what it is designed to do. Section 4 of the standard specifically cites implementation and requires that a maintenance plan be established, and this plan includes identifying the responsible party and agreeing to develop a written maintenance program that as a minimum includes an inventory of items to be inspected and maintained, performance objectives possible sources in – Appendix A, condition indicators of unacceptable operation – Appendix B, modifying inspection / maintenance task frequencies based on these objectives, the plan also requires documentation and tracking of maintenance and requires authorization to be executed with check in periods to ensure the goals of the maintenance plan are being accomplished. The majority of what is called "maintenance" which does not include this plan provided in Section 4 is reactive only (aka: "run to failure") Subpar maintenance programs lead	The WO32 impact evaluation's goal is to evaluate commercial maintenance programs, both statewide CQM and other programs, and estimate energy savings. The statewide CQM programs require ACCA 180, but the WO32 team is not specifically evaluating the standard. The WO32 memo reports preliminary findings of the CQM programs prior to reporting savings estimates. The final report will fully describe the program and program requirements including ACCA 180. The preliminary findings supported an overall recommendation of more focus on the energy savings tasks that need to be performed by technicians. The findings of the specific technician actions observed and results of independent measurements and testing were the common aspect across programs. The final report will provide energy savings estimates and detail specific to the statewide CQM programs.

to energy waste, occupant discomfort and poor IAQ / health effects. The purpose of this standard is to establish minimum HVAC inspection and maintenance requirements that preserve a system's ability to achieve acceptable thermal comfort, energy efficiency, and indoor air quality in commercial buildings. To exclude this from the program description and evaluation plan is to leave out what the Standard is designed to do.

The goals of the utilities, HVAC industry and the CLTEESP is to quantify energy savings / benefits of Standard 180 and "premium" maintenance services, evaluate feasibility of measures and upgrades that improve system performance, demonstrate the value to contractor business models based on quality and premium maintenance offerings and to demonstrate the value to consumers of properly maintained systems (per industry standards) and of new, but proven "premium" maintenance practice. These goals can only be attained by comprehensive HVAC programs through collaboration with industry. To state a redesign is necessary without transacting with Section 4 of Standard 180 is to miss a great opportunity to achieve these goals.

The report seems to indicate that the programs specify the use of the CEC RCA protocol for detecting and diagnosing refrigeration faults. This is actually not true in the SCE CQM Program. The design of the SCE HVAC Optimization Program recognizes the limitations of the RCA protocol, and merely specifies the metrics that must be considered in evaluating refrigeration cycle operation. Determination of the acceptable ranges for each of those metrics and the diagnoses of faults based on the required metrics was performed at the discretion of the servicing technician in the 10-12 program cycle. This represents a need in the industry for a reliable FDD protocol to support HVAC maintenance practices. The EM&V effort could be of some assistance in defining a fault detection protocol by providing the parameters

We agree definition of the FDD protocol used by the master technician is important information and this will be included in the report.

In the statewide CQM the CEC protocol is being widely used:

- 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"

At this time we are unsure of the method 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

and criteria considered for the study's fault diagnoses. Ideally the definition of the parameters and criteria considered could contribute to the development of improved FDD protocols. Additionally, the definition of the protocol used by the Master Technician is critical in interpreting the findings.	the impacts of the various methods. Manufacturer protocols, CEC protocols, and factory charge have been tested and the other methods still need to be tested. Current ex-ante claims do not consider this uncertainty, but are all based on findings from residential units repaired using CEC RCA protocols.
Please document the source. [In response to "The following 'rule-of-thumb' is assumed by most technicians: closed dampers 2% outdoor air (OA), 1-finger 10% OA, 2-fingers 20% OA, 3-fingers 30% OA, and fully open 100% OA."]	Rule of thumb positions from program training and interviews with technicians were translated into a set of specific displacements measured in inches for laboratory tests. The flow rates of the corresponding positions were measured in laboratory tests and reported as percentages of measured system airflow. For reference, SCE training videos recommend minimum damper position of 3 fingers open. PG&E program trainers recommend 1 finger open. Observations and interviews with technicians and observations of participant and non-participant units in the field indicate 1 to 3 fingers open is typical for most units.
When were the [field] observations conducted? The timing of those observations will greatly influence how we interpret them. A lot of improvements have been made to the HVAC programs between July 2012 and June 2013. If the problems were observed after program changes in 2013, then the observer's experience may have been quite different than observations made before program changes were put in place. We need to know this in order to know how to interpret their results.	Metering was installed July-August 2012, but observations of work were in November 2012, Feb 2013, and May-July 2013. For the highest volume contractors observations were in June 2013.
The interim report discusses observations conducted on all systems prior to technicians performing services as well as after and the raw number of issues as well as the issues per circuit. Issue type and frequency could inform continuous improvement. Is there a relationship between observed issues and faults discussed in same section of report?	The final report will provide pre and post-observation findings Preliminary fault percentages are as follows: air filters (25%), fan belts (worn, improper tension/alignment 33-40%), evaporator coil (dirty, fins, condensate pan/drain 24-42%), refrigerant charge (38%), panels (bent, missing fasteners/insulation 62%), non-condensables/restrictions (40%), contamination (44%), condenser coil (fins, blockage, corrosion 9-47%), economizers (filters, corrosion, wiring, sensors, controls, dampers 9-78%), capacitors (29%), transformers/wiring (5%), and failed compressors (4%).
Which service territories and which programs?	The final report will provide program level

Need a breakdown of units (tons capacity and circuits for each unit). [In response to “data loggers were installed on 44 units in two service areas to monitor pre and post-load impacts.”]	information. In general findings apply across programs unless noted in the memo.
Of the 44 units, how many had economizers? [In response to “data loggers were installed on 44 units in two service areas to monitor pre and post-load impacts.”]	Of the 44 units, 32 had economizers. The economizer repair issue was observed in two statewide and one of the local programs. The final report will include economizer detail.
Need the number of completed observations/interviews by technician, building, IOU territory, and city in addition to reporting the total number of units and circuits. [In response to “observations were conducted on 73 participant air conditioning circuits.”]	The completed report will contain this information.
How many units? [In response to “22 non-participant circuits.”]	The non-participant sample includes 19 units and 22 circuits.
Please define the qualifications of the Master Technician(s) Is the Master Technician known and cited by the HVAC Industry to be a subject matter expert? Has the Master Technician demonstrated he possess the knowledge, skills and abilities and has the endorsements and references for this role?	The CPUC selected and hired the WO32 Master Technicians based on their extensive industry qualifications, professional references, associations, subject matter expertise, and peer-reviewed evaluation studies and publications. The Master technicians have demonstrated that they possess the knowledge, skills, and abilities necessary to perform the evaluation and that they have the necessary endorsements and references for this role.
Please define the actual metrics considered and criteria by which the Master Technician evaluates those metrics in order to diagnose each fault or issue.	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 not providing technicians with procedures to test economizer operation will result in 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 not providing technicians with training and procedures to measure mixed air temperature to establish minimum outdoor air damper position to optimize cooling and heating efficiency and meet ASHRAE 62.1 minimum outdoor air requirements. The WO32 team is not aware of an industry/manufacturer procedure to optimize both outside air and efficiency. • Criteria of not providing technicians with procedures to check total static pressure, fan-belt-drive pulley RPM and turns, and belt tension/alignment to evaluate proper airflow to optimize efficiency. • Criteria of not providing technicians with specifications regarding proper measurement equipment and procedures to diagnose refrigerant system faults. The same criteria are used across all observations to ensure the results are based on facts and not opinions.
Are these in any particular order of importance? Are there percentages of these categories for the faults found? [In response to “Faults refer to aspects of the HVAC system that are outside acceptable manufacturer specifications and tolerances such as superheat, suction temperature, evaporator saturation temperature, condenser saturation temperature, airflow, temperature difference across the evaporator or heat exchanger, motor/compressor amps, Watts, voltage, cooling/heating capacity, outdoor air damper position, cabinet/duct leakage, coil fouling, economizer change over temperature, sensors, actuators, thermostat settings, etc.”]	We will present a table of faults in the final report. Currently we have frequencies, but we do not have savings associated and this cannot order them in terms of impacts. Preliminary fault percentages are as follows: air filters (25%), fan belts (worn, improper tension/alignment 33-40%), evaporator coil (dirty, fins, condensate pan/drain 24-42%), refrigerant charge (38%), panels (bent, missing fasteners/insulation 62%), non-condensables/restrictions (40%), contamination (44%), condenser coil (fins, blockage, corrosion 9-47%), economizers (filters, corrosion, wiring, sensors, controls, dampers 9-78%), capacitors (29%), transformers/wiring (5%), and compressors (4%).
May eventually? [In response to “may” in the sentence: “Issues will result in faults and faults impact energy efficiency performance.”]	In some cases issues contribute to false alarms, misdiagnoses, or missed detections of faults which impact energy efficiency immediately. In other cases, issues cause a fault that degrades energy efficiency over time such as contamination of the refrigerant system causing restrictions or non

	condensables. Some issues are more severe than others and some have more impact on functionality than efficiency such as bad contactors, capacitors, or wiring. In cases where observed technicians have issues with not repairing economizers (sensors, dampers, wiring, motors, controls) the energy efficiency impact can be immediate and long term.
Need list of issues found. How many led to faults? [In response to "Observations conducted on all systems prior to technicians performing maintenance services of commercial air conditioning circuits identified 707 issues or 9.7 issues per circuit."]	A table of issues will be presented in the final report. The WO32 EM&V team cannot determine which issues lead to specific faults as we cannot track issues and faults over time. The program could do this by requiring specific energy efficiency tasks be completed as a condition for incentives being paid for the unit to be brought to the "baseline." Issues not repaired could be resolved to minimize or eliminate faults.
How many units and circuits? [In response to "Observations conducted during and after maintenance was performed on 55 circuits identified 551 faults…"]	The interim report provides results for 31 units and 55 circuits. We will report the number of units in the final report.
How does this relate to the 707 issues found in the pre-CQM inspection[?] [In response to "on 55 circuits identified 551 faults ."]	This is a subset of the 73 circuits where 707 issues were observed.
Why not? [In response to "18 have not been observed."]	Thirteen (13) circuits were not observed due to contractors not notifying WO32 evaluation team prior to performing program services and five circuits were not observed due to contractors not performing services while being observed.
1. 90% are filter replacements 2. Were the 2 new contactors needed to return the unit to operation? 3. Did the open panels prevent unit operation? 4. Was the unit with the failed compressor inoperable or was just one stage inoperable? 5. Air filters, contactors and secure panels not mentioned as being the most important to energy efficiency, but are the only measures addressed in the majority of cases (94%) [In response to "During field observations participating technicians correctly diagnosed and repaired 52 faults including installing 45 new air filter sets nearly 90% of corrections	1. NA 2. Yes 3. Open panels and missing fasteners reduce efficiency. 4. Three units had failed compressors with one stage inoperable and repairs were not performed during observations. 5. Observed faults included air filters (25%), fan belts (worn, improper tension/alignment 33-40%), evaporator coil (dirty, fins, condensate pan/drain 24-42%), refrigerant charge (38%), panels (bent, missing fasteners/insulation 62%), non-condensables/restrictions (40%), contamination (44%), condenser coil (fins,

were filter replacement and 2 new contactors (inoperable?), securing 2 panels, restoring operation of 1 compressor (inoperable), and correcting 2 blower fans from 24-hour operation."]	blockage, corrosion 9-47%), economizers (filters, corrosion, wiring, sensors, controls, dampers 9-78%), capacitors (29%), transformers/wiring (5%), and failed compressors (4%).
The interim report then discusses faults pre and post for a subset of units where issues were observed. It would be helpful to know if the observed faults (approximately 10 per circuit) are the same pre and post or have new faults occurred during the time between the observations.	Agreed, a table will be provided in the final report. For faults impacting operation such as blower motor and belt drive failures, 100% were repaired. For compressor failures 25% were repaired (1 out of 4). Worn fan belts and belts with improper tension or alignment were not repaired. Approximately 50 to 67% of evaporator airflow faults were cleaned and repaired. Only 16% of condenser coil cleaning was performed properly per manufacturer specifications with chemical coil cleaners and rinsing inside out. Approximately 16% of panels with missing fasteners or insulation were repaired. None of the observed technicians followed manufacturer specifications to diagnose and adjust refrigerant charge. Non-condensables, restrictions, and refrigerant contamination faults were not repaired. Approximately 20 to 25% of contactor and transformer faults were repaired. No economizer faults were diagnosed or repaired during observations even though most had faults or did function properly (e.g., sensor, filter, wiring, control, damper, motor, actuator). Additionally, units that had reported economizer repairs were not functioning in later tests. In general, the average number of ex-post faults per circuit decreased by 1%, which was not statistically significant.
What is the frequency and distribution of the identification and repair of these faults by individual program? This would inform improvement efforts.	The frequency and distribution of identified and repaired faults by individual program will be provided in the final report.
Was this a ventilation requirement at this facility or a fault? [In response to "24-hour blower-motor operation."]	The blower motor was hard-wired to operate 24 hours per day as a fault which the technicians did not attempt to repair.
Given that on RCA was the only thing assessed on 45% of the non-participants, is this a valid comparison? It would seem that a true comparison of non-	The non-participant population was randomly selected and initial sample points did not include any economizers or multiple circuit units. The WO32 team will attempt to observe additional non-participant units for the final report to

participants with participants, the populations would be similar, and the review would have included the same items. [In response to "Observations of 22 non-participant circuits identified 72 faults or 3.3faults per circuit."]	provide a better comparison.
Knowing the sample size (see below) would be useful for giving context to the data. If this is a valid comment for the SCE program, providing a data table with the issues and their frequency would inform improvement efforts. [In response to "Of those surveyed approximately 92% of technicians surveyed had issues with either tools or procedures when performing maintenance services. …"]	This is a valid comment for all CQM programs. This is an HVAC industry issue and not a program issue. The final report will provide program level information.
Is this self-reported? were the tools actually tested and found inaccurate or were they only said to be? [In response to "92% of technicians surveyed had issues with either tools or procedures when performing maintenance services."]	This is an evaluation observation issue based on comparisons of technician tools and measurements to accurate measurement instruments used by the WO32 evaluation team. Laboratory tests of similar field instrument tools verified that tool accuracy as an industry issue and not a program issue.
Remove parenthetical and replace with appropriate and illustrative statistics. [In response to "(can we be more precise)"]	Agreed, the parenthetical will be replaced with appropriate and illustrative statistics.
This seems to be a basic training issue related to C-20 certification. Whether the unit is participating in the program or not, technicians should purge their hoses before connecting to the unit. Whether the unit is in the program or not, technicians should use proper tools to measure key system performance parameters. [In response to "One technician used contaminated refrigerant from a reclaim tank to add refrigerant, which is a violation of US EPA 608 regulations (USEPA 2002… Technicians also did not check or install fan belts with proper tension or alignment which causes reduced airflow, efficiency, and premature failure."]	Agreed, these are basic training issues. It illustrates the current practices in the HVAC industry.
It would appear that the training changed few behaviors in the field. [In response to "Interim field observation results indicate that 85% of technicians currently	Agreed based on the trainings observed.

perform maintenance measures in the program in the same way they did prior to enrolling in the program."]	
Since training is now offered, it would seem that it had little influence on practices. Training doesn't seem to be an issue, since most seem to continue to perform as the have always performed. It's not the training; it's that they don't seem to be motivated to change.	Agreed. This is an industry issue. Incentives are paid to contractors and customers, but technicians perform maintenance services. In order for programs to be successful, technicians will need to be properly trained, equipped, and motivated to perform energy efficiency maintenance services.
Previously to what? to the program? to utility training? [In response to "Here are responses from nine program participants in one program to the following question. 'Do you generally perform maintenance measures in the same way you did previously…?'"]	The survey introduction specified answering questions with respect to the "program." Participant Survey Introduction. "Hello! My name is [________], and I am conducting a survey and would like to ask 16 questions about the California HVAC commercial quality maintenance programs? Would you please spend 10 minutes to answer 16 questions to help us evaluate and improve the program? Your name and your company name will be strictly confidential. The survey question is as follows. "Do you generally perform maintenance measures in the same way you did previously (i.e., coil cleaning, adjust airflow, refrigerant test/service, economizer test/repair, adjust/replace thermostat, or notched v-belt)?"
The locking caps discussion does not seem to have any clear link to energy efficiency. What does this discussion intend to achieve?	The energy efficiency impact is when machine fit caps are over tightened leading to leaks and introduction of non-condensables to systems.
The 2009 Mechanical Code does indeed required that the "Refrigerant circuit access ports located outdoors shall be fitted with locking-type tamper-resistant caps." Though the building code is not really applicable in the case of service work since the code has to do with installation, not service. The key to this is the "located outdoors" part – since our program is based on rooftop mounted units which, for the most part, have all of the access ports inside of a screwed on service door, on a roof that is not accessible without a key, contractors are not going to be installing these caps since the primary purpose is to curb refrigerant theft, nor is there any requirement to do so.	In addition, many of the ACCA 180 items do not address energy efficiency. Some of the items address health and safety which the WO32 team feels is just as important as energy savings given the market transformation goals of the programs.
1. Which programs? 2. Is this a real or potential problem 3. Did the lack of these caps impact the efficiency of the units observed?	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 other programs do not provide

Provided by Nils Strindberg, CPUC

4. The absence of locking caps is not mentioned as important to the energy efficiency performance of HVAC units (see last paragraph, page 7) 5. While this may be good practice, this looks like a C-20 licensing issue and something the CSLB and permitting agencies ought to address. [In response to “For units without locking caps it is not a general program practice… The International Mechanical Code also specifies locking caps.”	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. This is a real problem. The International Mechanical Code also specifies locking caps.[2]
This alone, could be one of the major factors impacting CQM. Time taken performing this task is time not performing CQM more thoroughly and competently. This process should be streamlined to make sure it focuses on the important measures impacting efficiency. [In response to “Observations of training and technicians found that it may take an additional 2 to 4 hours to enter data for one unit into the program database in comparison to a normal maintenance.”]	Agreed, the process should be streamlined.
The program was required to “operationalize” Standard 180 and let it speak on its own terms. Section 4 requires performance objectives and condition indicators which increased the requirements of adding question to confirm these tasks are completed properly. Program Manager also agrees with Evaluators comments and has taken these recommendations to heart as they reflect our same observations. Steps have been taken on statewide level to address the impacts of time without losing the quality control. [In response to “Observations of training and technicians found that it may take an additional 2 to 4 hours to enter data for one unit into the program database in comparison to a normal maintenance.”]	The CPUC did not require the IOUs to “operationalize” Standard 180.
Why do them? [In response to “Most questions address	The WO32 team recommends that the CQM data collection questions be streamlined, retaining questions that address energy efficiency, health

[2] International Mechanical Code - 1101.10. Locking access port caps “Refrigerant circuit access ports located outdoors shall be fitted with licking type tamper resistant caps.”

maintenance activities that do not save energy."]	and safety. Data collection needs to be as simple as possible and no simpler and provide value to customers and technicians without being burdensome.
Hand-off to office personnel creates opportunities for the introduction of errors. [In response to "Technicians collected CSA data on paper forms and contractor office personnel then entered this CSA data into the program database, typically 30 to 180 days after work was completed."]	Agreed.
Can you please provide the actual results that back this statement up? While there may be a couple of cases where it took 180 days for the data transfer, I would be very surprised if that was in the range that would be considered "typical". [In response to "typically 30 to 180 days after work was completed."]	The WO32 team is still waiting for completed summary reports to be provided for observations of work that was performed in 2012. Detailed results will be provided in the final report.
Need to streamline the data collection effort to only those items needed for energy efficiency program tracking of savings. [In response to "Technicians in statewide programs provided the following comments: data collection process is difficult to understand and complete, tasks are out of order, there are too many irrelevant questions, and too much time is required to collect and enter data."]	Agreed, the process needs to be streamlined. The WO32 team recommends that energy efficiency, health, and safety items be retained.
Program Manager agrees with this observation. Program improvements are underway to address this issue. [In response to "too much time is required to collect and enter data."]	No response.
Stop doing this. [In response to "has too many questions that do not pertain to energy efficiency."]	Agreed.
Design data collection steps so that tasks are completed in logical order. [In response to "requires tasks to be performed out of order and inappropriate for season."]	Agreed.
This seems to support the idea that the statewide CQM programs are successfully educating technicians about Standard 180, which is excellent. The wording of this sentence	Two of the largest participants in the SCE program informed the surveyor that they either didn't know about Standard 180 until the survey questions were asked or they were unfamiliar with

seems to imply that the local programs focus should be educating their techs on Standard 180 as well. My understanding is that the local programs are not based on Standard 180, so this is misleading. [In response to "Twenty-three percent of technicians are unfamiliar with the ACCA 180 Standard. Most of these are local program participants indicating statewide CQM participants were the ones aware of ACCA 180."]	Standard 180 (i.e., answered with 1 unfamiliar). In PG&E two statewide participants provided a score of 5 out of 10 (indicating moderate knowledge of Standard 180).
This is not a C-20 contractor; how many of the observations were for these sites? Did they participate in the utility training? Will they bias the overall study results? [In response to "The sixth largest participant in one of the statewide programs in terms of incentives is a customer and not a contractor."]	This participant is responsible for a significant portion of SCE program claims and is only being used to represent that portion of the program population. The top 5 contractors are essentially each in their own certainty stratum.
For all programs? [In response to "Observed technicians did not test or repair economizers."]	Yes, this was for all observed programs.
Non-participants did not have economizers (page 8, first paragraph). Fair comparison? [In response to "most observed units had economizers."]	The non-participant population was randomly selected and does not include any economizers or multiple circuit units. The WO32 team will attempt to observe additional non-participant units for the final report to provide a better comparison.
Especially since most measure are filter replacement! [In response to "Based on interviews with participants and non-participants, most of the measures incented through the program are performed without incentives during normal preventative maintenance."]	Agreed.
Given this wide difference, did the study look at the same paired units pre and post? Also, the report then discusses faults pre and post for a subset of units where issues were observed. It would be helpful to know if the observed faults (approximately 10 per circuit) are the same pre and post or have new faults occurred during the time between the observations. [In response to "Field observations identified 9.7 faults per commercial air conditioning circuit prior to CQM program service and 10.3 faults per circuit after service, an increase of 6%."]	The WO32 team is in the process of completing pre and post observations. Paired pre and post data will be evaluated

The EPA low loss fittings help prevent refrigerant from leaking when applying the hoses, but they don't impact the contaminants (i.e., air) entering the system. [In response to "Lack of low loss fittings and failure to purge hoses causes non-condensables or contaminants to enter the system when adding refrigerant or attaching hoses."]	WO32 evaluation personnel observed technicians attach hoses without low-loss fittings to refrigerant systems. Technicians did not purge hoses of air and moisture. Hoses without low-loss fittings contain air and moisture which contaminate the refrigerant system when attached. Per EPA Section 608(a) "recovery and recycling equipment manufactured after November 15, 1993, must be equipped with low-loss fittings." http://www.epatest.com/608/manual/Manual.htm Low-Loss Fitting - any device that is intended to establish a connection between hoses, appliances, or recovery/recycling machines, and that is designed to close automatically or to be closed manually when disconnected to minimize the release of refrigerant from hoses, appliances, and recovery or recycling machines. EPA low-loss fittings prevent air and moisture from entering the refrigerant system by de minimis purging of air from hoses prior to attaching to the system and drawing refrigerant back into the system before disconnecting using a ball-valve with low-loss fittings. Small releases of refrigerant that result from purging hoses or from connecting or disconnecting hoses to charge or service appliances will not be considered violations of the prohibition on venting.
These seem like basic performance issues relating to C-20 licenses, competency, and management oversight. Without generalizing too much, is there a major gap with the HVAC contractor infrastructure which has the primary responsibility to perform duties per license requirements? If so, many other stakeholders need to be involved to correct, including the CSLB. [In response to "The quality of observed technician service was extremely low… and prevent cap over tightening."]	Yes.
Wouldn't this be true for both participants and non-participants? [In response to "Field observations of technicians indicate a lack of understanding	Agreed.

regarding how to properly diagnose faults and implement repairs to save energy.”]	
Persistence of maintenance related measures has been typically short, necessitating regular, periodic schedules; CQM requires the CSAs be signed for 3 years. [In response to “In one program more than 70% of repairs are not working one year later.”]	No. Participant interviews indicate that most contractors were previously signing multi-year maintenance agreements without program incentives. Based on observations, it appears that repairs were performed improperly.
This does not follow. Most of the discussion is based on what the technician failed to do, or when the technician performed maintenance related tasks, they were done incorrectly without the proper tools. Is there a bias against the program? [In response to “The problem appears to be with program design, implementation, protocols, and data collection and not with technicians who are working within established program parameters.”]	No. Technicians followed program guidelines and did what was expected. The 2010-12 statewide programs provided training on data collection which is both complicated and time consuming. The statewide programs generally assume the same energy savings per unit regardless of whether or not measures are installed correctly. The statewide programs don’t require contractors to perform specific energy efficiency measures unless technicians believe measures are necessary. This is a fundamental program design issue. If contractors are not required to follow manufacturer installation and maintenance protocols, then it is unlikely that they will achieve the ASHRAE 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.).
Agreed, but the program design (logic and theory) seems solid. [In response to “The programs should begin exploring program design changes to improve training, tools, protocols, and data collection.”]	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.