Energy Market Innovations

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Southern California Edison
HVAC Quality Maintenance Program

Rapid Feedback Process Evaluation

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Executive Summary

This is an Executive Summary of the Rapid Feedback Process Evaluation of the Southern California Edison (SCE) Commercial Quality Maintenance (CQM) HVAC Program. The full report documents findings from a "rapid feedback" process evaluation of the SCE HVAC CQM program (also referred to as the SCE HVAC Optimization program), which aimed to assess how well the program is operating in its delivery, to capture and contextualize the program design's evolution, and to facilitate continuous improvements to the program design and delivery operations.

Background and Purpose of Study

High-quality air conditioner maintenance is a highly technical activity in which improper execution of the necessary steps can lead to incorrect diagnoses of problems as well as solutions that can potentially have the opposite of the intended consequence—decreased efficiency. Statewide, the Nonresidential Quality Maintenance program aimed to create and launch a quality installation and maintenance brand, develop standards for on-board diagnostic functionality, and prioritize in-field diagnostic approaches (Program Implementation Plans, July 2012, p. 333-334). The SCE HVAC CQM program, as currently designed, is a market transformation program that began in 2010 and has roots in previous HVAC maintenance programs dating back to the 1990s. The SCE CQM program's short-term and intermediate goals can be described more specifically as aiming to operationalize Standard 180, increasing customer demand for quality maintenance, and enabling contractors and technicians to provide quality maintenance with the intention of increasing energy savings. The program aims to increase the prevalence and persistence of quality maintenance agreements between contractors and commercial customers. The maintenance agreements and the program's supporting tools, such as the Maintenance Planning System (MPS), are designed to address maintenance of whole HVAC systems by operationalizing ANSI/ASHRAE/ACCA Standard 180 (referred to as Standard 180 in this report).

Early field observations of CQM activities provided to the California Public Utilities Commission Energy Division (CPUC-ED) by the Work Order 32 (referred to as WO32 in this report) Evaluation Team identified potential problems with the program′s implementation. After discussions with the CPUC on May 6, 2013, SCE requested a study to identify and analyze the gaps in the end-to-end process in CQM training and implementation to further program improvements. The objectives of this rapid feedback process evaluation were to:

- Conduct a qualitative assessment of the CQM program theory/logic model to determine if it adequately reflects the program's intentions and design;
- Thoroughly document and map current program operations and perform qualitative evaluations of program activities and procedures related to the end-to-end process of CQM training, implementation, data collection, quality control of service procedures and data collection, technician feedback and follow-up, etc.;
- Conduct a gap analysis on program operational processes; and,
- Provide actionable recommendations for improvements to the overarching program design and various implementation processes.

The research team was able to meet the study objectives. Due to the study's four-month time frame, the research budget, and the research methods selected to meet the parameters of the study, some research questions were answered in greater depth than others. Some program processes and criteria deserve more in-depth review, including quality control procedures, training objectives, and parameters for acceptable HVAC unit performance (discussed in conjunction with "reaching baseline"). This study complements the WO32 HVAC impact study, which utilizes field observations. The complete WO32 HVAC impact study will be published in March 2014.

Summary of Key Findings and Recommendations

Overall, the findings collected in this study indicate that the program as designed has merit and has implemented many changes to policies and processes that were responsive to stakeholder needs. To be successful, though, the program should revisit some of the assumptions the program is built on and consider how to strategically address these issues. These overall findings are consistent with a number of the interim findings from the WO32 Evaluation Team; the WO32 Evaluation Team suggests that a complete program redesign is in order and they have doubts about the merit of the current program. The WO32 Evaluation Team is currently analyzing all the data collected on the 2010-12 program to finalize their evaluation and will provide additional feedback on the energy savings achievements and their view of the merit of the program in their final report.

Linking Program Strategy with Continuous Improvement

There is evidence that the program has embraced a continuous improvement model to respond quickly to contractor and customer needs, as well as evaluation findings. Yet, moving quickly leaves little time to anticipate unintended consequences. Program staff and contractors alike recognized the need to slow down the pace of the changes. Contractors need to know what changes are coming, when, and what impact it will have on their current and future contracts. The program has taken a lot of actions to be responsive, yet to our knowledge those actions are not situated in relation to an overarching program development strategy. EMI recommends that the program develop a strategy for implementing desired changes over the coming year. The idea is to do more, less often, with improved communication around the changes. The strategy would ideally: (1) tie to the program's logic model, listing critical issues and questions that affect connections between resources, activities, outputs, and outcomes; (2) identify and vet plausible solutions and alternatives; (3) name likely impacts on key stakeholders and steps taken to assist with their adjustment to changes; and (4) place changes on a schedule that can be shared externally as part of a stakeholder communication plan.

Refine Baseline Criteria, Set Performance/ Measurement Standards, and Strengthen Basis for Assessing Savings Claims

Reaching baseline is an important aspect of the program. It represents a contractor's efforts to bring customers' enrolled HVAC units up to a level of performance that meets Standard 180 guidelines and manufacturer-specified operating parameters. Section 4 of Standard 180 requires that contractors and customers agree on performance objectives and condition indicators to determine baseline. In an effort to reinforce that relationship and stay out of the middle of it, PECI program implementation staff and the SCE Program Manager stated that the program does not dictate what baseline looks like beyond Standard 180. However, in the opinion of this process evaluation team, the methods, tools, and precision of measurement were not clearly defined. There are a few underlying issues that complicate what it means to reach baseline level of performance. Because the program prescribes what tasks to do in what order, not necessarily which protocols to follow or which tools to use when performing these tasks, there are some inherent performance questions that should be addressed to better define what reaching baseline means and to strengthen the basis for assessing savings claims. Given the complexity and nuances in the industry, should the goal be to standardize how each of the Standard 180 tasks are performed or to use a Fault Detection and Diagnostic (FDD) system that measures the outcome? For example, is it more beneficial to standardize the process for cleaning a coil or to standardize measures that determine if the coil has been cleaned properly? Can measurements taken by different technicians who are possibly following different protocols and using different tools end up with the same data? Due to these concerns, EMI recommends revisiting which Standard 180 tasks can be agreed upon and standardized across HVAC units in terms of measurement best practices (including the use of FDD), performance parameters, and incentives for better-than-baseline performance.

Strengthen Contractor and Technician Selection Criteria

Contractor and technician selection and monitoring criteria must be strengthened to keep unethical contractors out, to ensure highly skilled technicians are invited in, and that staff are empowered to remove contractors or technicians if warranted. The program's current criteria for accepting contractors and technicians in the program includes safeguards against bad business practices and experiential criteria, including number of years of industry experience, certifications, and the ability to pass an open-book exam on Standard 180. However, more could be done to assess a technician's ability to complete work. EMI recommends increasing the depth of the post-training assessment to ensure not only that technicians understand how to work with the MPS to enter information, but also to make sure technicians are able to perform the tasks to standards set and monitored by the program. These standards also increase the probability of maximizing energy savings. Given that the program is increasing its role in training technicians on how to perform certain tasks, this assessment would be a natural fit with trying to understand what type of training a given technician will need. In addition, EMI recommends adding to the escalation policy some additional protections for program implementation staff against unprofessional conduct.

Establish Training Criteria

The program originally designed training to encompass selling maintenance contracts and how to follow Standard 180 by using the Maintenance Planning System (MPS) software. While the program tracked who participated in the Sales and Operations trainings and the technician trainings, the persons who were trained for a particular contractor were not necessarily the ones performing the work. As such, EMI recommends making sure the Account Managers and Field Service Technicians (FSTs) train the staff who will sell the maintenance agreements and conduct work documented in the MPS. This may be as simple as ensuring that contractors understand up front that all staff who are accepted into the program must attend training in order to have work approved in the MPS. In addition, the program decided within the past four months to expand training to help develop technicians' maintenance skills. Program staff indicated that this action was taken in response to early findings from WO32, as well as observations of gaps in technicians' maintenance skills. Given that the broader industry wrestles with the questions of whose job it is to fill training gaps in the HVAC workforce and how to bring technician's knowledge, skills, and abilities up to similar levels across the industry, EMI recommends that the program clearly define its training responsibilities, the standards that will be used to maximize energy savings, and the approach for teaching technicians how to do their work.

Tailor the Program to Sell and Continue the Customer Relationship

The program was designed primarily to interface with contractors and empower them to sell the program to their customers. There are a few additional ways the program could progress towards its market transformation goals by further addressing customers' needs for demonstrated savings potential and regular communication. As several contractors reported, there is no return on investment for small units (which they defined as somewhere between five and 20 ton units). They also did not enroll some rooftop units because they did not believe they could get the units to baseline performance. The lengthy incentive processing time was also a disincentive to enrolling additional units. EMI recommends that the program consider developing offerings that will yield a return on investment for small units, whether that is through a modified series of steps to service smaller units or through a different incentive structure. Both existing and potential contractors and customers need to see demonstrated the value of more expensive maintenance contracts. Targeted marketing campaigns that aim to educate potential program participants through real-life testimonials of energy and cost savings, coupled with the program's planned periodic

performance reports, could potentially expand the program's reach and increase the energy savings realized. Most immediately, though, the program must reduce the incentive approval and processing time. EMI encourages SCE to consider reducing redundant reviews, implementing a more finely-tuned sampling procedure, and hiring additional staff to reduce the time it takes for customers to receive incentive checks. It does not reflect well on the program to demand timely service and not deliver timely rewards.

1. Overview of Study

This report documents findings from a "rapid feedback" process evaluation of the SCE HVAC Commercial Quality Maintenance (CQM) program (also referred to as the SCE HVAC Optimization program), which aimed to assess how the program was performing, to capture and contextualize the program's evolution, and to facilitate continuous improvements to the program design and operations. For the purposes of this report, the program will be referred to as the SCE HVAC CQM program or simply "the program."

Early field observations of CQM activities provided to the CPUC Energy Division (CPUC-ED) by the Work Order 32 (referred to as WO32 in this report) Evaluation Team identified field implementation issues. After discussions with the CPUC on May 6, 2013, SCE requested a study to identify and analyze the gaps in the end-to-end process in CQM training and implementation to further program improvements.

1.1 Program Goals

Per the SCE Program Implementation Plans 2013-2014, dated July 2, 2012 (SCE PIP 2013-14), the statewide program was tasked with helping to achieve Strategic Plan goals that aimed to create and launch a statewide Quality Maintenance (QM) brand, conduct QM training, develop standards for on-board diagnostic functionality, and prioritize in-field diagnostic approaches. The SCE CQM program's short-term and intermediate goals can be described more specifically as aiming to operationalize Standard 180, increasing customer demand for quality maintenance, and enabling contractors and technicians to provide quality maintenance with the intention of increasing energy savings. The program aims to increase the prevalence and persistence of quality maintenance agreements between contractors and commercial customers. The maintenance agreements and the program's supporting tools, such as the MPS, are designed to address maintenance of whole HVAC systems by operationalizing ANSI/ASHRAE/ACCA Standard 180 (referred to as Standard 180 in this report).

1.2 Brief Overview of Program History

The program, as currently designed, began in 2010 and has roots in previous HVAC maintenance programs dating back to the 1990s. According to the SCE Program Manager, this program utilized Six Sigma[1] tools and stage gates to design the program and make the final decision to launch the program. In addition, according the PECI Senior Program Manager:

> "As part of this program development phase, SCE funded a field study in 2010 that examined the impact of HVAC quality maintenance service on energy use, indoor air quality, and thermal comfort in small commercial buildings. The field study's

[1] "Six Sigma is a rigorous and a systematic methodology that utilizes information (management by facts) and statistical analysis to measure and improve a company's operational performance, practices and systems by identifying and preventing 'defects' in manufacturing and service-related processes in order to anticipate and exceed expectations of all stakeholders to accomplish effectiveness." See http://www.isixsigma.com/dictionary/six-sigma/

> procedure was based on Standard 180 combined with specific prescribed economizer and thermostat optimization measures … The Field Study … resulted in several conclusions that greatly impacted the QM program design, especially with regard to software, incentive and required maintenance tasks."

The field development study was not designed to provide statistically significant evidence that implementing Standard 180 led to energy savings in all cases. However, the SCE Program Manager concluded that the study's findings indicated that energy savings occur as a direct result of implementing a maintenance plan that followed Standard 180 procedures.

This program differs from previous IOU HVAC programs. The SCE HVAC Program Manager described the program's development this way:

> "In 2009, SCE began the development of new program guidelines for acceptable QM that not only deals with refrigerant charge adjustments and the entire air conditioning system, but also economizers and indoor air quality. This development activity is fully described in the 2010-2012 HVAC PIP and identifies recommendations for achieving acceptable QM standards and a well-defined and documented approach for fault detection. The new comprehensive design specifically focuses on the impacts that maintenance has on thermal comfort, indoor air quality, and energy efficiency, addressing the common problems within the HVAC systems and resulting in deeper kW and kWh savings. This approach mitigates the energy savings risk realized in the previous RCA programs and deals with the complexity of servicing air conditioning systems designed for unique applications. Ultimately, this approach impacts the operating efficiency of commercial air conditioners in a cost effective manner by allowing skilled technicians to identify the 'best fit' opportunities for the specific system being serviced using transparent and standardized protocols."

The current program is designed to address maintenance of whole HVAC systems as opposed to individual measures. High-quality air conditioner maintenance is a highly technical activity in which improper execution of the necessary steps can lead to incorrect diagnosis of problems and remediation that can potentially have the opposite of the intended consequence—decreased efficiency. In June 2008, the California Energy Commission estimated that failure to properly install and maintain cooling systems can result in a 20% to 30% increase in summertime peak electricity needed by such systems.[2] As such, quality maintenance has particular strategic importance, despite cost-effectiveness challenges.

As stated in the Southern California Edison (SCE) Energy Efficiency Program Implementation Plans for 2013-2014, the statewide Nonresidential HVAC Quality Maintenance program will comply with industry standards set by the American National Standards Institute (ANSI), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), and the Air Conditioning Contractors of America

[2] Strategic Plan to Reduce the Energy Impact of Air Conditioners http://www.energy.ca.gov/2008publications/CEC-400-2008-010/CEC-400-2008-010.PDF

(ACCA) Standard 180. The HVAC CQM program intends to operationalize Standard 180 with the goal of improving commercial HVAC maintenance practices so that energy savings are realized. The program is aligned with the California Long-Term Energy Efficiency Strategic Plan (The Strategic Plan)[3] and coordinates with the Western HVAC Performance Alliance (WHPA)[3], an organization that brings a full spectrum of industry leaders together to develop initiatives aimed at reaching the Strategic Plan goals.

The HVAC CQM program is designed as a market transformation program that aims to increase the prevalence and persistence of quality maintenance agreements between contractors and commercial customers. The statewide metric for HVAC CQM programs (presented in 2011) tracks the percentage of commercial HVAC units (systems) serviced in an IOU service territory under a quality maintenance service agreement.[4] It can also be considered an awareness intervention to increase awareness and understanding of Standard 180, and a behavior change intervention to drive technicians to consistently perform HVAC maintenance work in compliance with Standard 180. In this sense, the program holds great promise because it has potential to act as a "gateway" for technicians to learn and implement quality retrofit (QR) and quality installation (QI) practices that could drive deeper energy savings.

This study focused exclusively on Southern California Edison's HVAC CQM program. To place this program's efforts in broader context, the CPUC allocated $61.8 million (65%) to SCE out of a total statewide Commercial HVAC program budget of $94.8 million. This is a significant investment in HVAC programs seeking to decrease the burden that air conditioning and heating place on peak energy demand. Air conditioning is the single largest contributor to peak power demand in California, accounting for nearly 30 percent of summertime total electric demand.[5] While SCE's HVAC CQM program is currently fully operational, it is in an early phase of its development given the complexity of the program. It is important to note that this program is truly innovative and is the first to effectively operationalize Standard 180 with full endorsement letters provided to the CPUC by key stakeholders, including the authors of Standard 180, Bob Baker of ASHRAE and Glenn Hourahan of ACCA. As noted in SCE's Customer Energy Efficiency and Solar Division Program Implementation Plans, 2013-2014, the CQM Program "may represent one of the more creative aspects of the HVAC 'Big Bold Energy Efficiency Strategy'." That said, some of the key assumptions upon which the program is built have yet to be fully tested. The program's continuous improvement model, which according to the SCE Program Manager was derived from Six Sigma methods, allows it to evolve its program operations and even its goals. As noted in Appendix A, between July 2012 and July 2013, the program made changes to its program activities and refined processes in response to feedback from participants, staff observations, and early feedback from the WO32 Team.

[3] The Strategic Plan: http://www.cpuc.ca.gov/NR/rdonlyres/D4321448-208C-48F9-9F62-1BBB14A8D717/0/EEStrategicPlan.pdf
[4] Southern California Edison.
[5] Donald Vial Center (2011), p. 92

1.3 Research Objectives and Key Research Questions

The objectives of this rapid feedback process evaluation were to:

- Conduct a qualitative assessment of the CQM program theory/logic model to determine if it adequately reflects the program's intentions and design;
- Thoroughly document and map current program operations and perform qualitative evaluations of program activities and procedures related to the end-to-end process of CQM training, implementation, data collection, quality control of service procedures and data collection, technician feedback and follow-up, etc.;
- Perform a gap analysis on program operational processes; and,
- Provide actionable recommendations for improvements to the overarching program design and various implementation processes.

Table 1-1 describes the research questions that guided this study and the data sources that were used to address the questions. Given the rapid four-month timeframe, the research budget, and the research methods selected to meet the parameters of the study, the process evaluators were able to address some questions in greater depth than others. This study complements the WO32 HVAC impact study, which utilizes field observations. The complete WO32 HVAC impact study will be published in March 2014.

SCE took the lead on the statewide CQM redesign and continues to be the "center of gravity" for this program. As such, this study focused solely on SCE's CQM program, but results will be shared with the operations staff at the other IOUs.

Table 1-1: Research Questions for this Study and Corresponding Data Sources

Research Questions	Document Review	Process Mapping Workshop	Program & Implement-ation Staff Interviews	Contractor Interviews	Technician Interviews
What are the program theory/logic model assumptions?	X	X	X		
Have program theory/logic model assumptions been supported by program stakeholder experiences? Should they be modified in order to meet program expectations?	X		X	X	X
Do the program implementation processes and operations align with the program theory/logic model?	X	X	X		
What implementation challenges exist?	X	X	X	X	X
What opportunities exist for increasing the program's efficiency and effectiveness in implementation of program goals/objectives?	X		X	X	X
Does ANSI/ACCA/ASHRAE Standard 180 provide sufficient guidance to achieve program goals? Are supplemental protocols required to meet program objectives?	X		X	X	X
How do training activities support the measure implementation and savings goals (i.e., is training addressing measures included in the ex-ante savings goals)?	X		X		
Do training activities adequately address both technical process and sales/marketing issues?	X		X	X	X
Do field technicians report following the program protocols and training guidance in terms of service procedures and data collection? If not, why not? Are there elements of the program protocols and training that field technicians believe are not worthwhile?					X
Are program QC and oversight activities adequate? How effective is feedback from QC back to technicians? Is the feedback of sufficient frequency and specificity to cause persistent improvements in service procedures?	X	X	X		

1.4 Methods

Given the evolving nature of this program, it was important to establish a cut-off date to ensure the accuracy of findings described in this report. This report includes program changes and findings communicated as of July 31, 2013. Modifications occurring after July 31, 2013, are noted as changes in progress and should be checked for accuracy. For this rapid feedback process evaluation, the research team employed four methods:

1. Background documentation and data review;
2. Process mapping workshop;
3. In-depth interviews with program staff, program implementation staff, and participating contractors and technicians; and,
4. Written WO32 Team clarification questions and answers developed from an early draft provided to EMI on July 22, 2013 of the WO32 EM&V Interim Findings Memo for Commercial Quality Maintenance.

Background Documentation and Data Review

EMI conducted a rigorous but expedited review of program performance in a structured and methodical manner. Because this review was expedited it is not exhaustive, however, EMI reviewed the program logic model and all program operational and relevant documents received from SCE, PECI, and DNV KEMA. EMI submitted a data request to SCE, PECI and DNV KEMA for all relevant program operational documents and key data. This included:

- Program PIP and logic model;
- List of all contractors and field technicians and contact information;
- List of PECI and SCE staff contact information;
- Program tracking data;
- Program's internal team manual;
- Standard 180;
- Incentive processing data;
- Copy of SCE HVAC Optimization Dashboard data visualization;
- Impact Evaluation Research Plan for Residential and Small Commercial HVAC Programs from WO32 DNV-GL/KEMA;
- Certification/Curriculum Vitas (CVs) of training staff (NATE certificate numbers, effective dates, expiration dates, certification types);
- Contractor/technician screening protocols and qualification requirements;
- Participating contractor agreement;
- Documentation of business competencies of enrolled contractors;
- Contractor Sales and Operations Training syllabus, program implementation staff checklist, training materials, and post-training survey;
- Technician application;
- Technician training procedures, materials/curriculum, copies of training dates (classroom, field, and on-going mentoring), and attendee lists;

- Document describing technician competency weaknesses found during Maintenance Planning System (MPS) trainings;
- On-site verification results – by contractor, type and date;
- Quality control/inspection procedures;
- Documentation on re-training activities;
- Preliminary findings from WO32 DNV-GL/KEMA technician observations;
- Sample termination letters.

Program Theory Review and Process Mapping Workshop

In any evaluation process, the purpose of the program needs to be clearly identified as the goals of the evaluation depend on the goals of the program. The process of reviewing the program theory helps facilitate this evaluation need. Program theories aim to describe causal relationships between a program and the change the program is trying to affect. Program logic models are often used to describe a program theory in terms of the types of resources a program uses to conduct a series of activities that result in specific outputs. Those outputs are hypothesized to lead to short-, intermediate-, and long-term outcomes. A program logic model provides a good way to identify monitoring and evaluation questions that test the strength of the links between activities and outcomes, and to better understand what other factors can have a moderating effect on those links. As a program evolves, components of the logic model should evolve to reflect the program's current theory of how it will affect change.

In this situation, the CQM program seeks to change California HVAC maintenance practices by encouraging customers and contractors to (1) adopt Quality Maintenance Services found in ASHRAE/ACCA/ANSI Standard 180; (2) commit to a written Maintenance Plan that has goals for improving thermal comfort, energy efficiency, and indoor air quality and (3) continue to procure/offer these services. These Quality Maintenance Plans must ensure that technicians use maintenance best practices known to result optimal system operation and reliability that, in turn, result in energy efficiency and peak demand reduction.

Process maps are often used to describe the series of steps a program takes to implement its activities and yield the desired outputs and outcomes. These maps help document how the program is conceptualized at an operational level. Process maps for the CQM program are presented in Chapter Three.

EMI facilitated a half-day workshop with key program staff and program implementation staff to review the program's logic model and map the key program processes. The following individuals are the key persons involved in the operations of this program, and all of them attended the workshop:

- Monica Thilges, PECI
- Brian Leatham, PECI
- Courtney Brown, PECI
- Todd VanOsdol, PECI
- Michael Blazey, PECI

- Kim DiCello, PECI
- Elsia Galawish, SCE (EM&V HVAC Consultant)
- Mel Johnson, SCE
- Devin Rauss, SCE
- Andres Fergadiotti, SCE

The process-mapping workshop was held in a SCE conference room on June 25, 2013. In preparation for the process mapping workshop, EMI reviewed the logic model titled, "PY2013-14 Nonresidential HVAC Quality Maintenance Program-Logic Model" filed with the SCE PIP 2013-2014 (p. 345), and used insight gained in the background review to develop a list of the processes that needed to be mapped. At the beginning of the process-mapping workshop, EMI reviewed the program logic model with attendees to ensure it still represented the program theory. The attendees worked with EMI to identify needed adjustments to the logic model.[6] After reviewing the logic model, EMI worked with attendees to review the processes. EMI put butcher paper up on the walls and walked workshop attendees through the different steps of each process, identifying the *who*, *what*, *where*, *how*, and *why* of each step. Each step was described on a large colored sticky note and placed on the butcher paper. The sticky notes were moved around as the group decided the order in which steps typically occur. This allowed the group not only to map key processes in a timely fashion but also provide important insights into bottlenecks, misunderstandings, and misalignments among stakeholders. This also provided a great opportunity to solicit input regarding changes the staff would like to make to the process and the barriers to those changes. After the meeting EMI created electronic versions of the process maps for review by program staff, program implementation staff, SCE evaluation staff, and the Project Team.[7] EMI made further adjustments to the process maps based on program staff and program implementation staff review. These maps intend to reflect the program as currently designed. Given the evolving nature of the program, some pending changes and critique of process steps are reflected in the descriptions surrounding the process maps in Chapter Three of this report.

Interviews of Program Staff, Program Implementation Staff, and Participating Contractors and Technicians

In-depth interviews comprised the primary research effort of this study. At the end of June through early July, EMI designed and implemented a series of in-depth interviews to gain a thorough understanding of the program, its operation, and implementation issues. EMI built on the data obtained through the CQM process-mapping workshop to conduct individual phone interviews with seven program and implementation staff. The purposes of the interviews were to gather additional thoughts and clarifications regarding program processes.

[6] The Senior Program Manager took notes on the needed logic model modifications. EMI received an earlier version of the logic model on July 5, 2013 that the program still used as reference.
[7] The Project Team consisted of SCE members, ED members and ED Evaluation Consultants and met twice a month to provide feedback and monitor the progress of this study.

Following these interviews, EMI synthesized findings from the interviews, process maps, and document review tasks to identify key issues to discuss with participating HVAC contractors/technicians. The SCE Project Manager approved the interview protocol on July 23, 2013, and the Project Team approved the sampling plan on July 3, 2013. Given the rapid timeframe and the fact that it is the busiest season for HVAC contractors, EMI used program staff and ED staff assistance as appropriate to solicit participation. EMI selected the following sample of contractors and technicians for interviews:

- 4 dyads[8] of the most active participants; total number of interviews = 8
- 2 dyads of less active participants; total number of interviews = 4
- 2 contractors who were approved for the program but either never became active or voluntarily ceased; total number of interviews = 2

Active contractors were defined as contractors with the greatest number of buildings with signed maintenance agreements as of July 9, 2013. EMI conducted interviews with six contractors (those in charge of contracting firms or managing technicians), five technicians (those who do the maintenance work for a contractor firm), and two enrolled contractors with no customer enrollments completed. After repeated attempts, EMI was unable to schedule one technician interview.

EMI sought to create a safe, objective environment for participants in these interviews, where candid data could be gathered from the respondents solely for the purpose of identifying improvement needs for the program. EMI will continue to keep these data confidential and took great care in ensuring that any identifying information was not included in this report.

Analysis and Reporting

After a thorough review of the background information from program-related documents — including information from the WO32 interim findings memo, a review of the program database, and data collected through interviews with program staff, program implementation staff, contractors and technicians — EMI assessed whether the program was performing as intended and identified operational gaps, issues, and challenges that confronted the HVAC CQM program and its training component.

This report summarizes those analyses and provides actionable recommendations for improving the program design and delivery operations. The goal of this report is to describe the **key** findings of the research and not necessarily all the data obtained.

[8] A dyad consisted of a participating contractor and a participating technician from the same company.

2. Program Theory

In this section we provide a description of how the program theory has been represented through two iterations of program logic models over the past few years. We also offer a third version of the program logic model that aims to improve upon the first two iterations.

2.1 Evolution of Program Logic Model

Program implementation staff first developed the 2011-2012 program logic model (see Figure 2.1). The 2013-2014 Energy Efficiency Program Plans, published in July 2012, included an updated version of the logic model for the Nonresidential HVAC Quality Maintenance Program on page 345 (see Figure 2.2). This model listed activities, outputs, and short-, intermediate- and long-term outcomes. It also highlighted instances when other market actors would be involved and indicated at what points in the program the market barriers would be addressed.

During the process-mapping workshop on June 25, 2013, the evaluation team reviewed the accuracy of the 2013-2014 logic model with SCE and PECI staff. Based on that conversation, the PECI Senior Program Manager intended to provide a revised version of the program logic model to better reflect important aspects of the program's design. The goal was to add details that would more clearly explain the boundaries of the program elements. While these revisions were not made this summer, the Senior Program Manager did provide a copy of the 2011-2012 logic model for comparison.

There are many differences between the 2011-2012 version and 2013-2014 version of the logic model that are worth noting. While not an exhaustive list, the following changes provide good examples of important differences:[9]

- The removal of the development of the Maintenance Planning System (MPS) as an activity.
- The removal of names of other market actors that influenced the program and the identification of which activities they influenced, such as the role HVAC contractors and associations played in influencing the CQM program measures implemented.
- The removal of a "Resources (Inputs)" line, which previously linked the groups involved and linked those groups to particular activities in the row below.
- Reorganized and decreased descriptions of components of the logic model. For example, in the 2013- 2014 logic model the activity "Train Technicians via Workforce Education & Training" leads to an output of "trained technicians" and a short-term outcome of "Increased Contractor Awareness and Capability." The 2011-2012 logic model defined who delivered the training and described the types of learning modes and outcomes. Specifically, the 2011-2012 logic model stated the "resource" was the PECI Field Team that conducted the activity, "Workforce Education and Training,"

[9] EMI compared the 2011-2012 version of the logic model to the 2013-2014 version of the logic model.

which led to an output of "Contractor Manual, training courses, ongoing mentoring, performance data," and a short-term outcome of "improved contractors/technician technical skills, knowledge, tools, and support." The SCE Program Manager explained that they made this change to better represent how the output of the Workforce Education and Training Program would be integrated into the CQM program.

- The 2011-2012 logic model highlighted how certain short-term direct benefits (improved HVAC performance, energy savings, and increased contractor revenues) can be maximized by other short-term outcomes, including early detection of issues, better targeting of measures, compliance with SCE requirements, strengthened relationships between contractors and customers, and increased customer awareness of measures, qualified contractors, and program benefits.
- The 2013-2014 version of the logic model highlights points in the program when market barriers are addressed. In the 2011-2012 logic model there is a brief mention in the program logic that address Strategic Plan goals, i.e., SP Goal 2 is noted in a long-term outcome box titled, "QI/QM becomes the norm."

In the 2011-2012 logic model, it is important to note that the following are likely erroneous:

- Ongoing Quality Maintenance appears as an activity that precedes EE Cooling Service Analysis. However, the Cooling Savings Analysis (CSA) is part of the QM process.
- Customer leads should likely precede three-year Maintenance Agreements as an output.
- There may need to be an additional link into the intermediate outcome box housing "Contractors: Revenues grow…," "SCE: Energy savings…," and "Customers: above benefits preserved …" from the short-term outcome above it that houses three kinds of direct benefits.
- The intermediate outcome "Uncertainties in energy savings reduced …" should likely link to output "Work Papers Calculators…"

In developing a revised version of the logic model, we drew from the strengths of the 2011-2012 and 2013-2014 logic models while clarifying important details about the program's boundaries. The revised version is titled, "PY2013-2014 Nonresidential HVAC Quality Maintenance Program Logic Model, Revised August 2013," (see Figure 2.3). In this logic model, we made the following changes for each section:

Activities

- Above the Activities line, we added some specific examples of industry groups to the "Other Market Actors" box to clarify which types of industry groups would be most influential, including: WHPA, unions, ASHRAE/other standards developers.
- We changed the language from "Develop Marketing Materials" to "Develop and Distribute Marketing Materials," because marketing material distribution is an aspect of the enrolled contractors' sales process.
- We changed "Recruit Contractors" to "Recruit, Enroll and Train Qualified Contractors." This addressed Market Barrier #1.

- The "Enroll and Train Qualified Contractors in the Program Material and Standard 180" box now has an arrow pointing to a new output: "Contractors Sign Participation Agreement." This is a separate document and a separate process step from the signing of the Maintenance Agreement.
- The "Contractors Sign Participation Agreement" box now has an arrow pointing to the "Recruited Contractors" output.
- We changed "Train Technicians" to "Train qualified technicians in Standard 180 and Using MPS."
- We added an additional activity that states, "Technicians' Knowledge of Program verified by Post-Training Assessment" to emphasize the program's attempt to emphasize the expectations of technician performance before they begin working on QM agreements. This activity feeds into the output "MPS-Trained Technicians."
- We changed "Recruit Customer Participants" to say "Recruit Eligible Customer Participants."
- We added the following activities:
- "Manage contractor performance." This activity connects to "Document Review and OSVs" and "Provide Incentives." This activity shows that incentives are dependent on the results of these reviews.
    - "Develop, Manage, and Distribute Access to MPS and its Contents for Contractor and Technician to Use" (e.g., program materials)
    - "Develop Sales, MPS, and Standard 180 Training Materials."
    - "EM&V and Continuous Improvement Process" which links to "Decrease in Savings Uncertainty." Although not specified in this model, this box could also feed back to program activities.

Outputs

- We changed "Recruited Contractors" to "Enrolled and Trained Contractors," because this better captures the points in the process contractors have already passed through.
- We changed "Inspection Reporting" to "Inspection Reporting and Follow-Up with Contractors and Technicians" to better define who received the reports.[10]
- We added the following outputs:
    - "Contractors Sign Participation Agreement," which has an arrow coming from "Enrolled and Trained Contractors" and an arrow pointing to the short-term outcome "Increased Contractor, Technician, and Customer Awareness."
    - "Training Materials" which has an arrow coming into it from "Develop and Distribute Marketing Materials" and which leads to "MPS-Trained Technicians" and "Enrolled and Trained Contractors."
    - "MPS Used to Track Enrolled HVAC Units' Performance" has arrows from "Maintenance and Repairs are Performed" and "Develop, Manage and Distribute Access to MPS and its Contents for Contractor and Technician to

[10] None of the interviewed contractors indicated they received any follow-up. This may reflect an inconsistency between program plans and practice or it may be a new process step that had not been implemented in July 2013.

Use," and leads to "Inspection Reporting and Follow-Up with Contractors and Technicians."

Short-term outcomes

- We changed "Increased Contractor Awareness and Capability" to "Increased Technician Capability to Perform QM" to more clearly assign performance of work tasks to technicians.
- We changed "Increased Customer Awareness" to "Increased Contractor, Technician, and Customer Awareness," and made a two-way arrow between this box and "Increased Technician Capability to Perform QM."
- We linked "Increased Employment & Increased Contractor Revenue from QM Work" to the intermediate outcome "Increased Pool of Contractors Practicing Quality Maintenance." This is a piece of the program logic model that may require refinement moving forward given some contractors' cost-effectiveness concerns.
- We added a new activity, "Increased contractor satisfaction," which can be linked to the "incentives" output, and the "Improved Customer Satisfaction" and "Increased Employment…" short-term outcomes.

Intermediate Outcomes

- We did not modify "Increase in QM Training Provided by the Industry." However, this is a point in the logic model that is worth considering tying back up to program activities.
- We added a new activity, "Customer awareness of QM leads to increased attention to QI and QRs." This links from "Increase in QM Training Provided by the Industry" and "Ongoing Maintenance Continues by Participants without the Program, Including Deeper Energy Savings." It links up to short-term outcome "Reduced Energy Usage, Improved Thermal Comfort and Indoor Air Quality" and the long-term outcome "CLTEESP Goal 2."

Long-term Outcomes

- We made no changes to long-term outcomes.

2.2 Logic Model Moderators: Factors Affecting the Links Between Boxes

In a logic model, there are typically boxes to represent resources, activities, outputs, and outcomes. The arrows represent the connection between the boxes. These connections are often influenced by "moderators" that affect "the direction and/or strength of the relationships."[11] It is important to pay attention to the effects of moderators on the connections between the boxes in a logic model because the strength of one connection can have ripple effects through other parts of the logic model. As a general example, suppose that the activity "conducting training" leads to the output "technicians trained," and that in turn leads to the short-term outcome "services performed to standard." Also, suppose that the strength of the connection between "conducting training" and "technicians trained" is moderated by the teaching format used to structure the training. If the teaching format meets teaching and learning needs, then the "technicians trained" output should be stronger and therefore more likely to result in "higher percent of technicians performing to standard." Based on the findings from this evaluation, we identified several categories of important moderators that will influence whether or not the program theory holds true. This list emphasizes the connections between activities and outputs. It is not a comprehensive list, but highlights the importance of key connections that the program can directly influence.

Contractor and Technician Selection, Remediation, and Removal Criteria

The accuracy and comprehensiveness of criteria used to qualify contractors and technicians for the program affected the links between "Recruit, Enroll, and Train Qualified Contractors in Program Material and Standard 180," and "Enrolled and Trained Contractors," and "Train Qualified Technicians in Standard 180 and Using MPS." The strength of the criteria used to remediate and, if necessary, remove contractors and technicians from the program through the program's escalation process affected the links between "Document Review and OSVs," "Manage Contractor Performance," "Maintenance and Repairs are Performed," and "Provide Incentives."

Technicians' Knowledge & Previous Training

A technician's previous training and their level of understanding of HVAC theory, such as refrigeration and airflow, will influence how effective the program's technician training will be in readying technicians to perform the maintenance work. This moderator affects the links between "Train Qualified Technicians in Standard 180 and Using MPS" and "Technicians knowledge of Program Verified by Post-Training Assessment," "MPS-Trained Technicians," and "Increased Technician Capability to Perform QM." It also affects the link between "Activities by Other Market Actors" and "Increased Pool of Contractors Practicing Quality Maintenance."

[11] Donaldson, S. (2007). Program Theory-Driven Evaluation Science, p. 30.

Use of HVAC Maintenance Tools

The accuracy and reliability of maintenance tools, as well as the way in which technicians use the tools, can affect the accuracy of the diagnoses, repairs, and energy savings estimates. The lack of agreement on best practices for using some HVAC maintenance tools also affects the accuracy of diagnoses. In the logic model, the use of HVAC maintenance tools affects the connections between "Maintenance and Repairs are Performed," "MPS Used to Track Enrolled HVAC Units' Performance," "Inspection Reporting and Follow-up with Contractors and Technicians," "Document Review and OSVs," "MPS-Trained Technicians," and "Reduced Energy Usage, Improved Thermal Comfort, and Indoor Air Quality."

Size and Condition of Unit

The size and condition of an HVAC unit affects contractors' and technicians' decisions about whether to include the unit in the program. This decision affects the connections between "Recruit Eligible Customer Participants," "Participants and Contractors Sign Maintenance Agreement" and "Maintenance and Repairs are Performed."

Thoroughness and Appropriateness of Service Performed

How thoroughly a technician performs specific tasks during HVAC service affects the unit's performance, and whether a service task is appropriate to conduct on an HVAC unit depends in part on the type of unit, climate, and conditions in which the unit is found. Decisions regarding how thoroughly a unit should be serviced and which tasks should be performed can impact the unit's operating efficiency and the cost-effectiveness of the service for the technician. While a set of tasks are prescribed through the MPS, the technicians' choices about how to perform certain tasks can affect the links between "Participants and Contractors Sign Maintenance Agreement," "Maintenance and Repairs are Performed," "MPS Used to Track Enrolled HVAC Units' Performance," and "Reduced Energy Usage, Improved Thermal Comfort and Indoor Air Quality."

Comprehensiveness, Credibility, Quality, Timing, and Format of Training

The comprehensiveness, credibility, quality, timing, and format of training sessions affect which contractors and technicians receive training, how much a contractor or technician learns, and whether or not they will apply what they learned. Instructors need to build trust and credibility with the contractors and technicians in order to build training opportunities that will result in knowledge gained and behavior changed. The ability of post-training assessments to accurately assess gains in knowledge, skills, and commitment to change affects how trainings are designed in the future and the program's confidence in their technicians. This set of factors will influence the connections between "Train Qualified Technicians in Standard 180 and Using MPS"," "Technicians' Knowledge of Program Verified by Post Training Assessment," "MPS-Trained Technicians," and "Improved Customer Satisfaction." It will also affect the connection between "Recruit, Enroll, and Train Qualified Contractors in Program Material and Standard 180," Develop sales, MPS, and Standard 180 Training Materials," "Training Materials," "Enrolled and Trained Contractors," and "Contractors Sign Participation Agreement."

Usability of MPS

The MPS provides guidance to technicians on what QM treatments are indicated to be needed and if they have been completed (according to information technicians logged in the MPS), the number of days left to complete a task in order to remain compliant with their Standard 180 task frequency guidelines, and measure-specific metric targets and ranges. The accuracy of the information inputted by technicians affects the connection between "MPS Used to Track Enrolled HVAC Units' Performance" and "Inspection Reporting and Follow-Up with Contractors and Technicians." Contractors and technicians should be able to use the MPS for generating reports that they can discuss with their customers about progress toward, and compliance with, maintenance plan goals, as well as reports on energy efficiency, thermal comfort, and indoor air quality. The accuracy and usability of these reports affects the connection between "Develop, Manage, and Distribute Access to MPS and its Contents for Contractors and Technicians to Use" and "MPS Used to Track Enrolled HVAC Units' Performance." The level of glare, connectivity, processing time and heat on the roof can impact how much data entry technicians are willing and able to do while still on the roof as opposed to entering paperwork into the MPS later. The usability of the MPS on wireless devices affects the connections between "Maintenance and Repairs are Performed," and "MPS Used to Track Enrolled HVAC Units' Performance."

Processing Time

The amount of time it takes to process paperwork affects multiple stages of the CQM program processes. In the logic model, processing time affects the following connections: "Recruit, Enroll, and Train Qualified Contractors in Program Material and Standard 18," "Enrolled and Trained Contractors," and "Contractors Sign Participation Agreement," "Train Qualified Technicians in Standard 180 and Using MPS;" "Recruit Eligible Customer Participants" and "Participants and Contractors Sign Maintenance Agreement;" "Manage Contractor Performance," "Provide Incentives," "Incentives Paid To Contractors," "Incentives Paid to Participants;" and "Document Review and OSVs," and "Inspection Reporting and Follow-Up with Contractors and Technicians."

The categories of moderating factors discussed above primarily concern the activities and outputs of the program. While the links between outputs and outcomes are affected by program activities, the influences are often indirect and they are confounded by external sources, such as the influence of the general Southern California economy and the availability of qualified HVAC technicians on the link between "Incentives Paid to Contractors" and "Increased Employment & Increased Contractor Revenue from QM work." The categories of moderators and connections listed above are worth keeping in mind when reviewing findings about the logic model and program processes in the next section and in Chapter Three.

Figure 2.1: 2011-2012 Program Logic Model

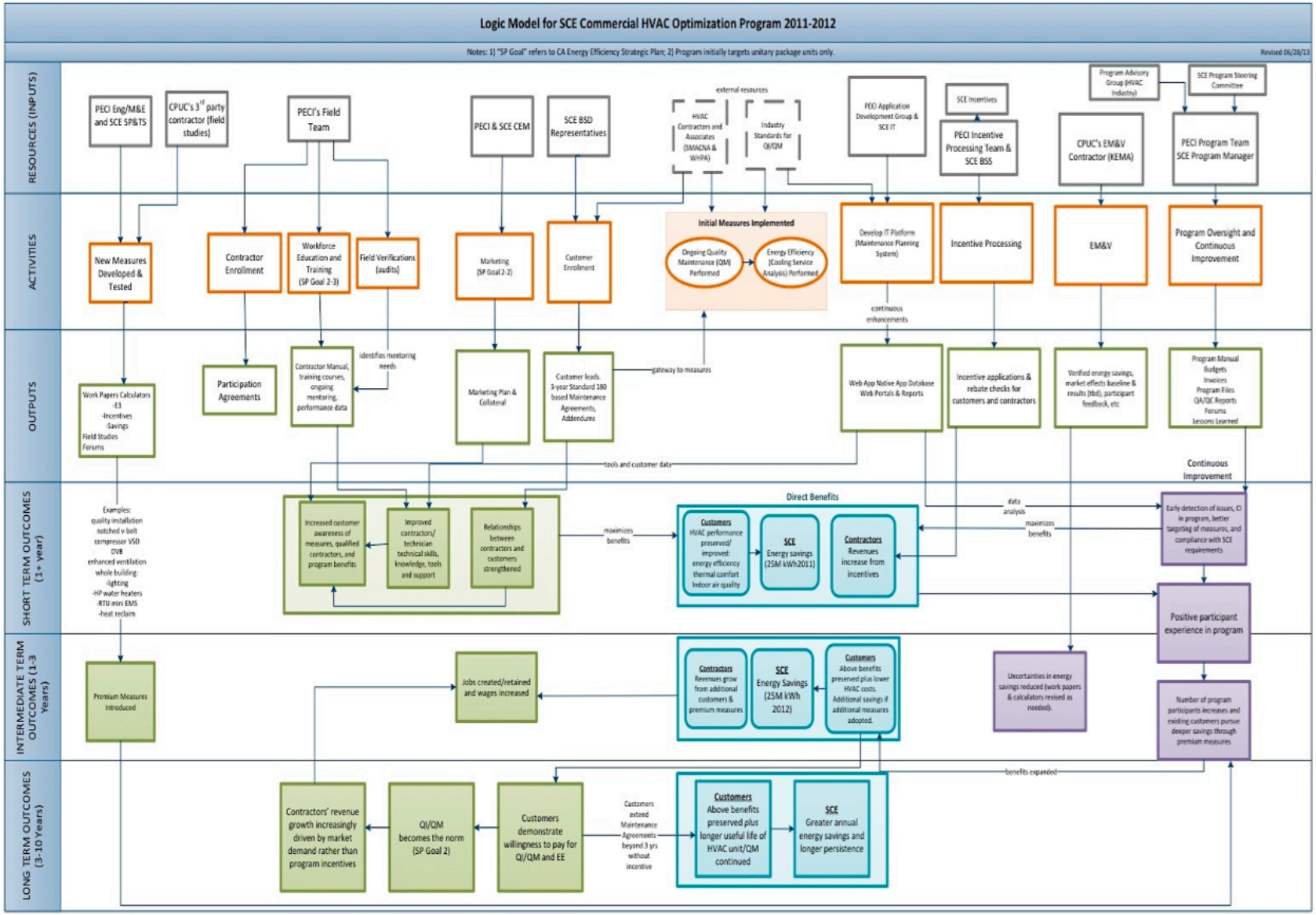


Figure 2.2: 2013-2014 Program Logic Model (Published July 2012)

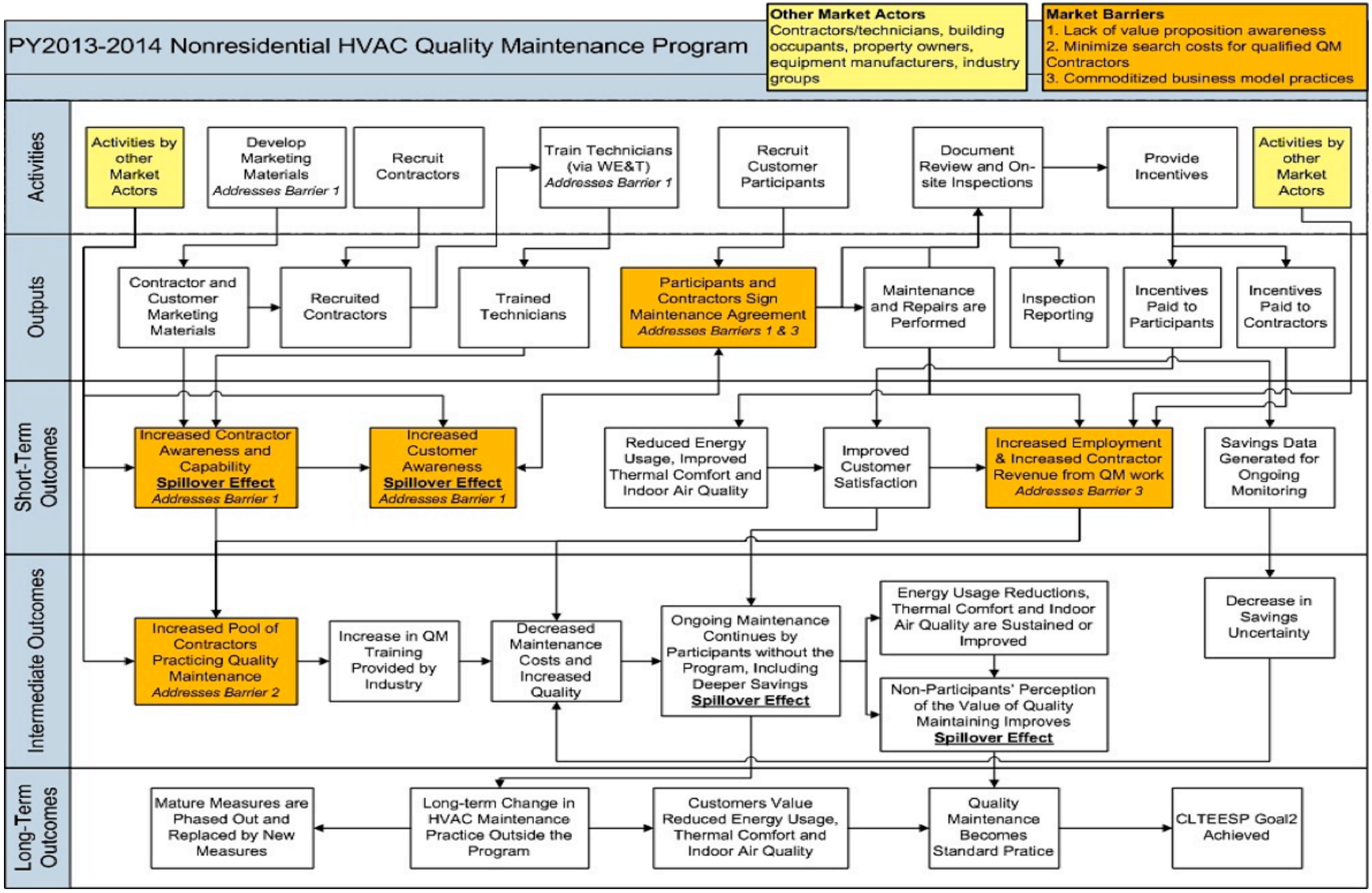
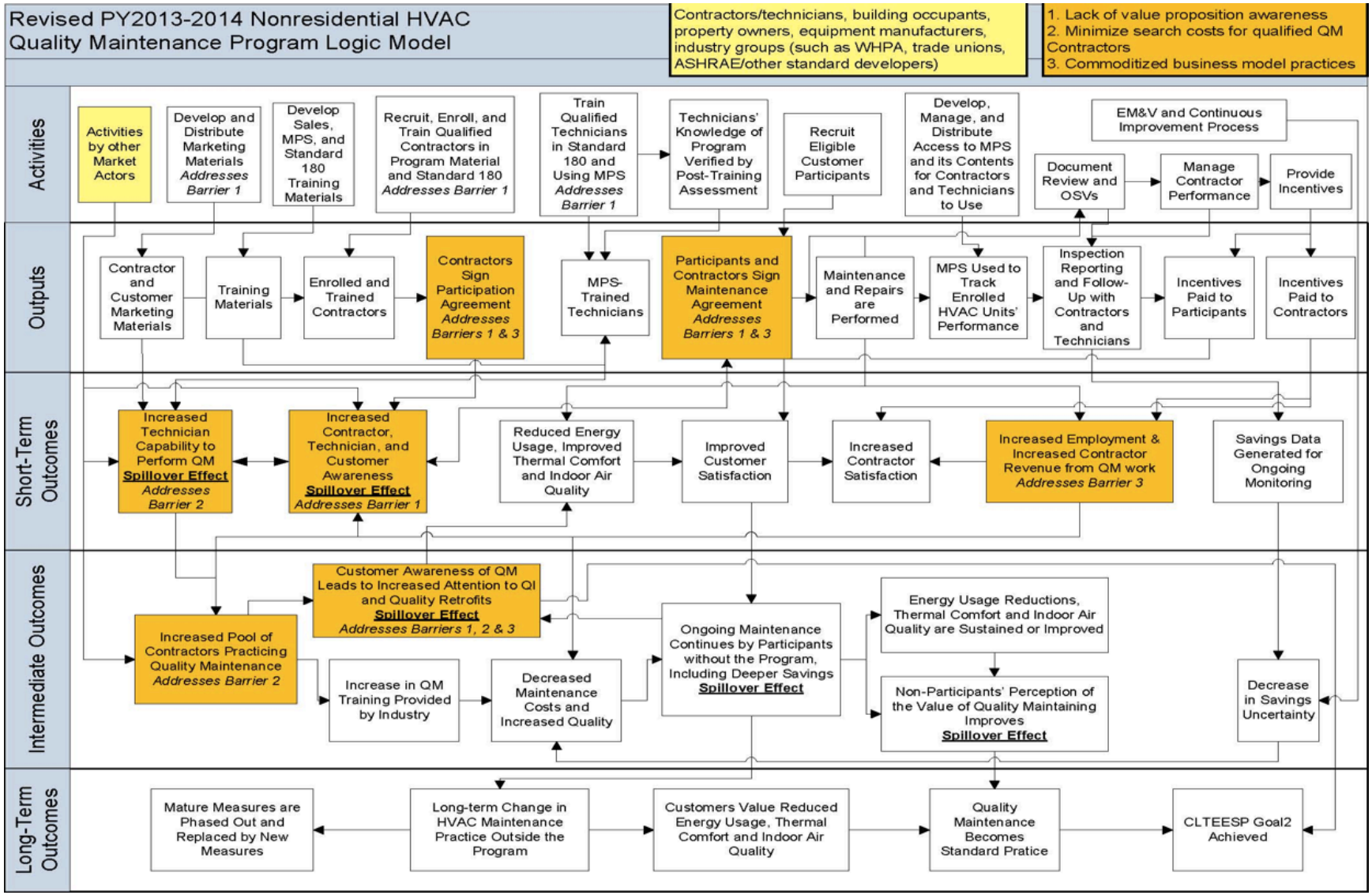


Figure 2.3: 2013-2014 Program Logic Model (Revised August 2013)



2.3 Findings about Program Theory and Logic Model

As mentioned above, the logic models help document the shifts in how the CQM program is conceptualized. In addition, there is a higher-order set of issues that EMI recommends addressing. After reviewing the logic models, staff interview notes, and contractor and technician interview notes, EMI found that there are some fundamental assumptions about how the program works that are still in question. These assumptions can best be described as elements that underpin the program's theory of *cause and effect (how it works)* as opposed to the logical flow of program processes (*how it operates).*

The CQM program was designed to change maintenance practices by creating demand for quality maintenance. The goal was to allow capable technicians sufficient time to do quality work, and therefore create demand for technicians with QM skills. Fundamentally, the program is based on the assumptions that (a) the program can accurately locate and select highly skilled contractors and technicians who, (b) are able to perform maintenance tasks using diagnostic tools that produce accurate, reliable results (c) according to Standard 180 guidelines in a way that will maximize energy savings. There are some assumptions embedded in the statement above that bear on the CQM program design that deserve exploration.

Accurate Selection of Highly-Skilled Contractors and Technicians

The most immediate assumption is that contractors and technicians with experience have the right knowledge, skills, and abilities to conduct maintenance in a way that will realize energy savings. This level of maintenance requires *knowledge* of Standard 180, competence in *how* to execute each step described in Standard 180, and ability to conduct the steps in the proper *order*. According to two Field Service Technicians (FSTs)[12], understanding how to do maintenance correctly requires understanding the principles of topics like airflow and refrigeration:

- "The theory is vital. That is what guys don't understand. [Without] theory, you are going to be lost. Starts from the beginning, [got to] understand the basics."
- "If you have a refrigerant issue, you can take out refrigerant or put in more, but that may not be enough to fix the issue. If [technicians] don't understand how refrigeration works, they can go crazy trying to figure out what will fix the issue."

As these quotes demonstrate, technicians need to understand fundamental HVAC principles or theory to understand why Standard 180 makes sense and why problems arise. This understanding is there for essential to enable them to solve problems that fall outside the confines of which to conduct a particular step of the maintenance process.

[12] "Field Service Technicians perform field quality control checks of work completed by HVAC Technicians," (HVAC Optimization Contractor Manual).

Previous evaluation findings[13] and staff interview findings point to a lack of consistency in the knowledge, skills, and abilities that experienced HVAC technicians have. This may be due in part to differences in technicians' training (e.g., independent apprenticeship, union apprenticeship, trade school, community college programs). Per one staff member's opinion, it may also point to a need for improved criteria for selecting contractors and technicians into the program. The current criteria are explained in the Contractor Recruitment, Training, Assessment and Removal section and the Technician Selection, Training, Assessment and Removal section below.

Accurate, Reliable Diagnostic Tools

There is an assumption that technicians have the right kinds of diagnostic tools and ability to use the tools appropriately to gather correct readings from customers' HVAC equipment. If they are not able to do this, the equipment may not be serviced appropriately and therefore may not reach its potential level of optimal operation and efficiency. As described by program staff, the program recently signed a contract with Field Diagnostic Services, Inc. (FDSI), to make FDSI's Service Assistant (SA) and Service Assistant Mobile compatible with the CQM program. Under this contract, SCE will fund user access to FDSI's service. As of August 23, 2013, SCE was negotiating a contract with Purdue University to evaluate Fault Detection and Diagnostic (FDD) protocols, including those provided by FDSI. In the meantime, it will be important to document which technicians are using which FDD protocols s for which maintenance activities. In the revised logic model, this provision would be best categorized as falling under the activity "Develop, Manage, and Distribute Access to MPS and its Contents for Contractors and Technicians to Use." However, the program could consider revising this language to more accurately represent the provision of other tools besides the MPS. The SCE Program Manager described the integration of FDD in the CQM program in the following way:

> "The CQM program strives to continuously improve both the protocols and tools that are available and/or required to be used by technicians. The MPS update in early 2013 includes a built-in fault detection protocol based on a combination of the methodologies presented in ASHRAE TRP 1274 and Title 24. These sources were used as the basis of the FDD protocol because they are open and publicly available. The MPS uses the protocol to establish default targets and ranges for refrigerant temperature and pressure and air temperature performance indicators. The MPS provides feedback to the user if measured values are above or below the acceptable range. Technicians may customize the target and acceptable range for most metrics. Technicians are responsible for diagnosing and remediating faults per Standard 180 and the manufacturers' recommendations. If there is no access or manufacturers' service recommendations available, the technicians are required to use the MPS tool and underlying protocol in an effort to provide suggestive guidance that may be used at the HVAC Contractors. The only discretion allowed is to utilize the manufacturers' service procedures or MPS. In both cases the data is required to be entered into MPS to ensure QA/QC requirements are met. The MPS is a software-only tool, so technicians must supply and correctly use appropriate and properly calibrated

[13] See "HVAC Educational Needs Assessment," submitted to SCE on October 12, 2012, and "California HVAC Contractor & Technician Behavior Study," submitted to SCE on September 14, 2012.

measurement hardware. The effort to make FDSI SA compatible with the MPS will provide to technicians an option to use a superior tool for FDD. The FDSI SA tool and underlying protocol are widely regarded as the premier solution for in-the-field RTU diagnostics. The FDSI SA tool may be used as either a software-only tool or integrated with FDSI measurement tools to provide direct upload of measured values. Compatibility with MPS will enable data from FDSI SA to be directly uploaded into the MPS to fulfill program requirements and facilitate incentive processing and savings claims. This will eliminate duplicative entry into the FDSI SA and MPS, and would eliminate data entry for this aspect of FDD entirely if the FDSI measurement hardware is used. In summary, technicians will have three options available to them for properly detecting and diagnosing faults in the program. They may:

1. Utilize the fault detection protocol that is built in to the MPS,
2. Utilize the manufacturer's fault detection protocol by entering their own targets and ranges for performance metrics,
3. Utilize the FDSI SA tool and protocol.

The program will document which of these three methodologies are used. While they are all offered, [we] will take steps as necessary to expand or contract the options for FDD. In the future it may be necessary to differentiate, with incentives offered and savings claimed, between basic FDD with simple protocols and tools and advanced FDD with advanced software-enabled algorithms integrated with purpose-built measurement hardware. The evaluation of the protocol used by MPS and the FDSI protocol by Purdue researchers would provide an unbiased performance benchmark for the two protocols, which could also be compared to the recently benchmarked Title 24 RCA protocol. This would allow utility programs to make informed decisions about which protocol(s) will result in reliable FDD, and will provide insights about what aspects of the currently available protocols need to be improved. This project would only evaluate the protocols, not the tools used to implement those protocols."

Application of Standard 180 and Energy Savings

The final part of the assumption above is that correctly following the steps of Standard 180 will lead to energy savings. Standard 180 was approved by ASHRAE in January 2008, and by ACCA in February 2008. Standard 180's purpose 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*." The Standard provides lists of maintenance tasks but stops short of defining how the tasks should be conducted. There still remains industry disagreement regarding if conducting maintenance according to Standard 180 will necessarily lead to energy savings. It is not clear if this disagreement is evidence-based or opinion-based. Either way, it will be important to test this assumption in the field by documenting *whether or not* energy savings were realized, as well as *how* the maintenance was performed and *the extent to which* Standard 180 was followed.

The majority of interviewed contractors and technicians indicated that they believed the program resulted in energy savings. One contractor pointed to the example that he has a

customer (a multi-billion dollar retail company) that had no maintenance program prior to participating in the QM field study. Through the program, the company, "found that maintenance pays," and now is participating in this program. With the exception of one technician, energy savings were especially emphasized if units had economizers. As one contractor summarized, "Economizers will get the most energy savings."

Contractors and technicians also discussed some of the mediating variables to realizing energy savings. One technician pointed out, "[it] depends a lot on air balance. With older restaurants, [we] don't know the condition of all the duct work which is an issue to saving energy." Another contractor is installing meters on every unit in the program to determine if quality maintenance results in energy savings. Another technician shared his belief that the most effective tactic to reduce energy is to ensure, "what controls the unit is working appropriately – turning on 30 minutes before occupancy and 30 minutes after. That is the biggest key from what I have run into. Coil being cleaned and belts/filters being changed makes it run more efficient but it isn't a huge drastic change as compared to making sure it runs when it needs to run." Another issue discussed by many of the interviewees is the temporal factor regarding energy savings. As one contactor described,

> "Maintenance pays over time. Need to optimize performance – need to do everything you can to the unit. Maintenance piece is [a] sustainability piece. Take [the unit] to the highest peak performance, then maintain [it]. It takes customers a year and a half [to] two years to see differences. Three years is a big barrier but very important."

Contactor and Technician Awareness of Standard 180

All of the contractors and technicians interviewed said they were aware of Standard 180, with the exception of one contractor. One technician identified that while he was aware of the Standard, he did not have a thorough understanding of it. This technician described his awareness this way, "I have heard of [Standard 180]. If you gave me a ten-question test with fill in the blanks – I wouldn't pass it. I never studied 180. It did come up in apprenticeship but it was just mentioned here and there." Nine of these contractors and technicians had prior knowledge of the Standard through industry association meetings such as ASHRAE or ACCA and through company discussions or training. One of these contractors indicated a large international customer brought the Standard to their attention. The remaining four contractors and technicians heard about the Standard through a focus group conducted to vet the program theory or through actual enrollment in the program. The SCE Program Manager noted that in order to participate in the CQM program a contractor must pass an exam explicitly based on Standard 180; it is an open-book test that requires the contractor to have a copy of Standard 180.

Contactor and Technician Opinions of Standard 180 and Impact on the Future

All of the contractors and technicians who were aware of Standard 180 indicated that the Standard was positive and that it, "represented what good maintenance should be." A number of interviewees indicated that having an industry-wide standard is important as it enables customers to compare apples to apples when considering different maintenance offerings, promotes energy savings, and drives higher quality work. As one contractor

described, "[it is] good to have a standard for everyone to shoot for." Another technician noted,

> "Standard 180 makes a notable change in the quality of the work conducted and is a great way of saving energy."

It is interesting to note that contractors and technicians did not separate Standard 180 from the MPS tool, which according to the SCE Program Manager, "operationalizes Standard 180." Thus, when talking about Standard 180, many noted the following drawbacks: it is too involved for most customers' needs, there is time-consuming data entry, and there is a negative ROI working on smaller units. The following quote from one contractor expresses some of these concerns:

> "I keep a copy of Standard 180 on my computer wherever I go. It is overkill for most clients. It is too much. Filters, belts, check temperature split, check charge once a year, if in valley where it is hot, check charge twice a year to adjust for seasonality, check electrical components, [check] motor amperage, everything else doesn't really matter. Shouldn't have to check 100 things on a package unit. It is just wasteful. Standard 180 was written by engineers, not written by people who do the work. Engineers don't fix things, they design things. They over-design the job so no one can come back to them and say they didn't know anything or they made a mistake. Most systems are 10 to 20% over-designed—more HVAC than you need. Standard 180 is great but not realistic."

In the quote above, the contractor stated that he believes HVAC systems are designed to provide more heating and cooling than needed, and thus suggested that Standard 180 may be an unrealistic goal for "over-designed" systems. Another contractor said,

> "On smaller units, testing refrigerant and putting in gauges is overkill. Paperwork is overkill. The number of questions is overwhelming. We spend more time on paperwork than on the unit."

Without being prompted, four contractors noted that given the paperwork requirements and incentive levels, the program was not worthwhile for smaller units. When asked to define smaller units, three of these contractors provided the following responses: 20 tons and less, under 10 tons, and 5 tons and under. One contractor noted, "[The program is] not worthwhile for the smaller units. Paperwork time doesn't justify incentives received." Another contractor stated, "Little jobs are not worthwhile. Smaller tonnages with less equipment are not as attractive. Pay back is not as nice. Smaller units don't have economizers."

All contractors indicated that they saw the full Standard 180-based maintenance as a premium service. One contractor explained it this way:

> "Yes, it is premium. You get more time to do it. We get a checklist of what we do. In regular maintenance contracts, customers pick what tasks and frequency they want done. For example, not clean coils but change filters. [Prior to program participation, one company] only washed coils once a year and changed filters every 3 months. With the program, we can do much more—replace belts, pulleys and clean and fix economizers. Normally without the program, you couldn't do this. We get more leeway on the money they let us spend on their units. "

This contractor also noted in the above quote that the program allowed him the ability to fix more aspects of the HVAC system than he otherwise normally would.

The majority of contractors and technicians indicated that Standard 180 will remain a premium service for the foreseeable future, although a few indicated that it could become the norm eventually. One contractor stated, "I wish this type of maintenance would be the norm for the industry. It is all driven by money. I don't expect it to become the norm." Multiple reasons—which echo barriers the program seeks to address—were given for this opinion, including: (1) Standard 180 service was cost-prohibitive to smaller companies, (2) there was a lack of customer awareness of Standard 180, and (3) customers not understanding the value of Standard 180 service as compared to very basic maintenance. As one contractor pointed out,

> "I don't see it becoming a standard as there are too many smaller mom and pop shops [that] don't want to spend a lot of money. If an HVAC company offers a minimum service based on Standard 180—there will always be companies that just want the basics. Standard 180 is too pricey."

Another contractor noted,

> "This program is an upgrade to get clients to do this maintenance. One company wants to provide this scope [type of service], when another contractor is coming in at half the price. Customer doesn't see the difference in scope." Another contractor stated, "It has potential—not enough people know about it right now." He went on to explain that continuing to market to the customer is essential to transform this market, noting the value of the utility doing this marketing as an independent, neutral third-party.

One contractor who believed that eventually Standard 180 would be considered the benchmark for quality maintenance explained, "When electricity rates go up, they will be forced to do it. Eventually it will be all that way. A lot of advancement is occurring in the controls industry. A lot of these units will be controlled by control systems. This is the solution, instead of data entry and trying to monitor the equipment." Another contractor who also saw the potential for eventual market transformation pointed out, "I think it can change over time. There is a market for it. There needs to be more utility marketing and push from the utility side to keep bringing this to the customer side. If multiple people are telling them, it becomes more of a reality."

Contractor Maintenance Offering Differences: In the Program vs. Out of the Program

The WO32 memo states "Interim field observation results indicate that 85% of technicians currently perform maintenance measures in the program in the same way they did prior to

enrolling in the program."[14] When EMI spoke with contractors regarding the differences between contractor maintenance practices inside and outside of the program, EMI found a more nuanced explanation. Seven out of the eight contractors interviewed indicated that their standard maintenance offering was similar to that recommended by Standard 180 and the Program. Two contractors indicated they not only followed Standard 180 but also often exceeded it. However, when prompted to consider how the offerings were similar or different, contractors and technicians provided responses that centered around four themes: time spent, thoroughness of service, documentation, and customer relationship. Below are some quotes that illustrate these themes:

> "We always had a comprehensive preventative maintenance program [although we were] not aware of 180. [We were] maintaining or exceeding Standard 180. Program helped us document this a little more and helped provide techs additional training. [We] didn't do sub cooling on most of those units. [We] pay more attention to economizers now with the Program.
>
> "Time is an issue. We do the same things but the amount of time spent differs. Through the program, I take the entire unit apart. I have time to do a much better job than I normally do. For cleaning the coil, you wouldn't take it apart in the normal service. I would just take the top and doors off and clean the coil. Regular maintenance, I would open the sides and clean the best I can. Time is the big issue. With program, [I can] do maintenance thoroughly."
>
> "The process is different. The tasks are the same, but we are not tracking and doing data entry. Don't do in depth refrigerant check—not checking super heat. Airflow is not checked. Test in and Test out is not done. We will note economizer not functioning but do not do the repairs. We don't wait for customer approval to do coil cleaning, filters, etc."
>
> "Very similar but a lot more in-depth information with program than [our] traditional [offerings]. We make sure economizers work, but do not do rigorous testing for performance. "
>
> "If we have the existing relationship and trust is built, we do that level of maintenance. In competitive situations, we are trying to implement this program while it is cheaper (i.e., while we can take advantage of the incentives to sell the premium service)."
>
> "We offer maintenance programs already based on standard 180—what we already offered includes even more detail than the program. Our project management scope is already based off of Standard 180. The program does not differ. The big difference

[14] Footnote from the WO32 Memo: "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 (i.e., coil cleaning, adjust airflow, refrigerant test/service, economizer test/repair, adjust/replace thermostat, or notched v-belt)? (Yes, No)" 1) Yes, since 1958, 2) Yes, since 1998, 3) Yes, for years with major accounts, 4) Yes, for 35 years, 5) Yes, been doing similar work since 2009, 6) Yes, for 30 years, 7) Yes, for 41 years, 8) Yes, since 2002, and 9) Yes, for more than 60 years. One participant provided the following response. "EMS installed in 2005 communicates and controls thermostats and economizers and receives diagnostic error codes (airflow, static pressure, compressor/motor faults), notched v-belts installed since 2008, coils cleaned with chemicals and power washer every three months since 1998, multi-layer air filters changed every three months since 2008."

> is the documentation. Techs would just write the detailed service report outside of the program. They would not answer 300 questions."
>
> "Maintenance is not being done as well without the program. [The] intervals at which maintenance is performed is not enough. [In the program, maintenance is done] quarterly as compared to annually or every six months.] Boilers and other equipment [that are under maintenance contracts with our company] are being neglected since we use so much time on the program itself."

In the quotes above, it is important to note that while most contractors mention that they have maintenance plans that cover most of the tasks listed in Standard 180, price competition or lack of time typically drive them not to perform certain tasks, or not to perform tasks with the same quality. Contractors differ in which tasks are normally not attended to as thoroughly as they are when they follow the program. In short, the program ensures that they have time to do a more thorough job, and to be able to document this for their customers.

One contractor indicated that his typical maintenance service offering was very different from that required by Standard 180. He described his typically compressed maintenance plan this way:

> "My basic maintenance offering that I sell all the time is 20 minutes. Moving this to 1 hour and 15 minutes doesn't pay. Customers would pay 2.5 or 3 times as much than basic maintenance program. Half of that time is spent filling out the paperwork—customer is not seeing value from the paperwork…Program doesn't make sense for 5 ton packaged units or below. …. [You will] burn it up in the first maintenance visit. Customers do not want to pay $600 per year a unit. They want to pay for a 10-minute visit to change filter—really cheap guys. Many customers pay $20 to $30 a unit a year for maintenance."

An important take-away from the quote above is the large difference in price between a quality maintenance plan and his normal offering. Speaking to the difficulty of translating the value proposition for customers, this contractor believes his customers would not see the value, especially for 5-ton or less packaged units. This may point to an important question for the program to address: How can the program attend to this challenge of contractors and customers enrolling some of the customer's rooftop units in the program and not others? As noted by one member of the impact evaluation team, not all units on a customer's building are required to be included in the program.[15] Not enrolling all units on a roof could leave potential energy savings untouched or may not account for really problematic units that will never perform at baseline.

[15] The program does not currently require all units to be enrolled in the program.

3. Program Processes

This chapter describes seven program processes, each represented by a section of the chapter:

1. Contractor recruitment, training, and assessment
2. Technician selection, training, assessment, and removal
3. Customer recruitment, enrollment, and initial unit recovery
4. MPS tool
5. Baseline
6. On-site verification
7. Incentives

Each section includes a process map, highlights key aspects of the process, provides feedback from program staff, program implementation staff, contractors, and technicians, and describes the evolution of the program process over time.

3.1 Contractor Recruitment, Training, Assessment, and Removal

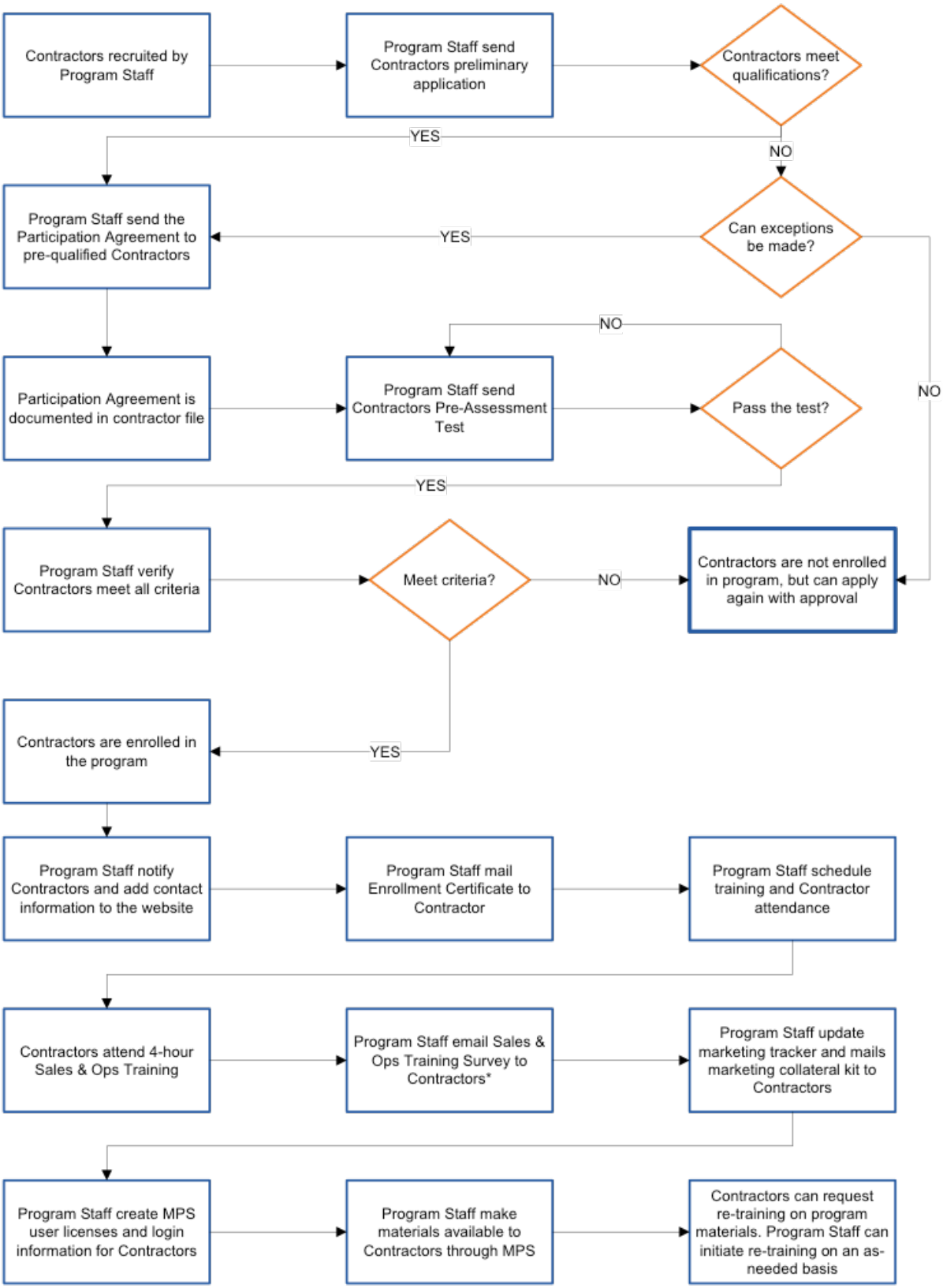
The first critical program activity is the recruitment of contractors to participate in the program, followed by the steps involved in enrolling qualified contractors and training them on program processes. Figure 3.1 below provides a detailed illustration of the steps involved in the processes surrounding contractor recruitment, training, and assessment.

Contactor Recruitment

As Figure 3.1 indicates, the process of initiating program involvement with contractors begins with the active recruitment of contractors. Contractors are recruited through existing relationships that SCE has with them through other programs, as well as through program implementation staff's outreach efforts at targeted events, such as meetings with unions, WHPA meetings, industry conferences, and trade shows. According to program implementation staff, they were directed by new SCE leadership to stop active recruitment of contractors in March 2012. They have not actively marketed the program since then. The Senior Program Manager said that the program has grown organically through program staff's and program implementation staff's personal networks, word of mouth, and as a result of one contractor aggressively pursuing its competitors' customers.[16] Additionally, customers asked their existing contractor to participate in the program, representing some customer-driven demand of the program. If the contractor fails to apply for the program, the contractor risks losing customers to a more aggressive competitor that is already participating in the program.

[16] The Senior Program Manager indicated that contractors who aggressively pursue competitors' clients is more the exception than the rule.

Figure 3.1: Contractor Recruitment, Training, and Assessment



Of the contractors interviewed:

- Three indicated that they were actively recruited by PECI;
- Two learned about the program from customers interested in the program;
- One heard about it from word of mouth and called PECI to inquire about the program;
- One was involved in the program from the time of initial program design; and,
- One did not recall how they heard about the program.

Contractor Eligibility Requirements

Once interested contractors have been identified, program implementation staff sends a preliminary application to establish a first touch point with the contractor. The application seeks to understand their firm's business and to determine if they are qualified for the program. In order to participate in the program contractors must meet the following criteria stipulated in the Contractor Participation Agreement (CPA), Exhibit D, pages 11-12:

> "The Contractor shall demonstrate a minimum of five (5) years experience in the commercial mechanical temperature control business by submitting copies of state and local licenses and certificates. The Contractor shall have no unresolved claims with the Better Business Bureau."
>
> "The Contractor shall be fully licensed, as applicable, and with a minimum of a C-20 license. Contractors must be insured to do business at SCE customer's sites, in order to provide complete service."
>
> The Contractor must employ "at least one (1) full time professional who has an engineering degree or at least 10 years experience in the field of refrigeration, boilers, and pneumatic, electric, and electronic controls." The Contractor must also "employ a minimum of (3) full time, HVAC service technicians," and up to five technicians per contractor firm can be enrolled in the program unless SCE pre-approves additional technicians.
>
> "Contractor applicants must take and pass an open-book, online exam about the content of ANSI/ASHRAE/ACCA Standard 180-2008 as a requirement for Program enrollment." The exam was created in collaboration with the HVAC Industry through Contractor Forums.

The program provides some flexibility in meeting these requirements. Program implementation staff work with contractors on a case-by-case basis by conducting interviews and website reviews to determine eligibility. At this point in the recruitment process, contractors can be removed from the program if the contractor does not meet certain criteria. Program implementation staff adheres to some criteria more stringently than others. In many cases, contractors who are not admitted did not meet the requirement that each firm have at least three technicians. Overall, the Senior Program Manager estimated that roughly one-third of interested contractors were enrolled.

The majority of the contractors interviewed in this study noted that the program enrollment process was very time-consuming. However, three noted that this was appropriate, "to make sure contractors are qualified." Two contractors indicated that they believed the enrollment

process needed to be more stringent, with one stating, "Too many people got involved that should not have been involved. This dilutes the program for the customer." Another contractor shared a similar sentiment:

> "[We] need to have a strategy to keep people out who are just chasing rebate dollars. Within the first six months of the program there was a contractor let into the program who was on COD with suppliers and hiring techs that were near convicts. I asked: Why did this happen? We were told that you (PECI) did financial checks, reference checks, and maintenance checks. I asked: How many references did you check? [A program implementation staff member][17] said none. [This staff member] then said 'you don't think they would lie do you?' Another contractor indicated that he referred a friend of his who is a general manager of a company back east who is opening a branch in the area to the program. He indicated that 'they won't let him because of the numbers of years experience in [the] SCE [territory].' I was happy to see that as it indicates program entry is more stringent again."

The Senior Program Manager concurs that it can be difficult to keep out contractors who are rebate-chasers or have reputations for committing fraud. However, the Senior Program Manager states that PECI conducted reference checks for all contractors, with the exception of the three contractors who were part of the contractor forums and helped to design the CQM program. Early in the program, program implementation staff was not empowered to remove or reject a highly problematic contractor who, according to the Senior Program Manger, verbally threatened program implementation staff and may have committed fraud. Program implementation staff was also not empowered to reject a contractor firm that submitted falsified technician documents during their original period of enrollment and was allowed back into the program. Program implementation staff members are continuing their effort to prevent another contractor firm from entering the program because the firm is a known rebate chaser and is suspected of committing fraud in other programs.

The program has an escalation policy dated November 2011, that provides guidelines for removing a problematic contractor or technician based on work that fails to meet program guidelines. The policy is described as a "four 'strike' process" that requires documentation of a contractor's or technician's failure to comply with the program and the program's response. The program's response escalates from communication to warnings and mandatory retraining, to probation to expulsion. The policy covers the technical quality of the work, but not standards of professional behavior.

Contractor Training and Assessment

Once qualified contractors have proceeded through all of the enrollment steps (provided in more detail in Figure 3.1), contractors are required to attend the Contractor Sales & Operations Training provided by PECI Account Managers and the Contractor Communications Manager. Table 3-1 below provides some key information about this training.

[17] Name was removed to protect identify of individual.

Table 3-1: SCE CQM Contractor Sales and Operations Training

Objectives	• Educate contractors on Standard 180 • Provide context of program history to contractor • Set goals and objectives for contractors in relation to the Program • Foster a relationship between program implementation staff and contractors • Equip participating qualified contractors with marketing tools to engage customers and set up both parties for long-term success
Training Topics	• Context of the program (e.g., current state of the HVAC industry, California's Strategic Plan, Standard 180) • Value proposition • Program processes • Incentive overview • Sales strategies and talking points • Workflow process • Web-based software
Training Format	• 4-hour in-person training • Sales Operations and Training Survey emailed to contractors following the training, which assesses basic knowledge of the program and the quality of the training
Point in Process	Directly following contractor enrollment in the program
Number Trained as of June 4, 2013	51

Following the Sales & Operations Training, program implementation staff sends contractors an open-book survey to assess the attendee's level of comprehension of the topics covered in the training (see Program Evolution section for recent update to this task). Finally, program implementation staff provides contractors access to MPS resources and send marketing materials on the program so contractors can be prepared to sell the program to customers.

Of the eight contractors interviewed, five attended the contractor training. Of the three contractors who did not go through training, one indicated he received training from PECI staff one-on-one. One contractor indicated that someone else on his staff went through the training, while the final contractor did not have to attend the training or take the assessment as his firm was grandfathered into the program. This grandfathered firm was the sole pilot contractor for the field study in 2010 that led up to the program launch, and was the first contractor to be able to sell the program and sign up the first few customers in 2011. PECI staff indicated that the contactor who participated in the field study did participate in the first sales and operations training with the other contractor forum participants on August 23, 2011. Contractors did not have much to say about the contractor training or the assessment. The contractors who indicated they remembered details about the training described the training as sales and program training as opposed to technical and skill training. One contractor explained, "They came to our office and trained us. Training included what the program is about and what you need to do to qualify. They explained what the program is all about and the goal that they need

to achieve. I took the 180 test. It was worthwhile. In some respects it was a little eye opening. Some of it is what we did, some was a bit more stringent." Many of the contractors indicated they remembered taking the assessment, but the majority indicated they did not remember anything specific about the assessment. One contractor stated, "We had to take a test. It was a good idea. It was based off of Standard 180. I don't remember it being hard."

Evolution of Program Processes

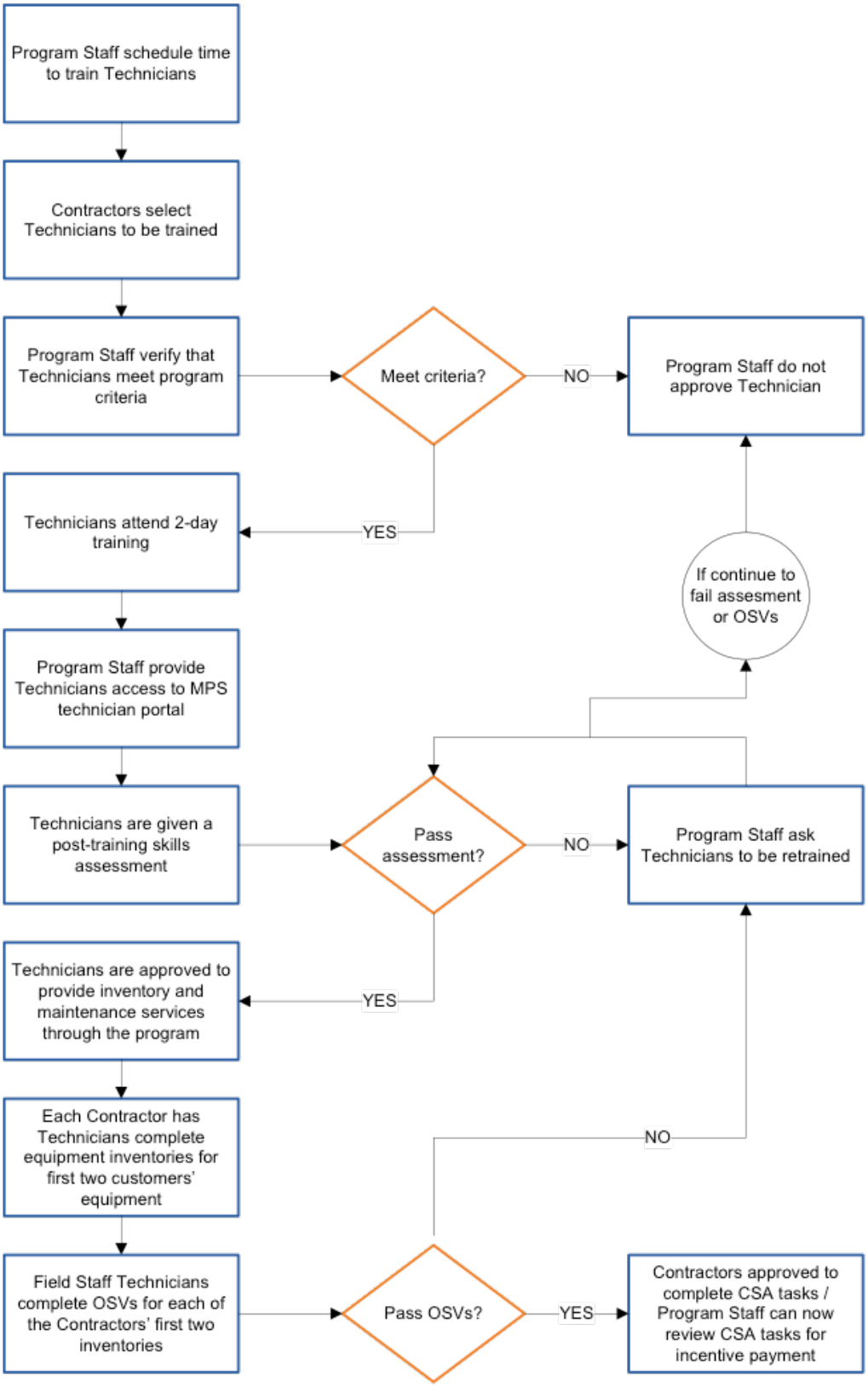
In the past year, the program made several changes to the Contractor Recruitment, Training, and Assessment process. Some of the changes were verified through document review, and some are recent decisions that have not yet been fully implemented. In June and July of 2013, the program hired an additional account manager and worked on improving consistency across account managers' approaches in order to reduce confusion among and improve support for contractors entering the program. This evaluation did not test the effectiveness of these efforts with contractors. In August and September 2013, the program plans to update the sales training presentation to help sales people better convey the value of QM to potential customers.

The program made recent changes to the contractor assessment process. The first Sales and Operations training survey was sent in October 2012. It was originally designed as a survey that would be sent immediately following the training to assess contractor's comprehension of topics covered during the training. There was an internal misunderstanding among program implementation staff and they did not send the survey to contractors trained after October 2012, and before August 2013. This mistake was identified after reviewing documents for this process evaluation, and program implementation staff sent recently trained contractors the survey in August 2013. The Senior Program Manager indicated that as of August 22, 2013, the original policy of sending the survey out immediately following the training will be observed.

3.2 Technician Selection, Training, Assessment, and Removal

After contractors are enrolled in and trained on the Program, the Program focuses on training technicians who will be providing maintenance services to customers. Figure 3.2 below provides a comprehensive review of the steps involved in the selection, training, assessment, and removal of technicians.

Figure 3.2: Technician Selection, Training, and Assessment



Technician Qualifications

During the enrollment process, contractors provide technician names and qualifications. As described on pages 11-12 of the Contractor Participation Agreement (CPA), technicians are required to have all of the following:

> "A minimum of 2 years Heating, Ventilation & Air Conditioning service experience."
>
> "A Universal EPA license, refrigerant Transition and Recovery Certification, Class II or Universal, as required by 40 CFR Part 82, Subpart F, and a current certification issued under a Program approved by the U.S. Environmental Protection Agency."
>
> "Hold either appropriate certification from one of the following recognized industry certification bodies: UA STAR, NATE, HVAC Excellence, RSES, NCI, NEBB, TABB, or an equivalent that has been pre-approved by SCE (please contact the Program for pre-approval), **OR** have an HVAC Technician Certificate from an accredited HVAC vocational training program or school."
>
> "Maintain compliance with any and all required License or Code requirements as specified by the governing jurisdictions where work will be performed."
>
> "The service technicians assigned to maintain mechanical systems will be qualified to service the equipment type under contract as well as associated pneumatic, electric, and electronic controls."

Program implementation staff is able to approve or reject technicians based on the documentation provided by contractors. The years of experience of the five technicians interviewed ranged from 8 years to 13 years. One contractor felt that the qualification for the technicians was too demanding. He noted, "They want NATE or two year college. This sounds reasonable, but NATE is typically for residential and we deal with commercial." This contractor went on to explain that his firm had extensive internal training and that it would be very disruptive and time consuming to get their training approved as a replacement for the program requirements. Thus, "All the techs have to scramble around looking for certificates, degrees, transcripts, etc., so they could become certified to work in the program. If the program were more open in the process, we could get hundreds of technicians certified to work in the program. NATE certification limits us." Another contractor felt the required training was an added benefit. He said, "Yes, we didn't have the training but went through online training to get certified. This was a good investment."

Technician Training

A two-day training is required for all technicians that are approved by the program. Trainings begin once a contractor recruit his first customer, so that training coincides with the technician's first hands-on experience with the program activities. Table 3-2 below highlights the key components of the technician training.

Table 3-2: SCE CQM Technician Training

Objective	• Provide hands-on rooftop training for performing unit inventory and inspection tasks using the program web app • Ensure technicians have the necessary program material needed to comply with the program requirements
Training Topics	• Standard 180 • Program processes for technicians • The MPS system and how to enter data • Troubleshooting issues with equipment
Training Format	• 2-day training, with one day of classroom training and one day of one-on-one rooftop training • Sometimes the rooftop training can be completed to coincide with the contractor's first customer inventory • The technicians must pass an in-person post-training skills assessment
Point in Process	Once contractors have selected three technicians to be trained (typically during the initial application process), and program implementation staff has verified that they meet program criteria, program implementation staff contacts technicians to schedule time to train them before their first inventory and after they have submitted their first signed Maintenance Agreement.
Number Trained as of June 4, 2013	146

All technicians interviewed indicated that the program technical training consisted of an in-class session followed by a skills assessment on the roof. The in-class session focused on the program and Standard 180. The on-the-roof session discussed the mechanics of using the MPS tool on the roof and how to effectively enter the appropriate data. These descriptions for both parts of the technician training were consistent across contractors and technicians. All contractors and technicians indicated that none of the training was technical in nature. As one contractor described, "[the focus of the training was] how to navigate the optimization website. They went through every single question and told us how to answer each question based on the different scenarios you see in the field. No training on how this is how you do air conditioner maintenance. The program wants trained folks who already know how to do maintenance, how to do Superheat measurements." Another technician described the training this way, "[The] most important thing [in the training] was the requirements of Standard 180. It was good training and very basic set up. It was very easy if you have a good AC and refrigeration background, no problem. They are not teaching us how to do it. I already know how to do these things. Not teaching how to do it but what to do." This finding is also consistent with the WO32 Memo, which states, "Observations of training classes indicate that the programs provide training on how to enter data into the program database, but do not provide sufficient training on tool specifications, diagnostic protocols, or feedback for technicians to improve energy efficiency."

Generally, contractors and technicians valued the technician training. One contractor explained that technicians do not think about efficiency of equipment, and stated that both the training and the program were definitely sharpening their skills. One example this contractor provided was increased knowledge about how controllers interact with different economizers. Another contractor explained that, "[the training] was good for what is required on-site and what you have to differently [in the program]." A third contractor described one benefit of the training as helping technicians understand the value of the work they do in the program. This contractor explained that the training,

> "does not enhance our technicians' knowledge of HVAC. The training is very task-driven. What it all means, why we are trying to do it, what we are trying to do in the program—that is important. Complacency is an issue with techs. This [training] is good for the techs—what is the value and return of our efforts going in. I want to be able to share with the techs the energy savings so they can share with the customer. They see customers every day. They can take some pride in the work."

Another contractor explained that, "Training is a cost impact for us but if it improves the system, so we can be as efficient as possible, it is worth it." One technician also noted that the training on Standard 180 helped him in diagnosing issues in the field, stating, "Honestly, yes, [Standard 180 Training] has helped me. The units have to be running at full capacity [and] every single component has to be working. Taking the unit apart, you find other issues and you mess with all of the wiring. You really get to know the unit."

There were some concerns expressed regarding the number of trainings, the quality of the training, and the quality of the trainers. One technician indicated that he thought there were too many trainings; he stated that training is a "waste of time when you get too much training. At the end what makes a big difference is the important stuff to train on, not the paperwork." The contractor from the same firm also shared concerns about the quality of the training and the quality of the trainers.

> "There has been very little value from any of their [PECI] tech or contractor training events we have attended in the past. These guys—the trainers in the field— are not the best technicians. They are competent enough to look for abnormalities. When they train my guys on how the program works, my guys laugh at them. They fight with trainers. They are trying to turn my guys into box-checkers. They are putting the focus on boxes, which are making certain assumptions to validate accepted practices."

Improvements in the trainings across time have also been noted by one contractor, who said, "We have had two trainings—one for old portal and one for new portal. Yes, these are useful. The latest training was very useful. This last one was finally dialed in." Concerns about the content of the training and the quality of the training were also expressed by the WO32 Team, whose memo stated, "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."

Internal Company Training

Many of the contractors described their firm's internal training programs, with more than half indicating great pride in their approach. One contractor interviewed was unionized. He explained that, "all techs go through apprenticeship programs. Many continue their education at school." He also indicated they attend vendor training throughout the year. Another contractor explained that they "were in a different boat than everyone else. We keep our techs well trained and hire skilled techs. We have weekly breakfast meetings that involve safety training, and other training. All guys are NATE certified. We offer in-house classes such as compressor tear down. Vendors offer training as well which we send our techs to." A third contractor explained that his company's internal training consisted of, "VFD trainings and manufacturer trainings. When there are good ones, we do them pretty often—two or three times a year."

Additional Training Needs

A few contractors shared additional training needs with the interviewer. One believed that refresher training would be good given the many changes in the program. Another requested a sales training to help him better discuss incentives given that the contract stipulates that incentives are not guaranteed:

> "[I have] spoken to PECI to get more sales training. Our guys have been very successful. [The contract indicates that] incentives are no guarantee—we want to know how to best broach this topic. Is there a better way to convey that the customer will get these checks even with that language? They are supposed to come here to do this soon."

Program implementation staff indicated that they are planning additional sales trainings.

Evolution of Program Processes

There are several active and planned changes to the technician training that were discussed during staff interviews, but for which this evaluation did not receive corroborating evidence through documentation or data from participant interviews. According to the Senior Program Manager, in late 2012 or early 2013 the FSTs added to their technician training a skills assessment of the technician's ability to perform work on the unit. The Senior Program Manager explained that the FST would coach the technician if they were unable to pass the skills assessment. If, after the coaching the technician still could not complete the task appropriately, the technician would not be enrolled in the program.

In April 2013, the SCE CQM program implementers increased technicians' required number of years of experience from two to five and made additional changes to the training, including more instruction on how to do quality HVAC maintenance work. PECI also hosted a technician appreciation event on April 22, 2013, during which additional training on coil cleaning and other tasks were provided. At the time of the program implementation staff interviews in June 2013, the interviewed FSTs had not completed a training session with the revised procedures. Program staff and program implementation staff are also partnering with outside firms to develop additional skills trainings that focus on "how to do" the work

in addition to the program-specific "what to do" trainings. According to program staff, part of the revised training includes seven training videos that are posted on SCE's "It's About Q.net" website and were publicized in the May 2013, monthly newsletter. The Program Manager stated that improvements to the training class intend to help ensure that technician knowledge, skills, and abilities are visibly present. One FST described the situation this way,

> "[Technicians] don't have a problem with doing the work. They don't always understand what they are being asked to do—the terminology throws them off. Most of the techs—80% to 90%—are very fluent with their work … [but] some guys have been around for a long time and don't know how to do simple things."

It is important to note that the FSTs and program implementation staff recognize that most technicians enrolled in the program are able to perform the work well. That said, there is a strong interest in making sure all enrolled technicians are able to perform the work well and that is why training is under revision. A FST explained that the revised training is "going to try to establish some base level of expertise so that a tech knows why he's doing what he's doing." When asked if he felt training technicians on basic skills falls within this program's boundaries, the FST said he was not sure, but stated that they would try and address it nevertheless. He then made the following comparison:

> "It's like high school algebra. If they didn't get it then, they're not going to get it when they're 40 years old. If you know some basics, then you can go from there. If they are competent enough to work our program, then they can sharpen themselves, go to some workshops, and improve their understanding. My goal is to get them to understand what they don't know. I think we can make as good an attempt as anyone can make in the industry of trying to address the issue. "

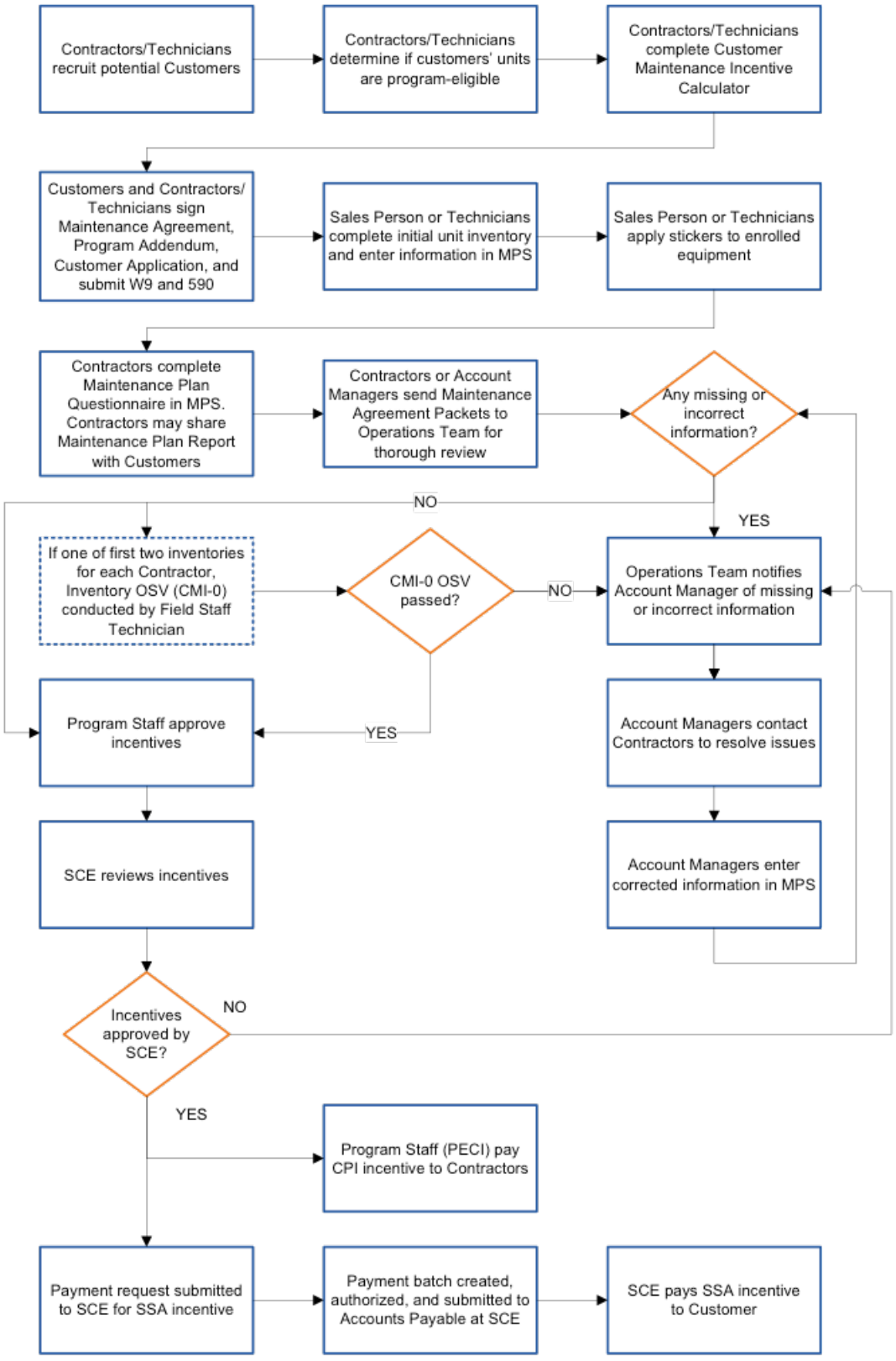
This quote summarizes a sentiment held by other staff: it is not clear whose responsibility it is to ensure that all technicians hold the same basic level of knowledge, skills, and abilities, and yet the program is taking steps to make sure its enrolled technicians understand the "whys" and "how to" of HVAC maintenance.

According to the SCE Program Manager, the program also put a mentorship program in place on July 30, 2013. The program created two tiers of technicians—Level 1 and Level 2—to allow less qualified techs to conduct, "work related to HVAC Optimization while under the direct supervision of a mentor that is a Program-approved Level 2 Technician," (see Appendix C: Level 1 Technician Application).

3.3 Customer Recruitment, Enrollment, and Initial Unit Inventory

Customer recruitment is an on-going process for contractors enrolled in the program, as the customer-facing component of the program. Though program implementation staff does not have much direct interaction with customers, they must complete tasks behind the scenes to ensure that the program is running smoothly. Figure 3.3 below provides a detailed account of the steps involved in customer recruitment, customer enrollment, and the initial unit inventory. Each step relies heavily on contractor, technician, and program implementation staff compliance with program processes.

Figure 3.3: Customer Recruitment, Enrollment, and Initial Unit Inventory



Customer Recruitment

Of the contractors interviewed, half indicated that they were involved in the customer recruitment process and the other half indicated that they had an account management and/or sales department responsible for selling the program to customers. In the latter situation, two of the contractors indicated that they may, "go along, if they need help explaining how the program works." In addition, all contractors indicated that they could call on PECI to accompany them on a sales call to answer program questions. Technicians reported rarely being involved in the sales process.

Of those that participate in the sales process, contractors emphasized that the message delivered was one of value as opposed to price. As one contractor described,

> "The sales staff is very well versed in what we offer and how we differentiate ourselves. Price difference and value differences can easily be explained. Discussing Standard 180 is a big part of the sales process. We are not the cheapest out there by any stretch of the imagination. We need to rely on the value we provide in our service."

It was obvious in the discussion that this was a source of pride for contractors and that they derived great satisfaction in offering quality maintenance through the program, as opposed to "drive-through maintenance," which plagues a segment of the industry. Program implementation staff, however, still recognize cost as a primary driver for maintenance contracts and hope that their revised sales training will help shift the sales discussion from cost to value for more of the contractor firms. It is important to note that a customer does not have to enroll all units in the program. As the SCE Program Manager noted, a customer may have limited operations budget and/or may want to prove that the program works on some units before rolling out to all units. There are also units for which replacement is a better option than a maintenance plan. These units may be recommended to the Quality Installation program.

Effect of Program on Contractor Business

The active contractors EMI interviewed generally believed the program was beneficial for their company. One contractor identified that the program was beneficial for, "customer and client growth, pull-through work, and increased maintenance agreements. There is not a lot of downsides if managed properly." Contractors also expressed that there is little margin in the actual program tasks but that the pull-through work from the repairs is what makes the program attractive. As one contractor described it, "Margins are not high, but that is not the way we go after it. We get the money through the pull-through work." Another contractor explained that the program has brought in $500,000 of additional work for the company. He stated, "[The program has brought in a] half a million in new business. It reduces the seasonality issues in this industry."

Contractors did indicate that due to program changes, they are losing money on the first enrolled customer accounts. As one contractor states,

> "Changes in [the] beginning of the year really threw a monkey wrench into our processes. Our biggest problem is we were given a scope of work in 2011 and sold that scope. In beginning of 2013, they completely changed everything, requires more time, additional visits, but we have already sold the original scope of project. This doesn't work. [This] added a whole other hour plus. Yet we are not compensated for this time. We are pretty close to losing money on these deals. This leaves us high and dry. We are scrambling and started screaming about it day one. They are making steps in the right direction and are getting closer and closer each month. We have committed to the customer to do these things, so we still have to do these things. I am questioning if we should have gotten in on the ground floor. I think it was still worth it. It was good to be ahead of the competition, but it came at a price tag. I wish they [had] been more transparent with these changes. I don't care if you (the Program) make a change but if we are accessing one portal that we worked out all the kinks and then it changes it is very frustrating. They need[ed] to grandfather in old customers with the old portal and then use new customers with the new portal."

All but two of these active contractors described maintenance as a predominant service and key to their company's revenue. Once contractor explained that, "Maintenance is our bread and butter." Another contractor commented on the importance of maintenance to ensure a steady stream of work, stating that,

> "Maintenance is the most important part of our business. With a nice maintenance base, the rest follows—service work, project work, etc. We do a lot of new construction. 50% of our revenue is from new construction, 50% is from maintenance. Our goal is build the maintenance base. Construction is up and down and maintenance is more steady."

One contractor who did not identify maintenance as at least 50% of the company's revenue indicated that, "Half of my company's revenue is service, 40% of that is preventative and full service maintenance. It is substantial to overall revenue." The other contractor stated, "maintenance programs are critical to fully utilizing service technicians labor when there are no service calls or projects. It makes up a third of my service revenue."

Active contractors were split about how they use the program to drive business. Half of the contractors indicated they sell the program to any customer, existing or not, that qualifies for the program. Interestingly enough, the other half of the contractors indicated they used the program to develop new business relationships and purposely did not propose the program to existing clients unless they believed they were in jeopardy of losing the client or if the client brought the program to them. As one contractor explained,

> "A lot of customers we can't normally get because we are so expensive. The incentives open the door to new customers. We don't bring program up to existing clients. If we are about to lose a client, we use this incentive to keep the client. If client asks about it, then we sell them the program. If we are about to lose someone because of price, we may pitch program."

The two enrolled contractors with no contracted maintenance agreements indicated they could not sell the program. One of these contractors implied that other companies were given an unfair advantage; he expressed his experience as,

> "I have been signed up since the beginning. I can't sell the program. We started off at a disadvantage. When they first invited us, Edison has already given 4 to 5 major HVAC companies a head start of 2 months. A lot of premium accounts were already taken. If I run into a large-scale customer like a school district or a large facility I try to sell it. I have 2 or 3 I am trying to sell to school districts right now. I just lost a mall since another contractor offered bigger rebates. [This opportunity] only comes around occasionally. I am not seeking out large customers. Only a very small slice of the market cares about premium service."

Initial Inventory

Most contractors reported that sales staff completes the initial inventory on a unit in the program, including capturing the model, serial number, filter list, number of compressors, etc. Two companies indicated that this model evolved over time; early in the program, the technician completed this task. Technicians indicated that the information noted by the sales representative in the MPS is often incorrect, such as listing the wrong number of circuits.

Technicians explained that sales staff often carries tool bags, but that sales staff, "often get lazy and do not open the panels." Since they do not open the panel, sales staff will go off the unit data tags if they are visible. Contractors said this approach is effective; however, if they are no longer readable, they, "guess or go off prior knowledge," which is likely the cause of the inaccurate information. Another technician indicated he did the initial inventory, describing it in this way, "I do the unit inventory—model serial number, filter sizes, belt sizes, walk around the unit, check exposed duct work, etc. First show up on the roof. Put stuff into tool - cooling capacity, SEER, model number, economizer, refrigerant charge, etc. To input all info, it takes 20 minutes for a single unit."

Evolution of Program Processes

On the backside of the customer enrollment process, the program made a few changes in the past year that affected administrative processes. According to program implementation staff, in April 2013 the program changed the format of the Service Account Validation Tracker to make it easier to copy and paste information between the MPS and the tracker. In May 2013, the program consolidated incentive application forms.

In August and September 2013, the program plans to make several improvements related to securing customer incentives and reporting information to the customer. The program plans to develop a process for dealing with contractors that have been inactive in the MPS long enough that customers are at risk of losing incentives. It is also planning to integrate the Early Retirement program to allow this program's contractors to take advantage of reduced costs of new units.

3.4 MPS Tool

Since the MPS Tool is the tool by which Standard 180 is operationalized, program staff views it as the heart of the CQM program. The MPS appears multiple times in the activities and outputs of the logic model as the tool that technicians are trained to use to guide their work,

record customer unit information, receive guidance on needed maintenance tasks, and develop reports documenting energy savings for customers and the program. The MPS plays a role in most processes mapped in this evaluation report, including contractor and technician training, documenting the initial unit inventory and baseline measurements, and receipt of incentives.

The program implementation staff launched the original MPS in 2011, and has since made routine adjustments to the tool. The most significant modifications occurred with the rollout of the Enhanced Question Bank in February and March of 2013, and subsequent revisions in June 2013. This section describes key aspects of the MPS tool and important changes made over the course of the last year. While it was out of scope for this evaluation to conduct software usability tests of the MPS with technicians and office staff, key utilization issues are noted.

Question Content, Question Order, and Changes in the MPS Tool

The program has instituted many upgrades in the MPS Tool throughout the program (for a complete list of changes, see program implementation staff's August 13, 2013, memo titled "SCE HVAC Optimization Program Improvements March – August 2013"). Most contractors and technicians acknowledge that these upgrades, while challenging from a process perspective, were helpful. Most interviewees pointed to the March 2013, upgrade as especially impactful. As one technician stated, "My initial attitude was that [the program] was going to be a failure and that I don't want to be involved. When they did a big upgrade in March, I saw the light at the end of the tunnel and how it might work. The work has gotten easier for field people and office people." Another technician said, "As time is going, the optimization program is learning; as time goes by, we are learning too. [They are] taking out questions that were not necessary. [For example,] there were a couple questions—involving a chilled water system—the optimization program was not involved with water systems. They took those questions out finally. They also took out duplicative questions."

From a process and sales perspective, these upgrades have been challenging. One contractor explained these challenges as "tough," and noted that his company, "could be in the $100,000 or so range for sunk costs. That is a big loss. I think the program realizes they need to go the other way. They know they need to get down the number of hours it takes to complete the program. We initially quoted based on old specifications, which have changed. They are tweaking [the program] to save us more time. I don't see it getting worse from here. I am thinking it hit the bottom and we are going up from here. They are open to our suggestions." A technician had a similar view, and pointed out that all the changes are, "a little frustrating. Getting training for each change takes time. Ask what happened to the other information? When are they going to make up their minds what information they want? Changing question and way you answer them in annoying." Another contractor shared, "Paperwork is horrible. Paperwork keeps changing—had to go back and check things again. If they changed it, we would have to transfer info and often go back and get new info. Every time there is a change—that is an impact to our bottom line. No financial incentive to go back and redo something. I think they know they need to make it easier." Finally, one contractor questioned the value of the numerous changes; "PECI keeps doing program updates every week. They keep changing the scoping. All they have done through MPS is added complexity—complexity with no or little value."

There were many concerns expressed regarding the content and order of questions in the MPS Tool. One contractor described the MPS as, "the worst thing about the program," and explained that, "to do a semi annual you have to do part of the annual. It is out of order." This contractor acknowledged that the improvements have made it better, but indicated that it was still not optimum. Another contractor explained that, "The only issue I have is the number of questions. [It takes] a lot of time. [The tool has gone from] 200 questions to 100 questions. It has improved, but it is still very time consuming. They should only include the most important things to check. If you live in the desert, you are not going to have condensation. Not the same environment. Answer questions about things that would never exist here, which is a waste of time." This data aligns with the WO32 Memo in which the WO32 Team report that, "approximately eighty percent of statewide participants indicated that programs ask too many redundant or irrelevant questions."

MPS Improvements

There were many specific improvements recommended for the MPS beyond the need to simplify and reduce the time required for data entry. One recommendation was to ensure that semi-annuals include all the relevant questions. One contractor said, "don't make you do something in the annual that isn't due in 280 plus days in order to do the semi-annual." The same contractor requested additional functionality be added to the MPS so that the program remembers any questions that were responded to as "N/A" in previous steps. Another contractor indicated that tasks should be able to be customized per unit to eliminate some of the questions. In addition, multiple contractors requested an MPS App for entering data that they could link with their company software.

Data Entry

The MPS Tool was initially designed for the data to be inputted on-site. The reason for this was to provide the technician with immediate feedback about how the unit was performing on each task before proceeding to the next task. Program implementation staff estimated that at the beginning of 2013 roughly half of the contractors had office staff enter data instead of entering it live on the roof and now roughly 65% were entering data live. Program implementation staff reported that the "biggest offenders" who had office staff enter information were now transitioning to tablet computers for data entry. Program implementation staff explained that glare off the computer screen on a bright roof could pose a real barrier to data entry. Lack of Wi- Fi Internet connectivity was also a frequent problem that contractors reported, as was staying on the roof when it was hot. One FST recommended a hybrid approach of entering some data live on the roof and then filling out other data in a cooler location, like their truck or a restaurant.

Of the six active contractors interviewed, two indicated technicians input the data on-site; two have developed a hybrid approach where they enter some data on-site and some on paper later; and two contractors reported solely relying upon paper to record the data. For the four contractors that are doing some or all of the data entry on-site, all are using tablets to enter the data. Many challenges were discussed regarding data entry on-site, including: glare, text size, tool latency, inconsistent Wi-Fi access, greasy hands, and temperature on the roof. In order to

best understand these issues and how they have been worked around, here are some quotes in contractors' and technicians' own words.

> Wi-Fi issues and Glare: "Issues with iPads include dropping off the network and website. It would be nice for their program to be an app and just enter it and email it in. Glare was an issue but we purchased glare reducing screen protectors, which helped a lot."
>
> Wi-Fi Issues: "The data entry is the challenge. Internet connection not being great is a huge issue. I average 10 units a day, if I have a bad connection, I may be only able to do 6 units."
>
> Wi-Fi issues, Greasy Hands, Glare, and Temperature: "We had connectability problems. Not all sites have Wi-Fi. We had to do hot spot on our techs phones. This was not working on their phones, so we had to get separate cards on their tablets. That seemed to speed up the process. Techs are not used to doing computer work, hands are greasy, getting a lot of glare and 120 degrees on the roof."
>
> Latency and Learning Curve: "The website has a lot of lag time and delays in between, inherent in new programs and in a web-based program. If you could just enter all the data and then click submit that would be a great improvement. The one-minute lag time between submitting each question makes is a much longer process. Drawback is data entry. Needs to get simpler on the data entry side. [The program] eventually will get there. Techs will get more comfortable with working with tablets on the roof. There is a big learning curve right now."
>
> Size of Text, Glare, and Temperature: "The letters and the little boxes are too small—hard to read in bright sun. Glare is an issue. It is often hot on the roof. It should ask you the most important info so you are answering the key questions on the roof and the rest not on the roof."
>
> Glare and Color of Text: "Glare is an issue. When answering test-in questions, the min and max parameters are in a faint gray color—they are hard to see."

For those four technicians who enter some or all of the data on paper and then input the data into the computer off-site, they report that data is entered the same day in most cases; two of these contractors indicated the maximum time between collecting and entering the data is five days. Of those four contractors, three rely upon the technician or office staff to do the data entry, while the remaining contractor has a technician complete the data entry. Those using a hybrid option believe is it doing well. Once contractor stated, "We input data for test in and out data on the roof. All the other stuff, [for example the] condition of [the] filter is noted on paperwork. We can do all those things on the list in a matter of minutes—simple checklist stuff. We spend an hour entering that data. Test in and out has to be checked. Hybrid process is working pretty well." The paper version of the tool includes 30 pages of questions to answer. Consistently, contractors and technicians reported they spent more time inputting the measurements and answering the questions than they do working on the actual unit.

Evolution of Program Processes

The program implementation staff has made many changes to the MPS system since January 2013. From the program implementation staff's perspective, the rollout of the Enhanced

Question Bank (EQB) within the MPS in February was a significant change that required input from all three IOUs (SCE, PG&E, and SDG&E). The revised MPS checked everything the technician did to make sure it was correct. However, it put stops on work during the test-out process, not allowing contractors to proceed if inputted values fell outside of the recommended parameters. This proved frustrating and costly for contractors. The program gathered feedback on contractors' experiences using the EQB. In June, the program revised the MPS so it does not stop work but rather creates alerts if there is a problem and allows technicians to proceed with subsequent steps. The contractors are now allowed to verify all test-out worksheets (final CSA performance data entered into MPS) after the contractor has had an opportunity to verify the data. As of May 2013, the Coil and Airflow test-in and test-out worksheets allow the technician to enter data based on manufacturer's recommendations, FDD technologies, and technical expertise. The calculations now provide guidance as opposed to strict parameters that the equipment must perform within. The program also made efforts to streamline the MPS by reducing the number of questions asked, reducing redundancy, and minimizing the number of clicks required to move from one page to the next. Planned improvements in August 2013 through end of the year include redesigning paper forms to better align with technician workflow and MPS data entry requirements, and integration of diagnostic tools.

3.5 Baseline

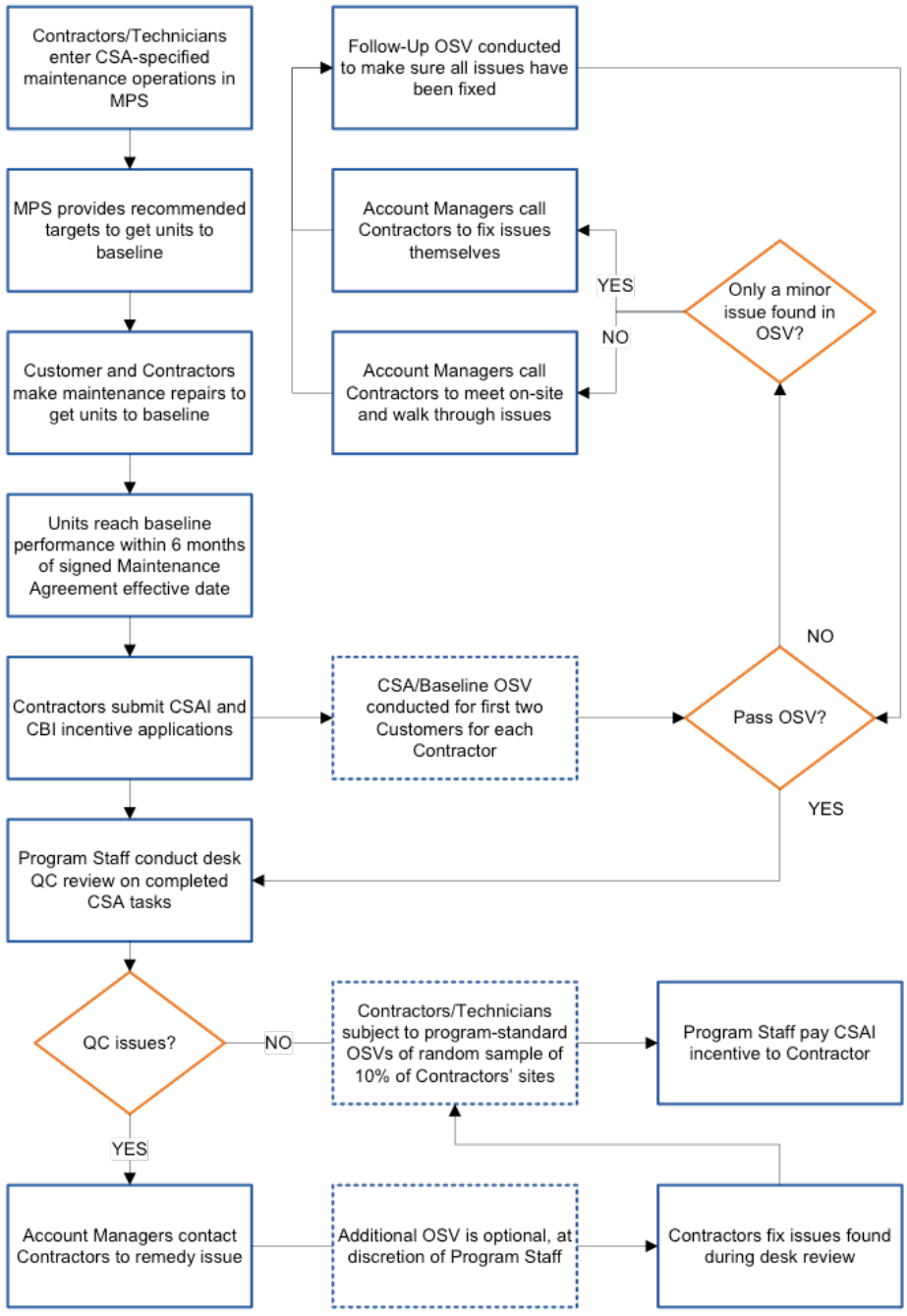
Reaching "baseline" is a critical component of the program. When a technician successfully brings a unit up to "baseline" performance, it means that the unit is operating according to Standard 180 guidelines and manufacturer specifications. This process is also referred to as the Cooling Service Analysis (CSA). The 2008 ANSI/ASHRAE/ACCA Standard 180 included 30 inspection/maintenance tasks for Rooftop Units (see Table 5-20 in that document). However, the CSA provided through the CQM programs includes 40 or more maintenance tasks, which is 30% more than ACCA 180. A Senior Product Manager at PECI specified that in the SCE HVAC CQM Program there are up to 15 Standard 180 maintenance tasks and up to 23 Standard 180 energy tasks, based on the tables in ASHARE/ACCA/ANSI Standard 180 January, 2012 revision (5-1 Air Distribution Systems, 5-2 Air Handlers, 5-7 Coils and Radiators, 5-8 Condensing Units, 5-9 Control Systems, 5-12 Economizers - Air Side and 5-16 Furnaces, Combustion Unit Heaters). He also indicated that there are up to 9 Test In Worksheet Tasks and up to 9 Test Out Worksheet Tasks based on the CSA Measure Work paper. The SCE Program Manager explained that the goal of the program is to operationalize Standard 180; however, since the program is based on a comprehensive set of DEER energy efficiency measures, DEER requires additional QA/QC tasks for such measures as Thermostat Scheduling Adjustment and economizers, which is why the additional tasks were added to the program.

Figure 3.4 below shows the program steps related to bringing a unit up to baseline and the various checkpoints it must pass. While this process seems straightforward on the surface, achieving baseline is not an easy concept to turn into consistent practice because of the numerous exceptions to MPS performance that must be considered in relation to the unit's potential performance and the types of tools used to take measurements or readings. The SCE Program Manager explained the exception process this way:

> "Since HVAC performance is a dynamic process with many input variables and there is not an industry standard protocol for detecting, diagnosing, and remediating faults, there can be exceptions to what would be considered optimal or normal

operation by the algorithms embedded in MPS. Additionally, equipment configurations can cause exceptions to the data points that are available to inform diagnostics and performance analysis. For example, not all HVAC units are equipped with service ports to facilitate measurement of suction pressure, so an exception to the requirement to measure suction pressure and determine sub cooling must be made in those cases. The program does not waive required repairs, and does not intend to pay incentives for units on which all required repairs were not completed."

Figure 3.4: Baseline



Reaching Baseline

Based on descriptions from program implementation staff and program materials, reaching baseline can be described in the following way: after the technician completes an initial inventory of the system, the technician collects "test-in" data from the HVAC unit. The MPS makes recommendations that the technician uses to identify needed adjustments and part replacements. Baseline standards are defined in the program's document, "HVAC Optimization Cooling Service Analysis (CSA) Task Guide." It is important to note that the technician is required to make adjustments based on the algorithms in the MPS for tasks that the program is able to establish clear requirements for, such as the requirement to repair economizers. For certain diagnostic processes, such as refrigerant charge testing, the MPS provides guidance informed by the best openly available sources. In those cases, as a PECI engineer explained, "The MPS is more guidance than mandate. We don't tell the technician how to do the job."

Once recommended changes are addressed, the technician gathers "test-out" data to verify that the unit is performing at baseline standards. This process may be iterative, and must be completed within six months. The technician then submits information through the MPS to be approved by program implementation staff, including exceptions to meeting the CSA Task standards. Once approved, the contractor receives a Baseline Incentive and the CSA incentive (CSAI), which they may choose to pass along to the customer.

Contractors and technicians expressed varying but similar definitions of what it means to bring a unit to baseline. One contractor stated baseline means, "Coils have been cleaned, drain lines are flushed, economizer is working, and refrigeration charge is running to optimal efficiency level." Another defined it as, "Getting the unit to normal operating performance." Another stated, "Baseline is defined by the results of the data being inputted in to the program.

Engineers looking into data and saying it is operating as designed." Yet another technician explained baseline as being, "Based on the field diagnostics tool measurements passing."

One technician explained that as the process evolved, he had a junior, less-experienced technician do the basic tasks—described by him as, "the more normal maintenance stuff"—such as the coil cleaning, the drain line flush, filter and belt replacement. He explained that the SCE program certified technicians do the more complex, detailed tasks, such as the refrigeration checks.

The requirement to bring a unit up to baseline within six months is an appropriate timeframe most of the time, but exceptions are frequently requested. According to staff, completing the CSA within six months is often manageable, but they regularly send contractors' requests for exceptions to SCE to extend the six-month deadline. At the beginning, extra time was sometimes granted in order to give contractors time to adjust to program requirements. Now that contractors are familiar with the program and additional staff members are available to proactively assist contractors through the process, the most frequent reason for an extension is because the contractor needs extra time to receive a replacement part. If a contractor misses the six-month deadline, the contractor and customer will be allowed to remain in the

program but will not be eligible for the baseline or CSA incentives for the unit that was delayed.

Four of the six contractors indicated that the six-month timeframe to complete the CSA was adequate. The other two contactors indicated that the ability to request an extension was a needed function of the program. These two individuals explained that air temperature often resulted in the need to request a delay. As one contractor explained, "There were a lot of cold days this winter, so we couldn't do testing because temperature minimums were not met. It was good to have an extension." Technicians reported the average time to get a unit to baselines was two to eight hours, barring any unforeseen issues. Another technician indicated it takes him up to eight hours on a large unit; he stated, "I don't do the label until the unit says it passes our field diagnostic tool. If there is an issue I find out why the tool says there is an issue. I then clean, fix, and run the tool again to ensure it passes. FDS wants everything down the middle. I then stick the sticker. If a unit is in good shape – depending on when coils dry, I estimate it usually takes me an 8 hour day on a very large unit." This may be an example of the general concern that contractors are cherry-picking units to include in the program so as to not take on problem units.

Tools and Diagnosis

As with any type of diagnostics, the data used to make judgments about whether something is performing within an acceptable range is only as reliable as (1) the tool that produces the data, and (2) the person's ability to interpret what that data means. The WO32 Memo emphasizes, "Correct fault detection diagnosis (FDD) and repair are important for HVAC maintenance. If technicians cannot correctly perform FDD and repairs, then it will be impossible for HVAC maintenance programs to realize ex ante savings." The memo then addresses "problems correctly identifying faults using the California Energy Commission (CEC) refrigerant charge and airflow (RCA) protocol." It is important to note that the SCE HVAC Optimization Program recognizes limitations of the RCA protocol. The Program specifies the metrics that must be considered in evaluating refrigeration cycle operation and does not specify use of this protocol.

In the broader HVAC community, there are ongoing discussions about which tools are most reliable and how technicians should interpret the data. For example, FDD tools have been the subject of study for WHPA in recent years.[18] While FDD tools are allowed and encouraged in the program, the program does not yet support one particular technology over another because the FDD protocols still need to be evaluated. As reported by a program implementation staff member,

> "The program is currently under contract with the FDSI to help them make their Service Assistant and Service Assistant Mobile products compatible with the program. As a part of this contract, SCE is also funding program user access to FDSI's services.

[18] See presentation dated July 12, 2011, titled, "Purdue University Update to the Western HVAC Performance Alliance AFDD Subcommittee – July 2011"
http://www.performancealliance.org/Portals/4/Documents/CommitteeWorkspace/AFDD/Purdue%20FDD%20evaluation%20update.pdf

> SCE is in the midst of negotiating a contract with Purdue University for James Braun to evaluate FDD protocols, including FDSI's protocol."

Further complicating the use of a particular tool is knowing what range of performance is acceptable for a given unit. While guidelines generally apply to many units, there are exceptions and the program has to be able to determine which situations warrant these.

As one FST explained, diagnosing what can and should be done for a relatively new, well-maintained system is more straightforward than diagnosing what should be done—and perhaps more importantly—what is *possible* to do to improve the performance of an old, ill-maintained system. One program implementation staff member said the technicians, contractors, and program engineers sometimes have to work together to determine what is an acceptable range of performance for a particular unit and what course of action should be taken.

Technicians were asked specifically if they use certain tools in their work. Table 3-3 below highlights the prevalence of different tools used by technicians.

Table 3-3: Tools Used by Technicians

Tools	Number of Technicians
Digital Refrigeration Gauges	5*
Electronic Wet Bulb Thermometer	5
Digital Thermometer	5*
Type K Thermocouples	5*
Pipe Clamp Thermometer	5*
Current Clamp	5
Humidity Probe	5
Multimeter	5
Software	3
Type K Thermocouple with Wet Sock	3
Anemometer	3
Analog Compound Gauges	1
Flow Hood	1
Flow Plates	1
Duct Leakage Tester	0

Three of the five technicians indicated they use Field Diagnostics Software. These technicians indicated that this software was very helpful in conducting the tasks required by the program. However, one technician pointed out that sometimes he does not trust the readings. He explained,

> "The field diagnostics tool is an electronic device, you can't trust it and need to be wise about the readings it is giving you. I use it, but I think we are human and better than a machine. If the machine is telling you the current temperature return is this and you know it is not, I put in my best estimate into the tool."

Four of the five technicians discussed upgrading their tools for the program. Three of these four discussed their respective company's purchasing digital gauges for them, while the fourth technician indicated that he had to buy the digital gauge himself. One technician explained that,

> "I have my digital gauges, pocket humidity thermometers and temperature/pressure chart. I had to buy the digital gauges for the program. I used to only use mechanical. If the tool goes down, I need to have those. I needed to buy humidity pocket thermometers. We don't normally use those. I now use these tools on all my maintenance jobs. Tools help technicians diagnose problems better. It brings out things that you don't normally think about."

Technicians with digital gauges indicated they were very happy with the benefits of the digital tools, especially the time savings. As one explained, "I use the digital gauges on all jobs. With these digital gauges, it cuts my job time by 20 to 30 minutes."

The WO32 Memo indicated that approximately half of technicians did not have EPA low-loss fittings on their refrigerant hoses. Of the technicians that did have low-loss fittings, "many did not purge their hoses of air and water vapor prior to attaching to Schrader Vales." Given these preliminary findings, technicians were asked if they have EPA low-loss fitting on their refrigerant hoses and if they purge the hoses of air and water vapor prior to attaching to Schrader valves. All of the technicians self-reported that they had the EPA low-loss fittings and those they always purged the hoses. This is inconsistent with the observations noted in the WO32 memo. However, this could be due to the fact that the data is a result of self-report bias or sampling differences.

Prescribing Processes and Tools

When contractors and technicians were asked if the program should prescribe specific maintenance processes and the tools used, the reactions were mixed, even among contractors and technicians from the same company. One contractor explained that, "there should be some recommendations for specific maintenance processes and tools used." The technician from this company disagreed, and stated, "I would rather do it my way. Cleaning and washing is not a big issue. It would be a waste of time." Another contractor indicated,

> "Detailed instructions would not be valuable. To be in the program, you had better understand maintenance. You need to get in there and get your hands dirty. A Standard 180 help sheet on the web page would be helpful that included definitions of what is meant by each of the tasks."

The technician from this same company shared this view, but only for experienced technicians. He noted, "[Prescribing maintenance and tools] would be good for the not-as-experienced technicians. For certified Journeyman, if you don't know how to do a Standard 180 type of maintenance you have a problem." The contractor and technician from another company both saw the benefits, and interestingly, both specifically used the example of coil cleaning. The contractor stated, "[It] would be helpful, yes, this is what you need to do to raise energy efficiency by cleaning coil this way." The technician stated, "Yes this would be valuable. This would help people learn how to wash a coil the right way. Many people out

there don't know how to do this." It should be noted that there is an active WHPA Working Group, the CQM Standard 180 Maintenance Task Working Group, which is working to operationalize the maintenance tasks documented in the Standard. This group first met in March of 2013 and continues to meet weekly to accomplish this large task, currently scheduled for completion in March of 2014.

Evolution of Program Processes

The program has modified the MPS in a few ways over the past year to take into account the use of varying tools and interpretation of diagnostic data. According to program staff, the program was designed with the intention of incorporating FDD and recently began to make FDD tools compatible with the MPS. With the introduction of the Enhanced Question Bank, the program instituted requirements in the MPS for the technician to fix the unit's performance on a particular set of tasks before proceeding to the next set of tasks. Reflecting the difficulty of enforcing a particular range of performance for certain tasks, the program found it necessary to remove work stops and allow the technician to proceed with successive steps while the technician if it was possible to bring the unit up to performing as designed. This was partly due to delays caused in servicing the unit and partly due to the fact that exceptions to performance ranges are sometimes warranted. For each of the task groups—Thermostat & Scheduling, Economizer, Coil & Airflow, and Refrigeration—the MPS currently requires that technicians follow these steps in this order: (1) provide Test-In Worksheet metrics, (2) address tasks identified by the MPS as having a meaningful impact on worksheet metrics, and (3) provide Test-Out Worksheet metrics. Work stoppages currently occur at the point of applying for incentives. As explained by the SCE Program Manager,

> "The MPS reviews selected Test-Out Worksheet metrics provided by the Technician to make an initial determination if the metrics are within ranges or statements of acceptable operation. If the technician-provided data indicates the unit has not been repaired (i.e., the economizer is not functioning or the refrigerant system is not operating within recommended levels) that Status is recorded in the MPS and technicians are prevented from submitting for program incentives for bringing the unit to "Baseline."

3.6 On-site Verifications

There are three types of on-site verifications (OSVs) that occur within the program. All OSVs are unannounced so that contractors and technicians do not know ahead of time which units will be inspected. The first OSV verifies that the unit inventory was completed correctly. As explained by the SCE Program Manager, "This is used to verify that the model & serial number of the equipment as well as the SCE Sticker number are all in agreement with the information entered into the MPS. This is conducted on the first two sites entered by each contractor and in some cases more often if the first two sites had any errors." The second OSV verifies that the CSA or baseline assessment was completed correctly. Per the SCE Program Manager, "During a CSA OSV, all of the Standard 180 maintenance items are verified as being performed, the economizer operation is checked, the temperature differentials between the supply and return air as well as the condenser air. Refrigerant readings are not taken. At a minimum, 8% of all of the sites submitted to SCE are subjected to a CSA OSVs." The third type of OSV verifies that the ongoing maintenance is being

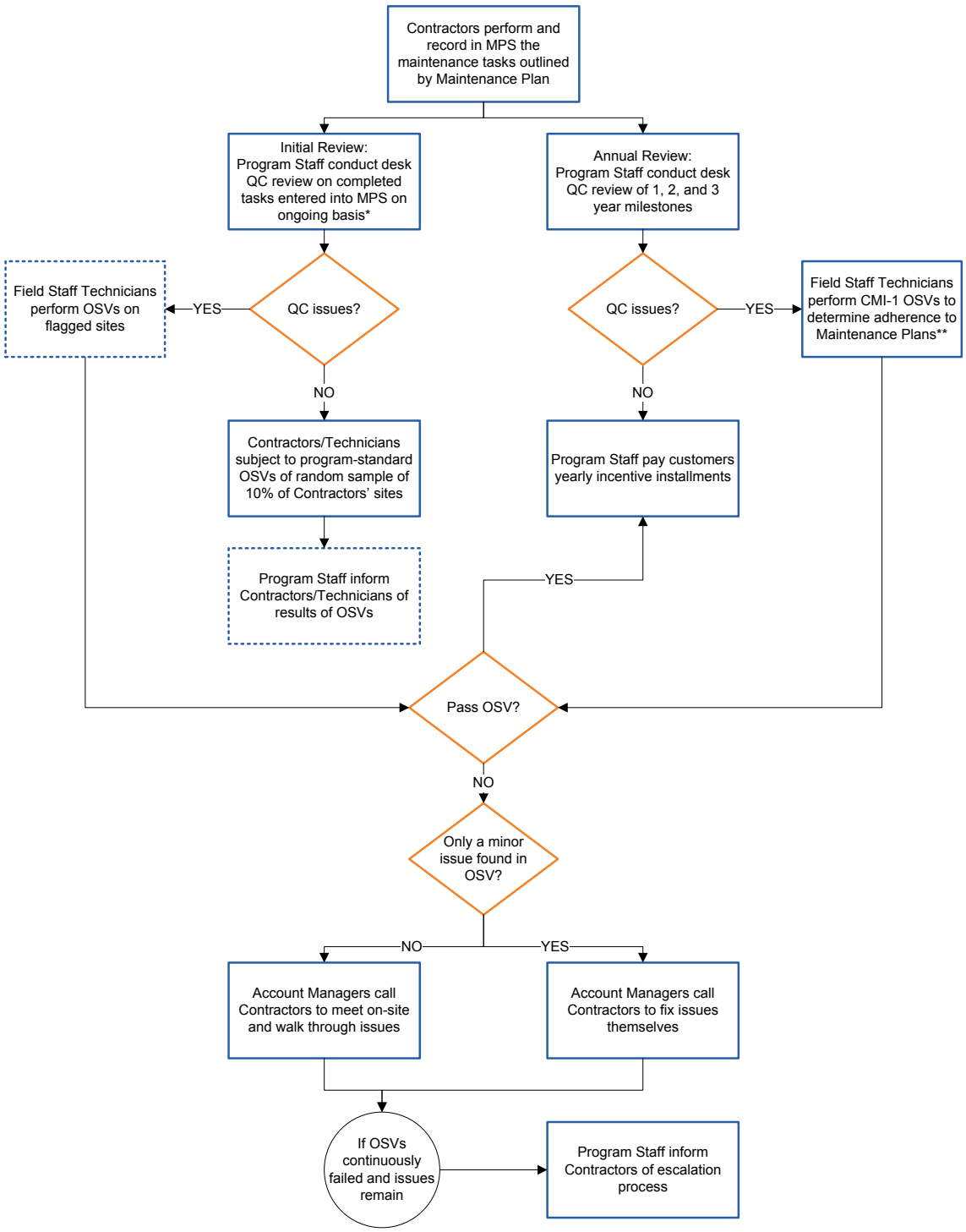
completed as reported; this is done on a random basis or selected purposefully due to concerns about the validity of submitted data. The SCE Program Manager noted that, "The third type of OSV is a Maintenance Adherence Verification (MAD) or CMI1 inspection that is performed to verify that the equipment is being maintained in accordance with the Standard 180. Belts, filters, and temperature differentials are measured between the supply and return air as well as the conditioned air, control compartments are checked for cleanliness, and coils and drains are checked to insure that they have all been maintained. At a minimum, 2% of sites submitted to SCE are subjected to MAD OSV inspections." These inventories are referred to by multiple names. As such, Table 3-4 is a helpful quick reference for the three types of OSVs. The first two OSVs are mentioned in Figure 3.2, Figure 3.3, and Figure 3.4 above.

Table 3-4: On-site Verifications Performed by Program

On-Site Visit	When Conducted	Requirements	Additional Triggers	If not passed?
CMI-0 / SSA Unit Inventory OSV	After initial unit inventory	OSVs are required for the first two customers for each contractor	-	If the first two are not passed, then OSVs are continued until passed
CSA / Baseline OSV	After contractor has been approved by program to perform CSA tasks and after units have been brought to baseline	OSVs are required for the first two customers for each contractor	Account Manager and Processing Team can request OSV if concerns arise during desk review of CSA tasks entered in MPS. Random OSVs are also conducted.	Account Manager calls Contractor to discuss over the phone or field staff meets Technician/ Contractor in field
CMI-1 / Random OSV	After Contractor has passed baseline and is performing and entering into MPS on-going maintenance tasks	Each year, 10% of Contractors' sites have OSVs, either by random selection or as a follow-up to QC issues found by Program implementation staff	Account Manager and Processing Team can request OSV if concerns arise during desk reviews of yearly activities or new tasks entered in MPS	Account Manager calls Contractor to discuss over the phone or field staff meets Technician/ Contractor in field

Figure 3.5 is a process map describing the how the third type of OSV is triggered and conducted.

Figure 3.5: Ongoing Maintenance and Reporting



* Currently, this step consists of an informal check, but a more robust desk review process is in development.
**The CMI-1 on-site verifications are mandatory for first two incentives paid per contractor.

Program implementation staff explained that a contractor must pass the first two inventory OSVs (CMI-0 or SSA Unit Inventory OSV) before receiving the CMI0 incentive. Likewise, the contractor must pass the first two baseline inventories (CSA /Baseline OSV) on units covered under the contractor's first two customer maintenance agreements before the contractor is allowed to receive CSA incentives for other contracts. If the contractor does not pass the first two OSVs, the FSTs continue OSVs with the contractor until the contractor passes. Once a contractor passes two baseline OSVs, the contractor is either randomly submitted to OSVs or selected for OSVs based on concerns raised during desk reviews of CSA data as well as data continually entered into MPS.

Two of the six contractors indicated that they had been involved with OSVs. One contractor, who was present for an OSV, indicated that the staff member took temperature readings and checked contactors, filters, and the coil, with no pressure readings. This contractor indicated that it was a visual inspection, with no gauges used on the units. The second contractor, who indicated that he had been present on a few OSVs, stated that he was only present because the staff had trouble getting access to the buildings. He indicated they conducted some on-site field-testing as part of the OSV. He described the staff as "easy to work with." Both of these contractors indicated that they did not receive any feedback from the staff during or after the OSV. Another contractor who has not been involved with OSVs expressed frustration regarding the lack of feedback,

> "I am not involved. Technicians are not involved. We are not notified. I asked for a letter regarding OSVs stating we are in good standing to share with customers. PECI does not close the loop on this unless I ask. I am trying to bring good news to the customer since they are not seeing incentives. How do they know we are doing what we are supposed to be doing?"

In the quote above, the technician points out a need for communicating results with the customer. Program implementation staff recently indicated that they plan to develop customer reports describing year one results.

OSVs are another area where program implementation staff indicated that training and coaching took place. However, EMI did not receive corroborating evidence of this practice through documentation or data from participant interviews. According to the FSTs, if they find poor quality work during an OSV they call the technician and ask them to meet on the roof. The FST requires the technician to perform the work while the FST is there. According to the interviewed FSTs, if the technician performs the task incorrectly the FST works with the technician to teach them the proper approach. This lack of corroborating evidence may not mean this is not occurring; rather, it may be that the small number of contractors and technicians interviewed did not have any quality work issues.

Evolution of Program Processes

The Senior Program Manager indicated that the OSV process is one aspect of the program that needs to be tightened up and clarified. The Program Manager described one change that was made earlier in the year (date not specified). Specifically, the OSV guidelines were too stringent and causing work delays, so a change was made on minor issues to allow the FST to conduct a follow-up visit to ensure a problem was corrected instead of requiring the

technician to meet the FST on the roof. The SCE Program Manager explained their current policy on dealing with minor versus major infractions

> "Our policy is that minor inconsistencies such as a slightly dirty control compartment, filters that are not dated but have been replaced and are clean, etc., are not in-themselves cause for failure of any CSA or MAD OSV, unless this is a problem that the contractor has had repeatedly. Non-operative equipment, belts that are frayed/broken, clogged filters, incorrect model numbers, debris left on the roof, temperature differentials that fall outside of the target range or inoperative components of any kind are all grounds for failure of any OSV."

In the fall of 2013, the program implementation staff plans to refine the CSA OSV process. The CSA OSV is currently conducted at the contractor-level because different technicians may service one particular unit. The program is looking for a way to pass CSAs at the technician level, instead of the contractor level, in order to better ensure that each technician is able to perform the CSA. Program implementation staff indicated that an upgrade to the MPS should allow the program to identify which technician is performing the work on a unit. Program implementation staff have also acknowledged that using multiple names for the various OSVs can be confusing, and that it would be a good idea to clarify the naming structure.

3.7 Incentives

As described in Table 3-5 below, there are four types of CMI incentives and three other types of incentives that the program offers. The customer receives incentives when they sign the Maintenance Agreement and for each of the three years that the unit is maintained at baseline level of performance. The purpose is to decrease the elevated cost of a quality maintenance contract and to ensure that the customer continues each year of the three-year agreement.

The contractor receives incentives when a customer Maintenance Agreement is signed and when a customer's HVAC unit is brought up to baseline. The purpose is to decrease the costs of the additional overhead required to secure a Maintenance Agreement with a customer and to reduce costs associated with repairs that are not required by the program. In addition, the third type of contractor incentive—which may be passed on to customers—partially covers the costs associated with repairs and work needed to bring units up to baseline. Table 3-6 provides greater detail of the incentive amounts paid contractors, depending on tasks completed.

Table 3-5: Program Incentives Paid to Contractors and Customers

Incentive Name	Recipient	When Paid	Purpose	Incentive Level
Customer Maintenance Agreement Incentive (CMI) — Initial Installment	Customer	Following the Program's approval of application	• Decrease customer's additional cost to upgrade to a QM Service Agreement • Keep the Service Agreement in place and units maintained by Contractor for 3 years	• 20% of total upon initial approval • Up to $3,836 per HVAC unit, depending on equipment type, age, and future unit condition
Customer Maintenance Agreement Incentive (CMI) — On-going Installments	Customer	Following annual reviews that units are maintained at baseline		• 25% of total at the end of year 1 • 35% of total at the end of year 2 • 20% of total at the end of year 3
Contractor Program Incentive (CPI)	Contractor	When initial installment of CMI is paid	Compensate Contractors for overhead costs related to Service Agreement sale and unit inventory	$75 per enrolled unit
Cooling Service Analysis Incentive (CSAI)	Contractor / Customer (optional)	One-time incentive provided once units are brought to baseline	• Compensate Contractors for completion of tasks required to bring the units to minimum performance level • Contractor can pass along some or all of the incentive to customer	Amount varies by unit, up to $2,425 per HVAC unit
Contractor Baseline Incentive (CBI)	Contractor	When the CSA incentive is paid	Reduce some of the additional costs of minor repairs that are required but do not receive incentives	$50 per unit brought to baseline

Table 3-6: Cooling Service Analysis Incentives (CSAI) for Contractors

Task	Package Units			Split Systems		
	<6 Tons	6-25 Tons	>25 Tons	<6 Tons	6-25 Tons	>25 Tons
Coil Cleaning	$110	$130	$150	$165	$130	$150
Air Flow Adjustment	$25	$35	$45	$40	$35	$45
Refrigerant System Test	$25	$35	$45	$40	$35	$45
Refrigerant System Service	$120	$200	$260	$180	$200	$260
Economizer Functional Test	$25	$35	$45	$40	$35	$45
Integrate economizer wiring	$165	$175	$185	$250	$175	$185
Replace damper motor	$460	$510	$575	$690	$510	$575
Replace controller/sensor	$320	$370	$415	$480	$370	$415
Renovate linkage and other components	$180	$245	$310	$270	$245	$310
Replace T-stat	$200	$200	$200	$300	$200	$200
Adjust T-stat schedule	$25	$25	$25	$40	$25	$25

Role of Incentives and Incentive Amounts

Contractors and technicians indicated that the incentives were crucial to the program. As one technician stated, "The incentives are the only thing that makes the customers want to do it. It is money. This is a big factor." Another contractor explained that it is the incentives that provide the value proposition for the customer. He explained that, "The program is very beneficial to the client due to the incentives." Regarding the amount of the incentives, there were mixed reviews. One contractor indicated, "At this point, incentives are adequate." On the other hand, another contractor stated, "Incentives for doing economizers are OK. The other for airflow and refrigerant testing are inadequate. Incentives are lacking. Not covering time needed. My burn rate on this work is quite high." Another contractor explained, "Some of the incentives look really good. Others not." Generally for larger units, the incentive amounts are more attractive than for smaller units. For smaller units, as described in Chapter 2, the return on investment is less attractive. As one contractor explained,

> "The majority of the market is less than 5 ton package units – yet there are not good incentives for the customer. Most 5-ton units, if they have an economizer, it doesn't work. It isn't just hooking it up. It requires a big fix. Customers aren't going to pay $1,200 to fix an economizer for a $150 rebate. [The program is] not taking into account the reality of the market. If there is an economizer, it isn't installed correctly. This market is driven by price. Need bigger rebates to make a bigger impact. That is the key issue."

A number of contractors said the incentives were very helpful when it comes to economizers. As one contractor explained, "Customers jump on economizer incentives. We do a lot of economizer repairs. This is because price is an issue and the payback on these are longer than desired so the incentives really help."

Delay in Incentive Payments

All contractors indicated significant concerns with incentive processing time. The SCE Program Manager indicated at the time of EMI's interview on July 31, 2013, that he had over 900 incentives in his queue to be approved for payment. He indicated that this delay was caused by staff changes at SCE. PECI Staff also indicated that other reasons for the delay included program changes and navigating the processing of a new incentive type. Many contractors spoke about the impact of these delays on customer trust in the contractor and the program. As one contractor explained,

> "I would like to see incentives. Customer is outlaying money to [my company] for maintenance and repairs. The documentation states that upon maintenance agreement signing, they will get their incentive. [It] puts me in poor light when this hasn't been delivered. When they signed the agreement, neither the customer nor ourselves have received incentives for a number of units that have been brought up to baseline as early as March [2013]. [I] want the customer to get [his or her] incentive. SCE is doing a terrible job. [The customers] haven't lost faith yet. I tell them [the incentive] is coming. It is frustrating for me to keep saying that. [The PECI Account Manager] has been great. I meet with him once a week. First thing I ask him every week is where the incentives are. Clearly, each week there is no process being made."

Another technician noted that he gets, "A lot questions from the customer about when is my check coming? Often incentives are delayed. Incentive questions I refer to the Major Accounts Department." Another contractor also expressed this frustration,

> "There are lots of issues with incentives here—usually they are late, considerably late. Initially late due to new applications, now customers are waiting for end of year-one incentives. Customers are asking for their checks, but the incentives are backed up at the utility. This is not an answer we can give to the customer. It puts us in a really awkward position…Delays in incentives are giving customers a bad taste of program. A few have indicated they may not continue the program. They budget that money so when it is not there, there is a big issue. A customer recently wanted to speak with SCE regarding not receiving incentive."

Requests Regarding Incentive Payments

In addition to the obvious request to decrease the incentive payment cycle time, two additional requests regarding incentives were made during the interviews. One contractor pointed out that it would be very helpful if the program could provide an incentive accounting by unit. This contractor explained,

> "We committed to give back incentives to customers. We need to do an audit trail on our end. This is an accounting nightmare. We have a huge tracking spreadsheet. I worry we haven't seen any checks in awhile. If you got a quarterly statement of where you are and what incentives by unit have been sent, this would be a huge improvement. "

The other request originated from a technician. The technician asked for more training regarding the details of the different incentives. He explains his request this way,

> "It would be good for the field techs to really know what the incentives are so they can communicate that with their customers. Customers usually trust the technicians they see all the time as compared to the office people. I never really got too deep with the incentives on the dollar amounts and left that to the office. This was not really covered in the training."

Evolution of Program Processes

Program implementation staff reported several changes that took place in recent months. In May 2013, the program updated incentive applications to consolidate forms and clarify which parties were responsible for which portions of the application. In June 2013, the program redesigned the CMI-1 analysis template and reviewed inspection questionnaires for opportunities to reduce inefficiencies with the hope of reducing incentive processing time. SCE is also in the process of hiring additional staff to help review incentive applications.

4. Conclusions and Recommendations

This section provides conclusions and recommendations based on the findings of this Rapid Feedback Process Evaluation of the SCE CQM program. It is important to keep in mind that this is not a comprehensive process evaluation. Rather, this four-month rapid feedback evaluation was tasked with documenting and assessing the merit of the program logic model and processes, and making recommendations for improvements to the overarching program design and implementation processes. This evaluation is not tasked with assessing the validity of the program's data. Overall, the program as designed has merit and has implemented many changes to policies and processes that were responsive to stakeholder needs. To be successful, though, the program should revisit some of the assumptions the program is built on and consider how to strategically address these issues. In this section, we grouped the conclusions and recommendations into five topics that warrant attention.

4.1 Linking Program Strategy with Continuous Improvement

The program has embraced a continuous improvement model to respond quickly to contractor and customer needs, as well as evaluation findings. In this respect, there is ample evidence of the program responding quickly in 2013 to (1) feedback gathered in the spring from contractors about the Enhanced Question Bank roll-out, (2) concerns raised by the WO32 team in May, 2013, and even (3) questions raised during the process mapping workshop conducted for this evaluation in June, 2013. The downside of moving quickly is that there is little time to determine all of the potential impacts the changes may have on those involved, especially unintended consequences that may affect contractors and customers. Program implementation staff and contractors alike recognized the need to slow down the pace of the changes. Contractors need to know what changes are coming, when, and what impact it will have on their current and future contracts. The program has taken a lot of actions to be responsive, yet to our knowledge those actions are not situated in relation to an overarching program development strategy.

EMI recommends that the program take stock of the desired changes and develop a strategy for implementing those changes over the coming year. The idea is to do more, less often, with improved communication around the changes. A strategy does not need to be set in stone, but it should provide a roadmap that can be shared with key stakeholders, including SCE and CPUC decision makers, contractors, customers, and program evaluators. The strategy would ideally:

- Tie to the program's logic model, listing critical issues and questions that affect connections between resources, activities, outputs, and outcomes.
- Identify and vet plausible solutions and alternatives.
- Name likely impacts on key stakeholders and steps taken to assist with their adjustment to changes.
- Place changes on a schedule that can be shared externally as part of a stakeholder communication plan.

In addition to incorporating the program's planned changes into a strategic plan, EMI also recommends addressing the following topics:

- Reviewing the parameters specified in the MPS. Specifically, it would be helpful to determine which parameters should be defined as guidelines and which as requirements. What steps and activities should be required to make sure a customer saves energy on their HVAC unit? What can the program do to mitigate unintended consequences, like having customers and contractors not enroll units that cannot meet requirements?
- The next time the program is altered, it is important to address how program implementation staff can ensure that contractors do not lose money on their existing contracts. This is especially relevant when program changes require contractors to do more than they originally scoped in their early contracts with customers.
- What is the program going to do with customer data after the customer's three-year contract is up?
    - Will the program allow contractors to continue using the MPS to record performance data and produce reports for customers on HVAC unit performance and estimated cost savings? Could this serve as a tool to verify longitudinal energy savings?
    - Will the program transition customers out of the MPS database and ask contractors to continue tracking unit performance?
    - What are the legal implications of maintaining customer records past program participation dates?
- As ongoing funding is prioritized, it will be important to assess whether the program will continue relationships with existing contractors, and for how long. Additionally, what steps will be taken to invite the participation of new contractors to the program?
    - In terms of maintaining relationships with contractors, the program intends to work long-term with contractors while also bringing in additional interested contractors. If there are limited program funds, the program will eventually need to develop a policy for deciding whether contractors remain in the program at the exclusion of interested contractors that had not previously participated, or if the program will phase-out long-term contractors in favor of encouraging new participants in the program.

4.2 Refine Baseline Criteria, Set Performance/ Measurement Standards, and Strengthen Basis for Assessing Savings Claims

Reaching baseline is an important aspect of the program. It represents a contractor's efforts to bring customers' enrolled HVAC units up to Standard 180 guidelines and manufacturer-specified operating parameters. Section 4 of Standard 180 requires that contractors and customers agree on performance objectives and condition indicators to determine baseline. In an effort both to reinforce that relationship as well as stay out of the middle of it, PECI

program implementation staff and the SCE Program Manager stated that the program does not dictate what baseline looks like beyond Standard 180.

Our understanding of the process leading up to an assessment of baseline performance is that the test-in data gathered during an inventory, in combination with the CSA process, provide information upon which the technician assesses what repairs and adjustments are needed for the unit to perform at baseline. However, these parameters only provide guidance; ultimately, it is the technician's decision if the unit is performing at baseline. If the unit appears to be unable to reach baseline conditions (e.g., an old, ill-maintained unit that is incapable of meeting requirements), the technician or contractor works with the program implementation staff to develop feasible goals for the unit's performance. While this approach is fine in theory, there appears to be some evidence that these units are written up for replacement or not included in the program. Once those baseline goals are approved, the technician performs needed repairs and adjustments. The test-out data is used to provide evidence that the unit is performing at baseline level of performance. Program implementation staff confirms this level of performance and provide incentives as warranted.

There are a few underlying issues that complicate what it means to reach baseline level of performance. Because the program prescribes what tasks to do in what order, and not necessarily which protocols to follow or which tools to use when performing these tasks, there are some inherent measurement questions that should be addressed to better define what reaching baseline means. Addressing this will also strengthen the basis for assessing savings claims. EMI has compiled the following questions for consideration:

- Given the complexity and nuances in the industry, should the goal be to standardize how each of the Standard 180 tasks are performed or to use a FDD system to measure the outcome? For example, is it more beneficial to standardize the process for how to clean a coil or to standardize how to measure if the coil has been cleaned? Can measurements taken by different technicians - who may possibly be following different protocols and using different tools - end up with the same data? If not, how will the technician accurately compare test-in data with test-out data to determine if following Standard 180 resulted in energy savings? And for how long will these results be relevant?
- Can the program and other stakeholders agree upon performance and best practices criteria that result in energy savings? And can these criteria be applied across all, or at least the most common, HVAC systems?
- Baseline and Standard 180 are supposed to define the lower bound of performance. Is there more contractors can do to improve efficiency for units that reach baseline? Should that additional savings be rewarded with an incentive?
- What conditions warrant exceptions to performance parameters in the MPS? Can these exceptions be better defined, documented, and applied consistently across the program?
- How does the integration of FDD change the parameters or exception process, if at all?

EMI recommends revisiting which Standard 180 tasks can be agreed upon and standardized across HVAC units in terms of measurement best practices (including the use of FDD), performance parameters, and incentives for better-than-baseline performance.

4.3 Strengthen Contractor and Technician Selection Criteria

Contractor and technician selection and monitoring criteria must be strengthened to keep unethical contractors out, to ensure highly skilled technicians are invited in, and to empower staff to remove contractors or technicians if warranted. The program's current criteria for accepting contractors and technicians in the program includes safeguards against bad business practices, such as letters of recommendation and a clean record with the Better Business Bureau. It also includes experiential criteria, such as number of years of industry experience, certifications, and the ability to pass an open-book exam on Standard 180. However, more could be done to assess a technician's ability to complete work. It is possible that a technician could be highly skilled at maintaining systems, but not necessarily in an energy efficient manner.

EMI recommends increasing the depth of the post-training assessment to ensure that technicians understand how to work with the MPS to enter information. It is also important to make sure technicians are able to perform the tasks to standards set and monitored by the program. These standards also increase the probability of maximizing energy savings. Given that the program is increasing its role in training technicians on how to perform certain tasks, this assessment would be a natural fit with trying to determine what type of training a given technician will need.

EMI also recommends adding to the escalation policy some additional protection for program implementation staff against unprofessional conduct, including but not limited to physical or verbal threats.

4.4 Establish Training Criteria

The program originally designed training to encompass selling maintenance contracts and how to follow Standard 180 by using the MPS software. While the program tracked who participated in the Sales and Operations trainings and the technician trainings, the people who were trained for a particular contractor were not necessarily the ones performing the work. As such, EMI recommends making sure the Account Managers and FSTs train the staff who will sell the maintenance agreements and conduct work documented in MPS. This may be as simple as ensuring that contractors understand up front that all staff accepted into the program must attend trainings in order to have work approved in the MPS.

In addition, the program needs to establish training boundaries. In response to WO32 preliminary findings and staff's own observations of technician's maintenance skills, the program recently decided to expand training to develop technicians' maintenance skills. The broader industry wrestles with the question of whose job it is to fill training gaps in the HVAC workforce, and how to bring technicians' knowledge, skills, and abilities up to requisite levels

across the industry. In light of this, EMI recommends that the program answer the following questions and develop clear, measurable goals that tie into its program logic:

- To date, the program has largely strayed away from prescribing approaches towards particular tasks, understanding that some tasks can be completed in multiple ways. The program will need to decide which approaches it will teach technicians and which approaches it will not teach. Additionally, the program should address standardizing the measurement procedures for assessing if a task was performed well, and if it maximizes energy savings. It will be essential to keep in mind what impact these changes may have on the scope of the program. How can the program utilize and support the work of the WHPA CQM Standard 180 Maintenance Task Working Group that is currently attempting to operationalize the maintenance tasks documented in the Standard? How can the industry move forward with standardizing the measurement procedures for assessing if a task was performed well?
- How far should the program go to train individuals to master HVAC maintenance knowledge and skills?
- How will the program track individuals' progress toward conducting maintenance at the level and in the manners that the program finds acceptable? Will the program need to develop individual education plans to track, monitor, and grade the technicians' progress? What impact with the collection of these data and their associated metrics have on the way the program is run in terms of adding additional steps to the already lengthy application, enrollment, and training process for technicians?
- At what point should the program remove technicians who cannot perform the work to the level and in the ways required? How will the criteria for a well-performing technician be determined?

Because the program could easily devote many of its resources to developing, implementing, and assessing the effectiveness of its training offerings, it is especially relevant for the CQM program to determine what falls within the limits of the program and what does not.

4.5 Tailor the Program to Sell and Continue the Customer Relationship

The program was designed primarily to interface with contractors and empower them to sell the program to their customers. There are additional ways the program could progress toward its market transformation goals by further addressing customers' needs for demonstrated savings potential and regular communication. As several contractors reported, there is no return on investment for small units (which they defined as somewhere between five and 20 ton units). They also did not enroll some rooftop units because they did not believe they could get the units to baseline performance. Contractors reported that some customers are skeptical that they will actually save money by participating in the program or by continuing this level of maintenance, and are leery of the disclaimer on all enrollment documents that the incentives are not guaranteed. Even if they do save money, the time it takes to process incentives becomes a disincentive to enroll additional units.

EMI recommends that the program consider developing offerings that will yield a return on investment for small units, whether that is through a modified series of steps to servicing smaller units or through a different incentive structure. This could potentially expand the program's reach and increase the energy savings realized. In order to really expand the program and work toward market transformation, the program should increase marketing by developing targeted campaigns aimed at educating the customer with real-life testimonials of companies that have saved money by participating in the program. Contractors and customers—both potential and existing—need to see demonstrated the value of more expensive maintenance contracts. For current customers that have not yet enrolled all units in the maintenance agreement,, the periodic performance reports the program has developed should be tailored to convey how units are performing, what more can be done to save money, and the likely savings to be had from enrolling additional units.

4.6 Reduce Incentive Approval and Processing Time

Lastly, it is imperative that the program immediately reduces the incentive approval and processing time. EMI encourages SCE to consider reducing redundant reviews, implementing a more finely tuned sampling procedure, and hiring additional staff to reduce the time it takes for customers to receive incentive checks. It does not reflect well on the program to demand timely service and not deliver timely rewards.

Appendix A: SCE HVAC Optimization Program Improvements March – August 2013

Memorandum to File

Date: August 13th, 2013
Re: SCE HVAC Optimization Program Improvements March – August 2013 From: Monica Thilges
To: Mel Johnson, Southern California Edison

The purpose of this memo is to provide an update on the improvements that have been made to the SCE HVAC Optimization program in Q2 and Q3 2013 and are expected to roll out by the end of the year. I have divided it into three sections: program improvements, MPS improvements, and improvements on the horizon. As always, please let me know if you would like any additional information.

My best, Monica Thilges

Program Improvements

Program Improvement	Affected Users	Description of Improvement	Impact	Release Date
Updated incentive applications	Contractor & Customer	Consolidated forms and unnecessary information and clarified responsible partners	Reduced customer and contractor confusion and admin effort	May 2013
Improved Service Account Validation process	Contractor & Customer	Changed format of SA Validation Tracker to split address fields so they could be easily copied and pasted between MPS and the Tracker	Increased accuracy and decreased processing time	April 2013
Improved reporting on economizer, rebate and unit type mismatches	Contractor & Customer	Created reports to mitigate contractor errors around economizer, rebate and unit type mismatches	Decreased rebate rejections, improved rebate accuracy, and decreased processing time	June 2013
Streamlined year 1 incentive processing	Contractor & Customer	Redesigned the CMI1 analysis template to be automated and reevaluated the inspection questionnaires for efficiencies	Decreased processing time, which improves incentive payment timelines	June 2013

Program Improvement	Affected Users	Description of Improvement	Impact	Release Date
Improved contractor support	Contractor	Hired an additional account manager and implemented greater consistency across account managers	Reduced confusion and improved program experience for contractors	June / July 2013
Flat File reporting improvements	SCE	Improved the flat file infrastructure to generate file quicker with the most updated data dictionary	Improved reporting and accuracy with current data definitions	July 2013
Level 1 technicians	Contractor & Technician	Created role for less qualified techs to better match the way contractors work outside the program	Provide up leveling opportunities for less experienced techs and allow for more competitive pricing	August 2013
MPS homepage update	Contractor & Technician	Deployed abbreviated communication about MPS operational changes on the MPS login page at the time of each change	Reduced confusion with program software changes	July 2013
Technician skills assessment	Technician	The program has observed a lack of basic technician skills in the field, so a skills assessment has been integrated into the training	Improved technician performance	Q2 2013

Maintenance Planning System Updates

Program Improvement	Affected Users	Description of Improvement	Impact	Release Date
Which tech did what work	Program & Technician	A mechanism that discerns which user performed the maintenance vs. which user transcribed maintenance data into the MPS	Improved ability of the program to identify struggling techs and decreased audit risk	8/8/2013
What data can a tech see	Contractor & Technician	Contractors requested that we reduce un-necessary fields from their layouts and remove specific fields from their technician's views to protect confidential information and streamline technician work	Decreased contractor worries about security of sensitive information and a streamlined interface for technicians	7/25/2013
Removal / combining of questions	Technician	We removed a handful of questions, we combined some questions to avoid redundancy, and we made some questions more concise	Reduction of data entry time for technicians	July 2013

Program Improvement	Affected Users	Description of Improvement	Impact	Release Date
Incentive preview screen	Contractor	Display on the Incentive Preview screen a unit's treatment status and incentive amount so that contractors know which incentives they have earned and which worksheets affect which incentive	Increased transparency for contractors on incentives	6/20/2013
Refresh treatments	Contractor & Technician	Create a "Refresh" button in the Incentive Preview screen to ensure that correct treatment status is shown	Reduced confusion for contractor and technician	6/20/2013
Modify validation to serve as a guideline for Refrigerant and Coil and Airflow MIGs	Contractor & Technician	Modified validation from Coil and Airflow and Refrigerant worksheets to improve contractor and technician experience	Time savings for contractor and technician	6/13/2013
Delay verification for all test out worksheets	Contractor & Technician	Allow contractors to verify all Test out worksheets after contractor has verified the data, instead of a mandatory data lock earlier in the process which caused delays	Time savings for contractor and technician	6/6/2013
Revised Coil and Airflow test in and test out worksheets validation	Contractor	Revised validation in the Coil and Airflow Test in and Test out worksheets to enable manufacturer's recommendations, FDD Technologies and technical expertise; calculations now provide guidance	Increased incentive certainty for contractors	5/16/2013
Display CSA due date information in the Standard 180 tab	Technician	Display CSA due date information on the Standard 180 tab to ensure technicians are well aware of deadline	Eliminates CSA due date confusion for techs	5/2/2013
Move unit inventory questions down to the worksheets	Contractor	Moved ten unit inventory fields down to worksheets because some unit attribute data is unknowable or difficult to gather unit the tech is working on the specific sub-system	Allows contractors to verify unit inventories and begin work sooner	4/20/2013
New task status icons	Technician	Reduce the number of task icons	Reduced technician confusion	4/20/2013

Program Improvement	Affected Users	Description of Improvement	Impact	Release Date
Go straight to "edit" mode	Technician	Remove the "edit" button to reduce the amount of clicking and computer processing time	Increase efficiency for technicians	4/20/2013
ET split and superheat messages	Technician	In the case where the unit's superheat and ET split numbers cannot be found on MPS's QA/QC chart, MPS provides an explanatory message to the contractor	Helps technicians to bring units to baseline more quickly because they will know what MPS finds acceptable	4/20/2013
Unit at baseline report	Contractor	Contractors find it difficult to know if they are done everything for MPS to consider a unit to be at baseline for an entire building or customer account; so we created a report showing contractors the at baseline status for all units on a given building or customer account	This helps contractors to better manage their resource and business as a whole	4/20/2013
Separated non-controlling questions	Technician	MPS processes data each time data is entered into a field, so we removed validation for fields without dependencies or calculations	Allows the technicians to move through a worksheet faster	3/25/2013
Enhanced Question Bank	Technician & Contractor	Major overhaul of the MPS, designed to improve technician and contractor experience and increase quality of information gathered	Expected to improve tool for all parties	3/4/2013

On the Horizon

Program Improvement	Affected Users	Description of Improvement	Impact	Anticipated Release Date
Redesigned paper-based inspection forms	Technician	Redesigned forms to better align with technician workflow and data entry into the MPS	Reduced data entry time for technicians	August 2013
Inactive contractor procedures	Contractor & Customer	Developed a process to address a situation in which the contractor has not been active in the MPS and the customer is at risk of losing incentives	Improved experience for customers and increased support for contractors	August 2013
Year One Customer	Customer &	Launch a Year One Customer Report to communicate value to	Improved customer understanding of QM	August / September

Program Improvement	Affected Users	Description of Improvement	Impact	Anticipated Release Date
Report	Contractor	customer and create opportunity for contractor to engage customer	value	2013
Early Retirement Integration	Contractor & Customer	Integrate with Early Retirement program to allow program contractors to take advantage of reduced cost of new units	Great savings opportunity for customer	Q3/Q4 2013
Advanced Digital Economizer Controls	Contractor & Customer	New incentive opportunity for advanced digital economizer controls	Allows for participation in future new measures, like enhanced ventilation	October / November 2013
Enhanced Ventilation field test	Contractor & Customer	Field test of several applications of Enhanced Ventilation as described in SCE13HC045.0	Field test will inform considerations for launch of Enhanced Ventilation as a new measure in SCE programs	Install: Jan 2013 Final report expected: Sept 2013
Enhanced Ventilation	Contractor & Customer	New measure: enhanced ventilation	Greater energy savings for customer and utility	November 2013
Customer guide to select a contractor	Customer	Guide for customers to select a contractor	Demystify contractor selection	August 2013
ROI calculator	Contractor & Customer	Investment calculator to inform contractors and customers	Assist contractor in sales pitch and inform customer of benefits	August 2013
Integration of Service Assistant and Service Assistant Mobile	Contractor & Technician	Currently under contract with FDSI to integrate their tools into this program	Improved efficiency and diagnostic tools for contractors and technicians	Q3/Q4 2013
Revised technician training	Technician	Currently being revised to provide more skills training for techs instead of just program-specific instruction	Improved technician performance	Q3/Q4 2013
CSA OSV revision	Technician	Evaluate CSA work by technician instead of by contractor; awaiting greater certainty around what tech is doing the work that will come with new MPS upgrade	Improved ability to assess technician work and address weaknesses	Q3/Q4 2013
Review by Purdue of HVAC diagnostic protocols	Technician & Program	Currently negotiating contract with Purdue to review several HVAC diagnostic protocols for use in the program – Purdue's university status is proving challenging with utility contracting requirements	Improved diagnostic feedback for technicians and quality energy savings for utility	Q3/Q4 2013
Updated sales presentation	Contractor	Redesigned sales training to better train HVAC salespeople	Improved tools for contractor to sell program	August / September

Program Improvement	Affected Users	Description of Improvement	Impact	Anticipated Release Date
		on how to sell QM by overcoming common barriers, illustrating the value of QM, communicating the importance and benefits of Standard 180; presentation will include relevant industry articles and industry studies that tell a compelling story to the customer	and quality maintenance	2013

Appendix B: Interview Guides

SCE HVAC Optimization Program
July 2013
Interviewer: ELLEN STEINER
Approximate Length: 1 Hour

B.1 Introduction to Interview (Contractors and Technicians)

Hello. Thank you again for taking the time to speak with me regarding your experiences with the HVAC Optimization Program. As I shared with you previously, my company – Energy Market Innovations – has been retained by Southern California Edison to conduct an independent, objective evaluation of the HVAC Optimization Program. The objective of speaking with you today is to learn about your experiences with the program and its operations in order to identify what is working well and potential areas for improvement. It is important that you know that everything you share with me will be confidential and nothing will be reported that can be directly connected to you. I am interviewing a number of contractors and data obtained through these interviews will be reported in an aggregate matter. With this in mind, I hope that you will feel comfortable giving me your candid feedback and observations. Do you have any questions related to confidentiality or how this data will be used?

[Answer questions]

I have prepared a list of questions to guide our conversation today. However, it is not imperative that we just stick to my questions. If things come to mind as we are talking, please feel free to share them with me. I want this to be a dialog and not just a Q&A session. Let's get started.

B.1 Interview Questions for Contractors

Standard 180 and Program Awareness

1) First, can you provide a little information about your background and your current role at [insert company name]?
2) How did your company first become aware of the utility-supported program?
3) Are you familiar with the ANSI/ASHRAE/ACCA Standard 180?
4) As part of the SCE HVAC Optimization Program, it was essential for you and your company to be familiar with the ANSI/ASHRAE/ACCA Standard 180.
    a. Had you heard about the Standard prior to participating in the program?
    b. Do the maintenance steps and processes required by the program differ from the maintenance procedures you perform for customers outside of the program?
        i. If Yes: How? Please explain.
    c. What is your opinion of Standard 180? Benefits? Drawbacks?

Experience with the Program: Enrollment

1) Did you consider the utility's screening process in allowing you to participate in their program to be reasonable?
2) Did it require your company to make any fundamental changes in how your technicians did their work or required technician experience/capabilities?

Experience with the Program: Training

1) How was your experience with the trainings?
2) Do you see these trainings as a professional development opportunity for you? For your technicians?
3) Do your technicians have the support they need to be successful in this program?
4) Do you think there would be value in the program prescribing specific maintenance processes and the tools used?

Experience with the Program: MPS

1) Do you have direct experience using the MPS tool yourself?
2) Has your company experienced any issues with software upgrades?
3) What could be improved about the MPS system as it is now?
4) After your program-related 3-year agreements with customers expire, would you be interested in continuing the use of the MPS or be able to export the data to your own customer tracking system?

Experience with the Program: Cooling Service Analysis

1. What tools and diagnostic protocols if any do you need to conduct the CSA? Thermostat & Scheduling? Economizer? Coils and Airflow? Refrigeration? Combustion?

Tool	**Yes / No and Comments**
Digital Refrigeration Gauges(1)	
Analog Compound Gauges (2)	
Flow Hood (3)	
Anemometer (4)	
Flow Plates (5)	
Duct Leakage Tester (6)	
Humidity Probe (7)	
Type K Thermocouple with Wet Sock (8)	
Electronic Wet Bulb Thermometer (9)	
Digital Thermometer (10)	
Type K Thermocouples (11)	
Pipe Clamp Thermometer (12)	
Current Clamp (13)	
Multimeter (14)	
Software (15)	

2. Do you have EPA low-loss fitting on your refrigerant hoses?
3. Do you purge the hoses of air and water vapor prior to attaching to Schrader valves?
4. What must be achieved to get units to baseline?
5. Is the timeline to get units to baseline efficiency in 6 months after signing the maintenance agreement reasonable?
    a. What is the average time it takes to get a unit to baseline efficiency?

Experience with the Program: Ongoing Maintenance

1. How effective are the ongoing maintenance procedures in extending unit service life? What could be done to improve the procedures?
2. Do you think this program is changing the industry?

Experience with the Program: OSVs

1) Have you been involved with on-site verifications performed by field staff technicians?
2) What has your experience been like with the on-site verifications performed by program field staff technicians as part of the program?
    a. Experience with staff?
    b. What type of feedback have you been given?
    c. Are results presented in a clear way?
    d. Are the OSVs useful in terms of increasing your or your technicians' knowledge?
    e. Would you change anything about how those are completed or how the results are discussed with you?

Overall Experience with Program

1) What do you think is the potential of the program for reducing energy consumption?

Closing and Thank you

I believe that is all the questions that I have for you today. I am curious: is there anything about the program that I should have asked you that I did not? Is there anything else important about the program that you would like to comment on?

Thank you so much for your time today. Your insights were incredibly valuable. Should you think of anything else you would like to share, please do not hesitate to contact me.

B.2 Interview Questions for Technicians

Standard 180 and Program Awareness

1) First, can you provide a little information about your background and your current role at [insert company name]?
    a. How are you specifically involved in the utility-sponsored HVAC Optimization program?

b. How long have you been at this company? In the HVAC business?

2) Has your company been involved in HVAC system efficiency optimization in general?
   a. Did you provide these services to your customers prior to any utility supported programs?
   b. Could you provide a brief description of what those offerings might have been?
3) Are you familiar with the ANSI/ASHRAE/ACCA Standard 180?
4) As part of the SCE HVAC Optimization Program, you were required to be familiar with the ANSI/ASHRAE/ACCA Standard 180. Had you heard about the Standard prior to participating in the program?
   a. [If Yes]: Where did you first hear about it? How had you been exposed to the Standard in the past?
   b. [If Yes]: Had you ever referred to the Standard in your inspection or maintenance work prior to participating in the program? Please explain.
   c. Do the maintenance steps and processes required by Standard 180 differ from the maintenance procedures you perform for customers outside of the program?
      i. [If Yes]: How? Please explain.
   d. Do you consider the offering of Standard 180 based maintenance to be a premium service? [If Yes]: Do you expect it to remain so?
   e. What is your opinion of Standard 180?
      i. Does using the Standard make a notable change in the quality of the work conducted?
      ii. Does using the Standard reduce energy consumption of the units you work on?
      iii. Has the training on Standard 180 helped you in being able to diagnose issues in the field?

Interaction with Customers

5) Who in your company sells the program to customers?
6) How knowledgeable are the sales staff members about HVAC maintenance? About energy efficiency?
7) In general, how knowledgeable are your customers in the program about HVAC? How does this compare to your customers not enrolled in the program?
8) Do the customers you are selling the program to already have maintenance contracts in place? Does the program maintenance contract represent an "upgrade"?
9) [If applicable] Could you tell me about your experience selling this program to customers?
   a. How many customers have you approached about participating in this program?
      i. What percentage of your total customer base does this represent?
      ii. Is there a particular type of customer you are more likely to discuss the program with?
         1. [If Yes]: What type of customer is this?
      iii. Do you tend to discuss this more with new customers or existing customers? Why?
   b. Of those that you approach, approximately what percentage are interested in the program? What percentage ultimately participate?
10) How do you sell the program to customers? What value propositions do you use? Can you take me through a specific example of selling the program?
11) In general, how amenable are your customers to making improvements to their

maintenance processes? Why do you think this is?

12) What motivates your customers to participate in the program?
13) What benefits do you think customers want to see as a result of participating in the program?
    c. [If applicable] What are the barriers for customers that choose to not participate in the program?
        i. Is there anything that the program could do to make it easier for customers to participate?
14) The 1-year customer reports have been recently rolled out. Have you seen them? If so, what is your opinion? Are they helpful in communicating the importance of QM to the customer? What changes would you suggest?

Experience with the Program: Training

15) What training did you participate in to be able to work in the program?
16) How was your experience with these trainings?
17) Do you see these trainings as a professional development opportunity? Why or why not?
    a. What types of information have you learned from these trainings?
    b. My understanding is that the training includes some 1:1 on the roof with program trainers. Did you do this? If so, what did you learn from that experience?
18) What feedback, if any, do the program implementation staff offer to you about technical skills during these trainings?
19) When thinking about the program, do you currently have questions, issues, etc. that are unclear?
20) Did involvement with the program lead to any changes in the tools normally used on the job or how technicians perform their work (other than filling out the required paperwork)?
21) Did the training address calibration and maintenance of instruments (gauges and temperature meters etc.)?
22) Do you check the calibration of your instruments?
    a. If so, how frequently?
23) Did the program influence how you maintain and calibrate your instruments? How?
24) Do you think there would be value in the program prescribing specific maintenance processes and the tools used?

Experience with the Program: MPS

25) What has your experience been like using the MPS? What is your opinion of the MPS as a tool? Strengths? Drawbacks?
26) Have you experienced any issues with software upgrades? How have upgrades impacted your processes?
27) What could be improved about the MPS system as it is now?
28) Do your use the MPS live on the roof?
    c. [If Yes]: What device do you use (iPad, laptop, etc.)?
        i. Any issues with slowness? How often? Do you ever have issues with connecting to the internet during the service call? How often?
        ii. Any issues with visibility of screen or glare?

iii. Do you use the reference resources on the technician portal? Other paper resources?

d. [If No]: Why do you choose not to enter data live on roof?
   i. Do you have access to the information you need, while on the roof? If so, how? Do you carry a paper manual?
   ii. Who enters the data from the paper forms into the MPS?
   iii. What is your interaction with those who enter the data?

Experience with the Program: Initial Inventory

29) Now I would like to talk about your actual experiences on the roof. My understanding is the first step is to complete a unit inventory. Is this correct? Have you completed a unit inventory for the program?
30) [If Yes] Talk me through what doing an inventory looks like?
31) What are the objectives of the unit inventory?
32) What tools if any do you need to conduct an inventory?
33) How long does it take to conduct a unit inventory?
34) What happens after the unit inventory is completed?
35) When does the label get affixed to the unit?

Experience with the Program: Maintenance Plan

36) [Assuming identified as next step] What is involved in developing a Maintenance Plan?
37) What are the objectives of the Maintenance Plan?
38) What tools if any do you need to complete a maintenance plan?
39) How do you review the Maintenance Plan with your customer?
40) Is the Maintenance Plan Report generated from MPS sufficient? Benefits? Improvements?
41) How long does it take to complete a maintenance plan?

Experience with the Program: OSVs

42) Are you involved with on-site verifications performed by program field staff technicians (FST)? No
43) When have you been involved with OSVs?
44) What has your experience been like?
   a. Are the FSTs good to work with? Has their feedback been helpful?
   b. Are results presented to you in a clear way?
   c. Are the OSVs useful in terms of increasing your knowledge?
   d. Would you change anything about how those are completed?
   e. How are the results shared with you?

Experience with the Program: Cooling Service Analysis

45) My understanding is that the next step after the maintenance plan is to conduct the cooling service analysis. Is this correct?
46) Are you involved in conducting these analyses?
47) [If Yes] Can you walk me through what this step looks like? What do you do?

48) What tools and diagnostic protocols if any do you need to conduct the CSA? Thermostat & Scheduling? Economizer? Coils and Airflow? Refrigeration? Combustion?

Tool	Yes / No, Comment
Digital Refrigeration Gauges(1)	
Analog Compound Gauges (2)	
Flow Hood (3)	
Anemometer (4)	
Flow Plates (5)	
Duct Leakage Tester (6)	
Humidity Probe (7)	
Type K Thermocouple with Wet Sock (8)	
Electronic Wet Bulb Thermometer (9)	
Digital Thermometer (10)	
Type K Thermocouples (11)	
Pipe Clamp Thermometer (12)	
Current Clamp (13)	
Multimeter (14)	
Software (15)	

a. Do you have EPA low-loss fitting on your refrigerant hoses?
b. Do you purge the hoses of air and water vapor prior to attaching to Schrader valves?
c. Did the program influence the tools and diagnostic protocols used? In what way?
d. What are the objectives of the CSA?
e. How long does it take to conduct a CSA?
f. What must be achieved to get units to baseline?
g. Is the timeline to get units to baseline efficiency in 6 months after signing the maintenance agreement reasonable? What is the average time it takes to get a unit to baseline efficiency?
h. How effective are the cooling service procedures in reducing energy consumption?
i. How effective are the cooling service procedures in extending unit service life? What could be done to improve the procedures?

Experience with the Program: Ongoing Maintenance

49) Once the unit is brought to baseline, what happens next in the program?
50) What tasks must be completed as part of ongoing maintenance?
51) How often are these tasks conducted?
52) What are the objectives of these tasks?
53) How long do these tasks take?
54) What tools and diagnostic protocols if any do you need to complete these tasks?
55) Did the program influence the tools and diagnostic protocols used? In what way?
56) How effective are the ongoing maintenance procedures in reducing energy consumption? What could be done to improve the procedures?
57) How effective are the ongoing maintenance procedures in extending unit service life? What could be done to improve the procedures?

Incentives and Pricing

58) How satisfied are you with the incentive processing time?
59) How do you decide to allocate the baseline incentives? Do you share the incentives with customers? Why or why not?
60) Do you have any issues pricing the maintenance services so that you have enough time to complete all of the required steps?
61) What is your opinion on the paperwork that you are expected to complete?

Overall Experience with Program

1) Overall, how satisfied are you with the program?
2) Given your experience thus far, what would you change about the program?
3) Are there any particular strengths or areas for improvement that stand out with this program?
4) What do you think is the potential for HVAC maintenance in reducing energy consumption?
5) How well does the program address the potential?
6) What could be done to the program to further reduce energy consumption?

B.3 Closing and Thank You

I believe that is all the questions that I have for you today. I am curious: is there anything about the program that I should have asked you that I did not? Is there anything else important about the program that you would like to comment on?

Thank you so much for your time today. Your insights were incredibly valuable. Should you think of anything else you would like to share, please do not hesitate to contact me.

Appendix C: Level 1 Technician Application

LEVEL 1 TECHNICIAN APPLICATION

Southern California Edison
HVAC Optimization Program

Technicians are the cornerstone of the SCE HVAC Optimization program, and the quality of their work is an integral part of the energy savings achieved by the Program. The Program recognizes the value of comprehensive technician education, as well as the importance of advanced HVAC expertise amongst those implementing ANSI/ASHRAE/ACCA Standard 180.

Industry and stakeholder feedback has indicated that by involving less than fully-qualified technicians in the Program, we can create tremendous value to the industry by encouraging workforce development and allowing contractors more flexibility in their Program engagement. Less-certified technicians who do not meet Program requirements will be given the title Level 1 Technician, and fully-qualified technicians will be given the title Level 2 Technician.

Level 1 Technicians will only perform work related to HVAC Optimization while under the direct supervision of a mentor that is a Program-approved Level 2 Technician.

Please note the following guidelines:

1. Level 1 Technicians will not have a Program login.
2. The Program-approved technician with a MPS login is responsible for all work completed on any HVAC system under their supervision. All accountability falls on the Program-approved technician onsite.
3. We will allow no more than two (2) Level 1 Technicians to work under one (1) Level 2 Technician. This 2:1 ratio is designed to ensure quality work, while also creating an environment conducive to training and workforce development.
4. Appendix A lists suggested tasks for Level 1 Technicians (from Standard 180 Listed by Table Number).

REQUIREMENTS

The following eligibility criteria must be met to qualify as a Level 1 Technician:

1. Be currently employed by the contractor
2. Have a minimum of twelve (12) months experience in the HVAC industry field
3. Hold an active US Environmental Protection Agency (EPA) card (please submit copy of EPA card with application)
4. Work under the direct supervision of a Program-approved technician
5. Submit a signed Level 1 Technician Application
6. Have completed or be currently involved in an approved HVAC education Program with the commitment of becoming a fully-qualified technician (please submit copy of proper documentation)

TECHNICIAN INFORMATION

Contractor		**Date**	
Technician First Name		**Technician Last Name**	
Email		**Phone Number**	

EDUCATION

Please submit copies of all certifications that pertain to HVAC Optimization technician requirements.

Past Education	
Currently Enrolled	
Future Education Plans	

HONOR PLEDGE OF CONTINUING EDUCATION

As a technician participating in the Program, I am committed to the continued pursuit of knowledge, skills, and expertise in the HVAC industry.

Inherent in this commitment is the responsibility to:

1. Use my abilities and opportunities to pursue personal and academic growth and excellence.
2. Conduct myself with integrity in both Program-related and academic work, and as a citizen of the HVAC community.
3. Seek out the opportunity to prepare for a career of quality HVAC maintenance.

I,_____(Level 1 Technician Name, *please print clearly*), have read, understand and agree to comply with all requirements described in this Level 1 Technician Application, including all supporting policies described or referenced. I understand that by signing the Application, I consent to any other inquiry to verify or confirm the information I have given. I would like to participate in the Program and commit to the requirements outlined above.

Signature_____ Date _____

APPENDIX A

SUGGESTED TASKS FOR LEVEL 1 TECHNICIANS
Standard 180 Listed by Table Number

TABLE 5-1 (Air Distribution Systems)

1. Visually inspect … & **clean grilles, registers and diffusers**
2. Visually inspect ducting and vapor barrier & **correct as**

needed TABLE 5-2

1. Check for particulate matters & **clean or replace filter**
2. Check "P" trap & **prime as necessary**
3. Check for proper heating or cooling coils... & **clean as necessary**
4. Check the integrity of all panels… & **replace fasteners as necessary**
5. Check drain pan…. & **clean as necessary**
6. Check condensate pump… & **clean or replace as**

necessary TABLE 5-8

1. Inspect air cooled condenser surfaces…. & **clean as necessary**

TABLE 16

1. Check for particulate matters & **clean or replace filter**

TABLE 22

1. Check for particulate matters & **clean or replace filter**
2. Check the integrity of all panels… & **replace fasteners as necessary**
3. Check for proper operation of cooling coils... & **clean as necessary**
4. Check for proper operation of condensing coils... & **clean as necessary**
5. Inspect air cooled condenser…. & **clean as necessary**
6. Visually inspect exposed ductwork and vapor barrier & **correct as needed**

Appendix D: WO32 Team Responses to EMI Clarification Question Pertaining to Impact Study

EMI asked two sets of questions of the WO32 Team to inform this study. These questions were developed from an early draft provided to EMI on July 22, 2013, of the WO32 EM&V Interim Findings Memo for Commercial Quality Maintenance. The first memo of questions was sent on July 31, 2013. The second memo of follow-up questions was sent on August 20, 2013. The questions and answers are codified in this Appendix.

Memo 1: July 31, 2013

1. Please provide the observation protocols and applicable interview protocols for the four types of field observations that were conducted.

   Answer 1: EM&V on-site observation protocols for the four types of field observations follow the statewide or local program data collection protocols. EM&V master technicians obtained program data collection forms and attended program trainings to further clarify program data collection protocols. In addition, EM&V observation protocols include manufacturer specifications, acid tests (some units), field measurements of airflow and power measurements (for units in data logger sample and some non-data logger units), economizer damper position, refrigerant charge parameters, thermostat schedules, building type, occupancy, technician name, technician qualifications and experience, area served, and survey interview questions.

2. Please document how many sites and how many units are studied in each of the four types of field observations in each of the first CQM programs that are addressed in this memo. Please indicate how many additional sites and units of each field observation type are planned and when they are scheduled for completion.

   Answer 2: 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 25 units and 31 circuits. Non-participant observations have 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.

3. Please provide a table of the specific types (manufacturer, model, tonnage, number of compressors, number of circuits, number of economizers) of HVAC units in the study that are addressed in the memo.

Answer 3: In the interest of time, please refer to the SCE CQM Program tracking database for details of the specific types of HVAC units addressed in the memo. SCE can provide this information since the sites discussed in the memo are in the data logger sample or were visited by SCE program personnel during ride-along observations.

4. Please document when each of the observations and interviews were conducted that are addressed in this memo.

   Answer 4: Observations and interviews addressed in the memo were conducted from September, 2012, through July, 2013.

5. Please describe the objectives of the non-participant circuit observation.

   Answer 5: The objectives of the non-participant circuit observations are to evaluate prevalence and magnitude of maintenance faults on non-participant units compared to participant units. The objective is to measure program performance by answering the counterfactual question, what would have happened in the absence of the program? How do CQM participant units differ from non-participant units before and after CSA services are performed?

6. In the memo, it is stated, "Field observations were conducted of 73 participant air conditioning circuits and 22 non-participant circuits.[1] Observations conducted prior to technicians performing maintenance services of commercial air conditioning circuits identified 707 issues or 9.7 issues per circuit. Observations conducted during and after maintenance was performed on 55 circuits identified 551 faults or 10.0 faults per circuit (18 have not been observed)."
   a. Please document the definition of circuit and unit.
      Answer 6a: Packaged units can have one or more refrigerant circuits comprised of a separate compressor, evaporator coil, condenser coil, metering device, and refrigerant lines. Units larger than 5 tons can have 2 or more circuits. A unit is defined as a heating, ventilating, and air conditioning (HVAC) package consisting of one or more refrigerant circuits for cooling and heating if the unit is a heat pump or one or more furnaces if the unit is a gas packaged unit.
   b. Please provide definitions of "issues" and "faults," and identify the differences between the two terms.
      Answer 6b: "Issue" is defined as a problem or difficulty (http://oxforddictionaries.com/us/definition/american_english/issue). "Fault" is defined as a defect (http://oxforddictionaries.com/us/definition/american_english/fault).
      Issues are problems with tools or procedures that can impact fault detection diagnosis (FDD) and repairs. Faults can cause failures of components such as compressors, motors, economizers, sensors, or controllers. "Issues" cause "faults." 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

[1] Most packaged units have independent refrigerant circuits comprised of a separate compressor, evaporator coil, condenser coil, metering device, and refrigerant lines. Units larger than 5 tons can have 2 or more circuits.

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. Issues cause faults and faults impact energy efficiency performance.

c. Is the difference of number of faults per circuit pre and post statistically significant?

Answer 6c: The difference in number of faults per circuit pre and post is not statistically significant. For the 55 pre- and post-observed units, the pre-faults per circuit are 10.1 +/- 0.8 and post-faults per circuit are 10.0 +/- 0.75. In order to evaluate statistical significance using the paired t-test, differences between paired observations are evaluated. This paired t-test will be appropriate when a simple random sample of paired observations is selected from a normally distributed population. The t-test statistic in a hypothesis test about a population mean is found by dividing the difference between the sample mean and the hypothesized mean by the estimate of the standard error of the mean.[2] The mean difference in the number of pre-faults and post-faults per circuit is 0.09. The standard deviation is 2.11 and the paired t-test statistic is t_{54} = 0.32. The null hypothesis of maintenance services having no impact (i.e., α = 0.05), is defined by a t-score with *df* = 54 (i.e., n-1). The t-distribution varies depending upon the degrees of freedom (df). This refers to the number of values which are free to vary after we have placed certain restrictions on our data. The t-statistic cumulative probability table provides $t_{54,0.05}$ = 1.674 which defines the rejection region as t_{54} > 1.674. Since t_{54} = 0.32 is not in the rejection region, we do not reject H_0: μ_{N-M} = 0. The mean difference (μ_{N-M}) uses subscripts "N" to represent no maintenance and "M" to represent maintenance. The pre and post observation data does not provide sufficient statistical evidence to support H_1: μ_{N-M} > 0.

7. What is the specific relationship, if any, between "issues", "faults," and energy efficiency?

Answer 7: See 6b (above).

8. Please indicate the total time spent on diagnosing faults, as well as the number of faults found for each unit studied in the pre maintenance observations, post maintenance observations, and observations of units that did not participate in the program.

Answer 8: Average time spent diagnosing faults during pre-maintenance observations is 2 to 4 hours per unit depending on number of circuits and difficulty of installing data loggers. Average time spent diagnosing faults during post-maintenance observations is about 2 to 4 hours, depending on FDD and repairs performed by technicians. Average time spent diagnosing faults during non-participant observations is about 2 to 4 hours,

[2] http://www.stat.ucla.edu/~cochran/stat10/winter/lectures/lect20.html, http://lycofs01.lycoming.edu/~sprgene/M123/Text/UNIT_24.pdf

depending on number of circuits and willingness of non-participants to allow master technicians to evaluate units.

9. What are the objectives of the laboratory tests of field measurement instruments? Which instruments are being tested?

Answer 9: The following field measurement instruments are being tested: 1) digital instruments to measure refrigerant tube surface temperatures, 2) digital instruments to measure air relative humidity (dry-bulb and wet-bulb), 3) digital refrigerant pressure gauges, 4) analog refrigerant pressure gauges, 5) digital instruments to measure airflow (cfm[3]), 6) digital instruments to measure airflow static pressure, and 7) digital instruments to measure duct pressurization (and leakage). Tests are partially completed for refrigerant tube, airflow, and pressure measurement instruments at 95°F and 115°F, condenser entering air temperature and 80°F drybulb and 67°F wetbulb return air temperatures.

Refrigerant tube temperature measurement instruments are tested at 95°F and 115°F condenser entering air temperatures and 80/67°F indoor conditions. Tests at 55°F condenser entering air temperatures are planned. Approximately 100 instruments from 9 manufacturers are being tested.

Pressure measurement tests will be performed at five liquid and suction pressures (LP/SP) in pounds per square inch gauge (psig): 1) R22 low pressure (190LP/35SP), 2) R22 average pressure (270LP/70SP), 3) R22 high and R410 low pressure (320LP/105SP), 4) R410A average pressure (390LP/120SP), and 5) R410A high pressure (470LP/125SP). Measurements will be performed with refrigerant in hoses outfitted with EPA low-loss fittings left to soak in hot chamber to strain sensors. There are approximately 63 instruments or sensors to test from 8 manufacturers.

Airflow tests will range from 2,000, 2,500 to 3000 cfm (3 tests) at the following conditions 80DB/67WB/95F. There are approximately 25 instruments or sensors to test from 8 manufacturers.

Vacuum pump measurements will be performed with no vacuum/liquid drier, 30 minute vacuum with drier, 60 minute vacuum with drier. Tests are performed with airflow at approximately 3000 cfm at the following conditions 80DB/67WB/95F to evaluate the efficiency impact associated with each evacuation method. There are 4 vacuum pumps and 3 micron gauges to test from 7 manufacturers.

Fan belt tension and alignment measurement instruments tests will be performed with airflow at approximately 3000 cfm. Belts will be tested with proper tension and alignment, as well as loose and tight tension and misalignment of 0.25 and 0.375 inches at the following conditions 80DB/67WB/95F. The worst case measurements will be performed with fan belt tension either loose or tight and the belt misaligned by either ¼ or 3/8 inches. Out-of-box fan belt tests indicated tension was looser than manufacturer

[3] Unit of Measurement for Airflow is Cubic Feet Per Minute (CFM)

recommendations.[4] Out-of-box fan belt alignment tests indicated the belt was properly aligned. There are 14 belt tension and alignment instruments to test from 5 manufacturers.

Cold weather charging hood tests will be performed at 55F outdoor conditions. Digital refrigerant scale measurement tests will be performed with known weights or 1, 5, 10, 15, 25, 50, and 100 pounds to +/- 0.25 ounces. There are 4 instruments to test from 1 manufacturer.

10. In relation to this statement from the memo "Laboratory tests of +40% overcharge achieves manufacturer specifications, but causes a 14% reduction to a 2% increase in efficiency depending on damper position and outdoor temperature."
    a. Is your team indicating the manufacturer's specifications call for this overcharge?
       Answer 10a: Yes. This statement has been revised as follows. Factory charge is established without cabinet leakage and without an economizer. With closed economizer dampers the outdoor air leakage is approximately 15%. At factory charge conditions, laboratory diagnostic tests of the 7.5-ton two-compressor unit indicate both circuits have suction temperatures above the manufacturer specifications. Tests of +60% overcharge relative to factory charge yield suction temperatures within manufacturer specifications. However, +60% overcharge yields negligible efficiency improvements of -8 to +2% compared to +20% overcharge laboratory optimal. The +20% above factory charge (i.e., laboratory optimal) improves efficiency by 8% to 13% for closed damper, and 9 to 39% for 1-finger open.
    b. Is this an experiment?
       Answer 10b: Yes.
    c. In the mind of the team, does this imply a packaged equipment design flaw?
       Answer 10c: No. Manufacturers provide cooling charging charts and instructions for technicians to establish proper refrigerant charge for each circuit depending on field installation conditions. Variations in minimum economizer damper position, airflow, climate conditions, and other factors are encountered when technicians evaluate refrigerant charge using manufacturer recommended specifications. These tests are intended to show the sensitivity of the manufacturer's recommended procedures to conditions encountered in the field.

11. The memo indicates, "The most important maintenance faults impacting energy efficiency are improper damper position, compressor failure, refrigerant leaks, condenser fan failures, 24-hour blower-motor operation, belt-drive tension/alignment, non-condensables, restrictions, refrigerant charge, contamination, evaporator airflow, condenser coil blockage, economizer malfunction, and wiring." Please document how many of the faults that were observed both pre and post that fell into this category of "important maintenance faults impacting energy efficiency?"

[4] Out-of-box is defined as the condition of the unit or component as delivered from the manufacturer.

Answer 11: The following table provides interim findings of faults that were observed both pre and post for 55 circuits (see answer 6c).

Fault	Pre	Post
Improper Economizer Damper Position	76%	76%
Compressor failure/non-operable/leaks	5%	4%
Condenser fan failures	9%	9%
24-hour blower-motor operation	6%	5%
Belt-drive tension/alignment	31%	31%
Non-condensables	5%	9%
Restrictions	9%	9%
Refrigerant charge	60%	38%
Contamination	9%	100%
Evaporator airflow	52%	31%
Condenser coil blockage	41%	32%
Economizer malfunction	75%	75%
Wiring	5%	5%

12. The memo states, "Approximately 92% of technicians surveyed have issues with tools or procedures in terms of performing maintenance services. Approximately 50% did not have EPA low-loss fittings on their refrigerant hoses. Technicians that did have low-loss fittings did not purge their hoses of air and water vapor prior to attaching to Schrader valves."
    a. Please fully define the term "issues" and characterize the performance problems observed. Examples are given but this does not describe the complete picture.
    Answer 12b: "Issues with tools or procedures" is defined as having tools or procedures that are inaccurate and that cause improper FDD, contaminate refrigerant systems with non-condensable air and water vapor, or cause improper or unnecessary repairs.
    b. What criteria are used to define a performance issue?
    Answer 12c: Criteria include not having EPA low-loss fittings on refrigerant hoses or not 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. Laboratory tests indicate that 0.3% of non-condensable nitrogen as a fraction of factory charge will reduce efficiency by 12 to 18%. Improper maintenance of vacuum pumps and improper evacuation procedures will introduce non-condensables. Not installing liquid line driers when repairing a leak, reversing valve, thermostatic expansion valve (TXV), or compressor will cause 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). Moisture in the system may also 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. Laboratory tests indicate restrictions will reduce efficiency by 29 to 59%. Criteria of not providing technicians with procedures to test economizer operation will result in non-functional economizers. Laboratory tests indicate improper economizer damper position will reduce efficiency by 10 to 104%.

c. Also, please document the total sample surveyed and the actual number these percentages translate to?
   Answer 12c: The interim program participant sample is 10 technicians from 8 companies, representing approximately 73% of total incentives.
d. In the team's opinion, if we were to gather 10 master technicians in a room would they all agree with the criteria that are being used to define a performance issue?
   Answer 12e: Industry and manufacturer 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. Any 10 master technicians in the program will likely have different levels of knowledge regarding manufacturer and industry procedures.

13. The memo states, "None of the observed technicians used proper tools or procedures to measure relative humidity, airflow, economizer operation, damper position, coil cleaning, or fan belts."
    a. What criteria are used to define "proper tools or procedures?"
       Answer 13a: Tools must be calibrated to accurately measure humidity, air temperature, refrigerant temperature and pressure, airflow, static pressure, voltage, current, power factor, capacitance, belt tension, belt alignment, economizer functionality, damper position, and combustion efficiency. Procedures must be defined to guide technicians on how to properly perform FDD and make repairs with "user friendly" procedures, software, training, and data collection with real-time diagnostics and error checking.
    b. How many technicians were observed? How many companies did these technicians represent?
       Answer 13b: The WO32 master HVAC technicians have observed 15 technicians from 10 companies.
    c. What are the results of using these improper tools to measure these items?
       Answer 13c: Improper tools and procedures cause incorrect or unnecessary FDD and repairs.
    d. What are the criteria for determining which tools are proper to evaluate these items?
       Answer 13d: The criteria are based on manufacturer and industry specified criteria. The California Energy Commission requires digital thermometers to have dual channel capability in Celsius or Fahrenheit readout with accuracy of ± (0.1% of reading + 1.3°F) and resolution of 0.2°F, refrigerant pressure gauge shall have accuracy of plus or minus 3 percent, and airflow static pressure accuracy

shall be plus or minus 0.2 Pa.[5] The evaluation team is performing laboratory tests of measurement tool accuracy. Test results will be provided in the final EM&V report.

e. In the team's opinion, if we were to gather 10 master technicians in a room, would they all agree with the criteria that are being used to define the proper tools for evaluation of these items?
   Answer 13e: Industry measurement instrument standards need to be developed. The Criteria used to define proper tools are based on laboratory and/or field measurement calibration and application data. The WO32 EM&V study is performing laboratory tests of field measurement instruments to evaluate the criteria for proper tools. The lack of standards means that any 10 master technicians in the program would likely have different ideas regarding what constitutes proper tools.
f. Please describe the team's understanding of the definition of the baseline in the SCE Territory.
   Answer 13f: According to SCE, "Bringing a unit to baseline means that a contractor has completed all of the required repairs and maintenance to get the unit operating efficiently. Completing the Cooling Service Analysis (CSA) is often referred to as bringing a unit to baseline.[6]" The definition of the Standard 180 baseline is defined on page 2 of ANSI/ASHRAE/ACCA 180. "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." The WO32 team understanding of the SCE CQM program baseline definition and Standard 180 definition is as follows. If required repairs are not performed by technicians to bring a unit to the baseline, then the purpose of Standard 180 is not met. However, bringing a unit to the Standard 180 baseline does not provide sufficient evidence that a unit will be more energy efficient than it would be if a technician performed maintenance services without following Standard 180.
g. The memo does not address the test-in/ test-out procedures included in the SCE Program. Please comment on the team's observations of this process and if the units that were observed passed the test-out procedure during your observations.
   Answer 13g: The program requires test-in/test-out data for refrigerant charge and economizer measures but does not provide training regarding proper tools or procedures. Pre-observations found 60% of units with refrigerant under or over-charge and post-observations found 38% with under or over-charge. Therefore, refrigerant test-out services reduced refrigerant charge faults by 22%. However, all technicians were observed introducing non-condensable air and water vapor into the refrigerant systems. Three observed technicians did not repair broken open dampers, one increased minimum outdoor air damper position from closed to 1-finger open, and none of the technicians performed economizer repairs while being observed. The program provides incentives for

[5] California Energy Commission 2008 Building Energy Efficiency Standards – Effective January 1, 2010, 2008 Residential Appendices, pg. RA3-10, RA3.2.2 Standard Charge Measurement Procedure, RA3.2.2.2 Instrumentation Specifications. http://www.energy.ca.gov/title24/2008standards/
[6] Email message from Elsia Galawish, SCE, to Nils Strindberg, CPUC, July 18, 2013, 6:21 PM.

notched v-belts, thermostat adjustment/replacement, and coil cleaning but technicians generally perform these measures the same way without incentives. Approximately 92% of technicians surveyed had issues with tools or procedures in terms of performing maintenance services. Approximately half did not have EPA low-loss fittings on their refrigerant hoses. Of the technicians that did have low-loss fittings, many did not purge hoses of air and water vapor prior to attaching to Schrader valves. One technician used contaminated refrigerant from a reclaim tank to add refrigerant, which is a violation of US EPA 608 regulations. These faults cause non-condensables or contaminants to enter the system when attaching hoses or adding refrigerant. Additionally, few observed technicians used proper tools or procedures to measure relative humidity, airflow, economizer operation, damper position, coil cleaning, or fan belts. Most technicians did not check or install fan belts with proper tension or alignment which causes reduced airflow, efficiency, and premature failure. Field observations indicate a lack of understanding regarding how to properly diagnose faults and implement repairs. The problem appears to be with program design, implementation, protocols, and data collection and not with technicians who are working within established program parameters. The programs should be redesigned to provide more effective training, tools, protocols, and data collection.

14. The memo states, "Observations of training and technicians found that it can take an additional 2 to 4 hours to enter data for one unit into the program database."
    a. Data is entered into the tool at many different points in the program. Which stage of the process do these observations address?
    Answer 14a: The stage in the process is when technicians or office personnel are entering CSA data into the online data collection system.
    b. Can your team please describe:
        i. The number of observations that constitute this finding?
        Answer 14b i: Observations and interviews of 10 technicians performing work on 64 units indicate that it takes an additional 2 to 4 hours to enter all required data fields into the online data collection system.
        ii. How many companies those observations represent?
        Answer 14b ii: 8 companies.
        iii. The types of units for which data was inputted (i.e. number of compressors, number of circuits, etc.?)
        Answer 14b iii: 64 units and 112 circuits.
        iv. The program experience of the technician entering the data into the system (How many times has he/she historically inputted data into the tool?)
        Answer 14b iv: This information is unknown since the data is entered on paper forms by technicians and then entered into the online data collection system by office personnel. In one of the other statewide programs the technicians enter data on paper forms and this data is entered into the online system by the program implementers.
    c. From the observations, what contributed to the additional 2 to 4 hours of time it took to input the data?

Answer 14c: The data collection software includes approximately 110 to 160 questions and 290 to 425 fields of data per unit. Technicians must answer all questions in order to receive an incentive.

d. The memo mentions this finding was also from observations of training. Please describe which training(s) were observed and how many. Please describe why the team believes that observing a training would be a good indicator of the time it actually takes to complete data entry in a real life situation.

Answer 14d: One training class was observed in the SCE program and one two-day training session was observed in another statewide program. Virtually all field observed technicians collected CSA data on paper forms and contractor office personnel entered CSA data into the program database, typically 30 to 180 days after work was completed. In 2013, the program attempted to require technicians to enter on-site CSA data directly into the program database software. One technician was observed doing this, but it took too much time and he reverted back to paper forms. Therefore, in addition to observing training, only one technician in the field was observed using the online data collection systems and this technician told the master technicians he was going back to using paper forms. Interviews and observations of participants indicated that it takes about 2 to 4 hours to enter CSA data into the online database.

15. The memo specifies, "For the data logger sample the study attempted to work cooperatively with each program implementer to recruit contractors who received the largest share of incentives." Later in the memo it states that the 44 units with data loggers are in two service territories. The memo also goes on to say "One of the programs effectively recruited contractors for data logging who performed 100% of work. The other program recruited contractors for data logging who received less than 13% of total incentives in the program." Please confirm that SCE is one of those service territories and which percentage of total incentives applies to SCE.

Answer 15a: SCE is one of the programs and 6% (corrected from 13%) of total incentives applies to SCE for the data logger sample. This introduced "sample" and "referral" biases which could significantly affect the validity of results. In order to overcome sample and referral bias in the data logger sample, the EM&V study recruited 5 technicians from 4 companies for field observations who received 67% of total incentives. For SCE the field observation, sample includes participants who received 73% of total incentives.

16. The memo specifies "Observations indicate that technicians in this program enter CSA data on paper forms. Contractor office personnel use technician supplied paper forms to enter CSA data into the program database about 30 to 180 days after work is completed."

a. Please specify if this refers to the SCE program

Answer 16a: Yes. The SCE program allows six (6) months to bring the unit up to baseline (http://www.hvacoptimization.com/january-2013). "Are you approaching six-month CSA deadlines? As you likely know, any units you have enrolled in HVAC Optimization must be brought up to the baseline operating condition set by Standard 180. To achieve this baseline, and to be eligible for baseline task incentives, you must complete all the tasks prescribed by the Cooling Service Analysis (CSA) within six months of the effective date of the

Maintenance Agreement. Guidelines for completing CSA tasks: All CSA tasks must be completed with 183 days (approx. six months) of the policy effective date. The CSA incentive application must be submitted to the Program within 197 days of the policy effective date (approx. six months + two weeks). The program team will date stamp all incoming applications and reserves the right to reject any CSA applications received after the 197-day limit. As a best practice, we recommend submitting applications within two weeks of finishing work on CSA tasks."

b. If so, please indicate the number of technicians and contractors this observation refers to.
Answer 16b: These observations are based on interviews with 15 technicians and 14 contractors, representing approximately 90% of total incentives.

c. Please clarify if your team observed office personnel entering data into the program database about 30 to 180 days after work is completed, if this was shared with your team during the observation, and/or if it was based on a review of tracking data.
Answer 16c: The WO32 team learned about office personnel entering data from review of CSA forms for data logger sites provided by program personnel and interviews with participants. One statewide program participant who was interviewed said his company submits paper forms to the program implementer and the implementer enters CSA data into the online database.

17. Please provide more context and description around the statement, "Interim field observation results indicate that 85% of technicians previously performed maintenance measures in the same way."
    a. Please define interim field observations.
    Answer 17a: Interim field observations are mid-course observations based on the impact evaluation in progress.
    b. Also please explain what is meant by previously performed maintenance measures in the same way.
    Answer 17b: We mean that technicians perform service in the "same way" through the program as they did prior to participation in the program. Here are responses from the largest SCE program participants to the following question, "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)? (Yes, No)"
    1) Yes, since 1958, 2) Yes, since 1998, 3) Yes, for years with major accounts, 4) Yes, for 35 years, 5) Yes, been doing similar work since 2009, 6) Yes, for 30 years, 7) Yes, for 41 years, 8) Yes, since 2002, and 9) Yes, for more than 60 years. One participant provided the following response, "EMS installed in 2005 communicates and controls thermostats and economizers and receives diagnostic error codes (airflow, static pressure, compressor/motor faults), notched v-belts installed since 2008, coils cleaned with chemicals and power washer every three months since 1998, multi-layer air filters changed every three months since 2008.
    c. Please indicate how this was observed.
    Answer 17c: This was observed through interviews and communications with participants.

18. In terms of satisfaction scores, please indicate who was in the sample and how many subjects made up the sample. Please break this down by program and specify the specific numbers of the SCE territory. Also please include the specific wording of the questions and the rating scale utilized.

    Answer 18: Surveys were completed by 9 participating contractors in the SCE program, representing 73% of total incentives paid in 2010-12. Rating scale is 1 to 10. The specific wording of the questions is shown in the attached survey guides.

19. The memo states, "Seventy-one percent of participants indicated that they test and repair economizers. Observed technicians did not test or repair economizers, and most observed units had economizers."
    a. Please indicate how many participants were in the sample, how many respondents does 71% represent, and the method for obtaining this data.
       Answer 19a: The sample included 9 participants in the SCE program and 22 participants statewide. All participants were surveyed and direct ride-along observations were conducted of technicians in the field.
    b. Please provide more context regarding, "observed technicians did not test of repair economizers." How many units in the study had economizers? How many were not tested? How many were not repaired? How many technicians were observed for the total number of units in the study? What is meant by the term "test"? What does this observation indicate? Should they have tested the economizer during that maintenance visit observed? Were they planning to come back to repair the economizer? Was this asked?
       Answer 19b: Approximately 73% of units in the observation sample have economizers (i.e., 80 out of 110 units). Technicians tested 18 economizers, but none of the observed technicians performed repairs. The term "test" means a technician places the economizer in "service" or "test" mode to actuate the damper motor. This procedure does not fully test the economizer to determine if the economizer will function properly when outdoor air temperatures are below 70F to save energy. The observation indicates exactly what it says, "observed technicians did not repair economizers." Technicians were asked and encouraged to come back to repair economizers, but they have not done so.

20. The memo states "The evaluation study obtained paperwork for 17 units from the on-site observation sample. The program implementer provided data submitted by the contractor from the program database for these 17 units. Comparisons of technician paperwork to the program database found issues with incorrect entries for temperatures, pressures, required subcooling, and required superheat."
    a. Please indicate which programs these 17 units represent.
       Answer 20a: Statewide program in SCE.
    b. Please define "paperwork."
       Answer 20b: Paperwork is defined as data collected on paper forms to enter into the SCE program MPS.
    c. Please document the number of incorrect entries found per unit by program
       Answer 20c: Depending on available budget and time, this question might be answered in the final report after all EM&V data logger CSA maintenance tasks

are completed, and program paperwork is provided by implementers to the WO32 team.

d. How does the team characterize these incorrect entries?
Answer 20d: Incorrect entries are errors in paperwork information compared to information recorded during the observed CSA maintenance. Incorrect entries are also errors associated with data entries when calculated values or reported values are misunderstood by the office personnel and entered incorrectly. More examples will be provided in the final WO32 EM&V report.

21. What is the intended relationship between the laboratory studies and the impact evaluation?

Answer 21: Laboratory tests of maintenance faults (airflow, economizer damper position, refrigerant charge, and coil blockage), FDD, and efficiency (EER) will be used to determine the potential savings for each measure. Tracking data, observations, and survey responses will be used to develop realization rates for each measure. Laboratory and field test data will be combined with weather-normalized cooling load data based on building prototypes, vintages and climate zones to develop gross savings. Tracking data and realization rates will be mathematically and statistically combined with gross savings to calculate net load impacts.

22. The memo states, "In one program more than 50% of repairs are not working one year later." Which program does this apply to? How many units does 50% represent? How was it determined the economizers are not working? How many contractors and technicians are does this number represented by this number?

Answer 22: This is a local program and the current percentage is actually 62%, or 16 units out of 26 observed units. Field tests of economizers not working include: checking damper motor actuator, sensors, wiring/connections, control boards, and cold spray of sensor to determine if the economizer is capable of functioning. This represents at least two contractors. As noted above in question 19, while 71% of participants indicated that they test and repair economizers, observed technicians did not test or repair economizers. Most observed units had economizers."

23. The memo states, "Most questions address maintenance activities that do not save energy." Please explain which maintenance activities are addressed that do not save energy. Please note how the determination is made that these activities do not save energy.

Answer 23: The program data collection instrument includes 110 to 160 questions and 290 to 425 fields of data per unit. Interviews with participants indicate they previously performed preventative maintenance activities without the program. Activities not normally performed by technicians per manufacturer specifications include: condenser/evaporator coil cleaning, economizer diagnostic setup and repair (damper adjustment), refrigerant charge testing and service, and belt/sheave airflow adjustment. These measures have the potential to save energy if performed with proper training, tools, procedures, incentives, and data collection. Approximately 92% of observed technicians had issues with tools or procedures for measures that should save energy.

Observed technicians wash coils with water only. They are not opening condensing units to rinse between coils or rinse inside out to remove dirt per manufacturer specifications. None used proper tools to evaluate economizers or outdoor air damper position. Approximately 50% did not have EPA low-loss fittings on their refrigerant hoses. Those that did have low-loss fittings often did not purge hoses of air and water vapor prior to attaching to Schrader valves. 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. Only one technician used belt tension tools and none used belt alignment tools. Improper belt tension and alignment causes reduced airflow, efficiency, and premature belt/bearing/motor failure. Manufacturers provide instructions and charts for refrigerant charge testing/adjustment, condenser/evaporator coil cleaning, economizer diagnostic setup and repair, and belt/sheave airflow adjustment. Other activities in the list such as checking contactors are preventative maintenance items designed to avert outright unit failure, but are not energy savings activities per se.

24. What is the relationship between the lab study and the field study and how do the components integrate to inform the impact evaluation?

Answer 24: See answer 21 (above). The laboratory and field study are integrated to inform and guide each task in terms of research design, data collection, FDD, repairs, measures, and energy efficiency measures. Laboratory and field tests of maintenance faults (airflow, economizer damper position, refrigerant charge, coil fouling), FDD, and EER will be used to determine the potential savings for each measure. Tracking data, observations, and survey responses will be used to develop realization rates for each measure. Laboratory and field test data will be combined with weather-normalized cooling load data based on building prototypes, vintages and climate zones to develop gross savings. Tracking data and realization rates will be mathematically and statistically combined with gross savings to calculate net load impacts.

25. What is the relationship of the laboratory test on one particular unit to an assumed diversity of units in the field?

Answer 25: The 7.5-ton two-compressor unit was chosen for testing because it has 15% program market share, higher than any other unit in the programs. Other units will be tested that address the diversity of units in the field including: 1) Another 7.5-ton unit with TXV expansion device, 2) two 3-ton units with and without TXV expansion devices, and 3) field recovered units. Tests are being performed at Intertek Testing Services, Inc., Plano, TX. All units are fully instrumented and tested in an AHRI-certified laboratory per ANSI/AHRI Standard 210/240-2008 and ANSI/AHRI 340/360-2007. Most tests are performed at a range of "outside" drybulb/wetbulb temperature conditions in degrees Fahrenheit °F (i.e., 55/51, 60/54, 65/57, 70/60, 82/68, 95/75, and 115/80) to simulate various diurnal temperature swings across the California coastal, inland, mountain, and desert climate zones. Laboratory tests are being conducted to evaluate field measurement instrument accuracy, economizers, dual-compressor roof top units (RTU), single-compressor units, and field recovered units. The relationship of laboratory test results on these units will be representative of the diversity of units in the field based on dynamic similitude, which is a concept applicable to the testing of

engineering models. A model is said to have similitude with real applications if the two share geometric similarity, kinematic similarity and dynamic similarity. Similarity and similitude are interchangeable in this context. This means that units of similar design are expected to react in a similar manner. The laboratory units are being tested under a range of outdoor and indoor conditions with an economizer and varying damper positions, refrigerant charge, and airflow faults that are similar to conditions found in the field.

26. Can the team more specifically describe how the five CQM programs identified in this memo differ? For example, are the program theories different? Are the program designs different? Do program processes differ? Do the maintenance tasks required differ? How were these differences accounted for in the impact evaluation research plan?

    Answer 26: Statewide program theories are similar. Local program designs, processes, and measures differ, but have similar problems with respect to technicians achieving the performance baseline and improving energy efficiency. Statewide programs provide training on how to enter data into the program database, but do not provide sufficient training, tools, protocols, or feedback for technicians to improve energy efficiency. Local programs provide more training but all of the programs assume there are no significant industry issues with respect to technicians improving energy efficiency. Field observations of technicians in all programs regardless of the differences indicate a lack of understanding regarding how to properly diagnose faults and implement repairs to save energy. Observations indicate that technicians do not test, diagnose or repair all deficiencies, even though this is required in order to bring units up to the program-assumed performance baseline. Technicians are not properly repairing very many economizers. In one program it was discovered that more than 50% of repairs are not working one year later. These findings are similar to other evaluation studies.[7] Some units receive new economizer temperature sensors but the economizers don't work or dampers are set too far open to achieve the assumed energy savings. The problem appears to be with program design, implementation, protocols, and data collection and not with technicians who are working within established program parameters. 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.

27. Does the team believe in the basic premise that Standard 180 maintenance can save energy? If yes, under what parameters?

[7] A study of newly constructed buildings in California reported 64% economizer failures after 2 to 3 years of operation (Small HVAC Problems and Potential Savings Reports, California Energy Commission. October 2003. 500-03-082-A-25. http://www.energy.ca.gov/2003publications/CEC-500-2003-082/CEC-500-2003-082-A-25.PDF). Pacific Northwest National Laboratory study found 62.5% of economizers not working at a university laboratory building and 100% not working at a hotel in San Francisco. An evaluation in New England found 44% of economizers failed within 2 years. See Commercial/Industrial Persistence Studies, Appendix M: Persistence of Savings from Mechanical System Measures Installed in the Energy Initiative and Design 2000 Programs," prepared for New England Electrical Systems (NEES) by HEC Inc. June 1993. See Economizers in Air Handling Systems, Continuing Education and Development, Inc., Stony Point, NY.
https://www.cedengineering.com/upload/Economizers%20In%20Air%20Handling%20Systems.pdf.

Answer 27: ACCA 180 is a check list of 30 maintenance activities. It is a list of what to do, not how to do it. It does not provide instructions or information regarding how to save energy.

28. Does the order of the maintenance tasks impact how effective Standard 180 is in achieving energy savings? Did the team observe technicians conduct tasks in a specific order or was the order random?

Answer 28: Yes. Field observations indicate that refrigerant testing performed prior to cleaning coils and changing air filters can cause diagnostic faults that would not occur if the coils were cleaned and air filters were changed first. Some technicians test refrigerant charge before cleaning coils and installing clean air filters. This can produce incorrect FDD and lead to improper charge adjustments. None of the technicians purged hoses prior to hooking up and this contaminates the system with non-condensables. None of the observed technicians properly tested economizer or made repairs to non-functional economizers, but the program paid incentives anyway even though the unit was not brought to the performance baseline. The SCE program trains technicians to turn off power to units before removing panels and this removes fault codes from the unit. 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. The average statewide participant satisfaction score for data collection is 4.3 +/- 1.8 (out of a scale of 1 to 10). Local program participants had no complaints and provided higher average satisfaction scores for data collection of 9.0 +/- 0.9. All participants indicated that quality maintenance is important. Seventy-three percent of participants indicated they had pre-existing maintenance agreements with customers to perform quarterly, semi-annually or annual maintenance. Those that did not have pre-existing maintenance agreements are in local programs. The average statewide participant satisfaction score for training is 6.9 +/- 1.7, and the average local participant satisfaction score for training is 9.8 +/- 0.3. The average statewide participant satisfaction score for incentives is 5.8 +/- 1.5, and the average local participant satisfaction score for incentives is 6.4 +/- 1.4. The average statewide participant overall satisfaction score is 6.4 +/- 2.1, and average local participant overall satisfaction score is 9.0 +/- 0.8. One contractor indicated that the current statewide program has too many questions that do not pertain to energy efficiency. This contractor indicated that the current software is worse than using paper forms and requires tasks to be performed out of order and inappropriate for season (i.e., heating tasks during cooling season).

29. Does the team think there would be value in the program prescribing specific maintenance processes and the tools used?

Answer 29: Yes.

30. What should the program be changed to more effectively capture energy savings? Why should these changes be made?

Answer 30: 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. The programs should begin exploring program design changes to improve training, tools, protocols, and data collection. Program redesign is necessary to teach technicians how to properly diagnose faults and make repairs to achieve energy savings.

31. In terms of the SCE program, do manufacturer specifications or Standard 180 supersede what is done on the roof?

Answer 31: The purpose of Standard 180 is defined on page 2 of ANSI/ASHRAE/ACCA 180. "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." The standard defines minimum requirements to "achieve acceptable" … "energy efficiency." Standard 180 does not address energy efficiency performance beyond the minimum standard. The CQM program needs to be redesigned to go beyond the minimum standard. California policy puts energy efficiency "first in the loading order."[8] This policy provides funding for energy-efficiency programs aimed at reducing the consumption of electricity and natural gas. What is "done on the roof" should be guided by maintenance activities beyond minimum standards that result in energy efficiency improvements to reduce electricity and natural gas use. Energy efficiency improvements resulting from cost-effective maintenance activities that are identified from laboratory tests, field measurements, and manufacturer specifications should be the first priority of an HVAC CQM program. Standard 180 provides a minimum list of what to check during a maintenance call but does not provide instructions regarding how to maximize energy efficiency and save energy. Additional items identified through EM&V research and specific protocols for successful implementation are needed to achieve energy savings.

32. How does the team characterize the MPS tool? What is team's opinion of the tool?

Answer 31: The MPS data collection software is extensive and includes approximately 110 to 160 questions and 290 to 425 fields of data per unit. Technicians must answer all of these questions in order to receive an incentive. Program data collection per single-circuit unit should not exceed 100 questions, which would include 25 site or unit-specific questions. For each additional circuit only 25 additional questions need to be included. Two of the most important pieces of information are not currently included in tracking data or database exports obtained through data requests for two statewide, including SCE, and two local programs: 1) technician name, and 2) date work was performed. Approximately 80 to 90% of statewide participants indicated that programs ask too many redundant or irrelevant questions. Data collection requirements were expanded in 2013 to include not only each system, but each circuit. This makes data collection lengthy and often tedious. 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

[8] CPA, CEC and CPUC 2003. California Power Authority, California Energy Commission and California Public Utilities Commission, Energy Action Plan. http://www.energy.ca.gov/energy_action_plan/2003-05-08_ACTION_PLAN.PDF. See also http://www.energy.ca.gov/2008publications/CEC-100-2008-001/CEC-100-2008-001.PDF. (Accessed 2008-12-21)

comparison to a normal maintenance. Additionally, mistakes are often made by office personnel when entering data into the statewide program database. Most questions address maintenance activities that do not save energy. Without the program, technicians indicated that they would not answer so many questions to perform maintenance services. We recommend that the number of questions be reduced, and limited to only those measures that save energy (or absolutely required if ACCA Standard 180 is included in future programs). In separate data requests the counts of measures by technician are provided, but for the SCE and other programs it has required multiple data requests to link program official savings claims back to units where service was performed. Units with some, but not all measures completed have received some rebates and were not included in the detailed data request. The program workpaper assumes average savings for all units enrolled, but the program provides incentives per measure. For field measurement and observation knowing the specific measures for each unit is critical. A clear linkage between each unit in the program (as tracked in MPS) and official savings claims is recommended.

Memo 2: August 20, 2013

1. Please provide specific details on the sampling methods for each of the four types of field observations for each of the CQM Programs addressed in this memo. EMI requests to see a sample file that includes: the number of completed observations/interviews by technician, date (specific date preferable, month is acceptable), building, manufacturer, model, number of circuits, IOU territory, and city for each of the four types of field observations. This is essential to the work we are performing to understand the context around the data collected. Please note that we did read your response #3 to a similar question. However, given the complexities, we want to ensure accuracy of the data and believe getting the sample directly from you is the most effective way to ensure validity. Please also indicate the total number of observations that will be performed in 2013 for each of the four types of field observations to meet the WO32 research plan objectives.

   Answer 1. We can clarify details of the sample for the SCE CQM program. We are not providing the details for other IOU programs due to confidentiality requirements. SCE and PECI have a list of all units in the program that we have received through a data request. SCE and PECI have the dates of all data-logger and non-data-logger ride-along observations including make and model numbers. PECI provided CSA forms for all units except Site 1 in which the HVAC master technicians visited recently (see "M&V site tracker 6.6.13.xlsx"). We have attached the spreadsheet and forms received to date, although some additional forms are part of a pending data request. We were previously informed by PECI that some units at the SCE Costa Mesa site might receive additional work. The contractor has not communicated with us regarding when or if they will perform additional work. WO32 personnel called them a number of times to check. CSA data forms were requested for Site 1 in 2012. Therefore there will likely be no additional direct observations of pre-post monitored units or ride along direct observations for SCE CQM.
   The spreadsheet does not have dates of the ex-post inspections where HVAC master technicians will go back to sites to check economizer operation and operational issues. In the memo these were conducted for another IOU program. For SCE this work is

continuing and findings will be provided in the final report. A sampling plan of 50 units for the top contractors is currently under review.

2. In your response to Q1 you indicated, "EM&V on-site observation protocols for the four type of field observations follow the statewide or local program data collection protocols. EM&V master technicians obtained program data collection forms and attended program training to further clarify program data collection protocols."
   Can you please specify for the SCE program: 1) Specific Names of EM&V master technicians that attended training; 2) specific training(s) attended; and 3) dates of attendance?

   Answer: 2. EM&V master technician, Robert Eshom, attended SCE program training on 02/14/13 in Santa Ana, California. SCE program trainers were present and provided informal training to technicians during EM&V master technician observations conducted by Robert Eshom and/or Ean Jones. This occurred on 11/07/12 (Cost Mesa), 11/08/12 (Huntington Beach), 11/09/12 (Buena Park), 5/13/13 (Ontario), and 5/16/13 (Irvine). Additional observations have been and will be performed on units in 2013 to meet the WO32 research plan objectives. Findings will be provided in the final report.

3. In the memo it is stated, "Field observations were conducted of 73 participant air conditioning circuits and 22 non-participant circuits.[9] Observations conducted prior to technicians performing maintenance services of commercial air conditioning circuits identified 707 issues or 9.7 issues per circuit. Observations conducted during and after maintenance was performed on 55 circuits identified 567 faults or 10.3 faults per circuit (18 have not been observed)." In the response, you specified that it was not statistically significant, using a paired t-test for 55 pre- and post-observed units. You indicated the pre-faults per circuit are 10.1 +/- 0.8 and post-faults per circuit are 10.0 +/- 0.75. The sample size stayed the same yet the numerical values changed. We assume the post-fault number should be 10.3 and this was just a typo, but wanted to confirm?
   Also related, is that both in this excerpt as well as the except from the conclusion of the memo which states, "Observations conducted prior to technicians performing maintenance services of commercial air conditioning circuits identified 9.7 faults per circuit. Observations conducted during and after maintenance was performed identified 10.3 faults per circuit, an increase of 6%," there is an implication to the reader that you are comparing apples to apples with this. However, if we are inferring this correctly, the 9.7 issues per circuit value does not in fact represent the pre-maintenance paired t-test value, in includes additional sample points. The actual pre-maintenance paired t-test value is 10.1. Is this correct?

Answer 3: For the 55 pre- and post-observed units, the pre-faults per circuit are 10.1 +/- 0.8 and post-faults per circuit are 10.0 +/- 0.75. The pre-observation 9.7 faults and overall 10.3 faults per circuit include additional non-paired sample points. HVAC master technicians observed sites in SDG&E, and a business with multiple sites in both SDG&E and SCE from a contractor in both programs. Based on additional paired observations, it is likely that post-faults per circuit will change.

[9] Most packaged units have independent refrigerant circuits comprised of a separate compressor, evaporator coil, condenser coil, metering device, and refrigerant lines. Units larger than 5 tons can have 2 or more circuits.