California HVAC Contractor & Technician Behavior Study

Final Report

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INDUSTRY ACRONYMS

The following acronyms are used throughout this report.

AABC:	Associated Air Balance Council
ACCA:	Air Conditioning Contractors Of America
ASHRAE:	America Society Of Heating, Refrigeration, and Air-Conditioning Engineers
BAS:	Building Automation System
BPI:	Building Performance Institute
CEC:	California Energy Commission
CSLB:	Contractors State License Board
CST:	Condenser Saturation Temperature
EMS:	Energy Management System
EPA:	Environmental Protection Agency
EST:	Evaporator Saturation Temperature
HERS:	Home Energy Rating System
HVAC:	Heating, Ventilation, and Air Conditioning
HVACR:	Heating, Ventilation, Air Conditioning, Refrigeration
IOUS:	Investor-Owned Utilities
IHACI:	Institute Of Heating and Air Conditioning Industries
IGSHPA:	International Ground Source Heat Pump Association
LEED:	Leadership In Energy and Environmental Design
MCAA:	Mechanical Contractors Association Of America
MSCA:	Mechanical Service Contractors of America
NATE:	North American Technician Excellence
NBC:	National Balancing Council
NCI:	National Comfort Institute
PHCC:	Plumbing, Heating, Cooling Contractors Association
QI:	Quality Installation
QM:	Quality Maintenance
RMS:	Root Mean Square
RSC:	Required Subcooling
RSES:	Refrigeration Service Engineers Society
SEER:	Seasonal Energy Efficiency Rating
SMACNA:	Sheet Metal and Air Conditioning Contractors' National Association
SMWIA:	Sheet Metal Workers International Association
TABB:	Testing, Adjusting, and Balancing Bureau
TXV:	Thermal Expansion Valve
UA:	United Association
USGBC:	U.S. Green Building Council

EXECUTIVE SUMMARY

This report presents findings from the California HVAC Contractor & Technician Behavior Study undertaken by Energy Market Innovations, Inc. (EMI), Western Cooling Efficiency Center (WCEC), Verified, Inc., and Better Buildings, Inc. (BBI), on behalf of Southern California Edison (SCE) and Pacific Gas & Electric (PG&E). The purpose of the study was to gain a greater understanding of the HVAC market and to inform future California IOU HVAC program design. This project addresses the behavioral research area, Phase II, as recommended by Phase I, of the "HVAC Maintenance Energy Efficiency Study."

Through early conversations with key stakeholders, the research team identified the following research objectives to guide the research:

- To document contractors' and technicians' understanding of HVAC maintenance, installation, and service, and the protocols that exist within their companies for each.
- To identify contractors' and technicians' knowledge and use of industry standards such as ASHRAE/ACCA Standard 180 and Standard 4 (defined by the industry as "quality maintenance") and ACCA Standard 5 (defined as "quality installation") used by the California IOUs.
- To understand how contractors and technicians conduct diagnostics and remediation.
- To identify how contractors and technicians sell HVAC maintenance including product offerings, pricing structures, value propositions, and selling strategies.
- To document existing contractor business models.
- To identify contractors' and technicians' experiences with, interest in, and barriers to participating in utility HVAC maintenance/installation programs.
- To develop a sampling frame and a repeatable sampling frame definition process that best defines and characterizes the true population of California HVAC contractors.

The research team utilized multiple research methods to address the research objectives, including: (1) a telephone-based incidence study of California Contractors State License Board (CSLB) C-20 licensed contractors to determine the "true" population of HVAC contractors in the state of California, (2) an online contractor survey to understand behaviors related to HVAC maintenance, installation, and service, and to gain a better understanding of company characteristics, as well as contractors' understanding and use of standards, selling practices, and business models, and (3) an undisclosed field observation of residential HVAC technicians, followed by semi-structured interviews, to gain insight into how technicians actually provide HVAC services in the field. Due to the low sample size, the results of the field observations cannot be generalized to the entire population of HVAC technicians in California; however, the results highlight a number of important themes and provide additional data to support results of the larger surveys. Details of these methods are presented in Chapter 2 of this report.

Next is a summary of key findings across the various data collection efforts undertaken for this study. Following the summary of key findings is a list of recommendations that utilities may want to consider in implementing HVAC-related programs.

Summary of Key Findings

This section presents a summary of key findings with respect to the overarching research questions presented above. Also included is a summary of findings regarding contractor and technician training, as training and training opportunities may be important to consider for future utility programs.

Incidence of C20-Licensed Contractors in California

Results of the incidence study suggest that the CSLB C-20 list is not current with respect to contractor contact information. Thirty-seven percent of the phone numbers attempted for this study were deemed "unreachable," either because the number was disconnected, incorrect, or never answered after at least five call attempts. Although the list was pulled in December of 2011 and phone calls were conducted in April and May 2012, it seems unlikely that all 37% would have changed their phone number within this time period, and some had likely changed before the list was pulled. Contractors may close their business, move their business, or switch to another company, but this may not be frequently updated to the C-20 list.

The research team has outlined a repeatable process for defining and characterizing the true population of California HVAC contractors. Based on phone calls to 2,850 unique contractors, the research team estimated that the number of C-20 licensed contractors actively working in the HVAC industry in California is roughly 8,210 unique firms (90% confidence interval = 8,045 to 8,313).

Very few contractors focus their business on maintenance services. The overwhelming majority (97%) of active contractors reported that 50% or less of their company's jobs are in maintenance; only 3% said that maintenance represented more than half of jobs performed by the company. On the other hand, 37% of active contractors stated that more than half of their company's jobs were service-oriented, and 27% said that more than half of their company's jobs were installation work.

The number of contractors working with large commercial customers is small relative to the number of contractors working in the other sectors. While most contractors stated that they perform work in the residential (91%) and small commercial sectors (88%), the number that work in the large commercial sector is much lower (37%).

Utility Program Participation

Less than one-half of respondents who have participated in a Quality Installation or Quality Maintenance program are currently participating. Of the 297 installation contractors that completed the survey and conduct work in the residential sector (the IOUs are not currently offering a QI program for commercial customers), 81 (27%) indicated that they have participated in a Quality Installation (QI) program. Of these, only 35% stated that they are *currently* participating. Of the 296 maintenance contractor respondents who answered this question, 75 (25%) indicated that they have participated in a Quality Maintenance (QM) utility program, and of these, less than one-half (45%) stated that they are *currently* participating in such a program.

Many contractors are not aware of the existence of utility Quality Installation and Quality Maintenance programs. Of installation contractors that conduct work in the residential sector but had not participated in a QI program, 58% of respondents said they had not participated in a QI program because they were not aware that utilities offer such programs. Likewise, 58% of maintenance contractor respondents who had not participated in a QM program stated that they were unaware that utilities offer

these types of programs. Those who had participated reported advantages of participation including more satisfied customers and gaining new customers.

Awareness of "Whole House" programs is low, but reported interest in them is high. Although only 10% of residential contractors indicated that they had participated in such a program, 50% indicated that they would be interested in participating in such a program in the future.

Knowledge and Use of Industry Standards

Roughly 40% of contractors reported that they are aware of ACCA and ASHRAE industry standards, and most of those that were aware reported that their companies use the specifications on the job. Specifically, 39% stated they are aware of ACCA 5 (the residential and commercial HVAC installation standard), 45% stated they are aware of ACCA 4 (the residential HVAC maintenance standard), and 45% stated they are aware of ASHRAE/ACCA 180 (the commercial HVAC maintenance standard). Most of those aware of industry standards reported that they adhere to the majority or all of the standard's specifications on a job. Specifically, 83% of those aware of ACCA 5 stated that they adhere to the majority or all of the specifications on a job; reported adherence was 65% for ACCA 4 and 74% for ASHRAE/ACCA 180.

However, none of the technicians observed in a residential setting were knowledgeable of ACCA 4, and technicians stated that they did not use it as a guideline in their work. It is possible that the observed technicians were familiar with the contents of ACCA Standard 4, just not by name, but the technicians' observed maintenance practices did not come close to complying with ACCA Standard 4. While interviews completed for the field observations suggest that technicians may be more knowledgeable than their technical performance scores would suggest, technicians' behavior appeared more dependent on their company's protocols than on their depth of knowledge or ability to execute protocols.

Contractors and technicians do not generally associate "quality maintenance" and "quality installation" with industry standards, nor with utility programs. The most common criteria used to define quality installation was complying with city or state codes. Standards were only mentioned by 2% of respondents asked to define quality installation. However, installation contractors also mentioned specific tasks (correct system sizing, duct sealing) that are part of standards such as ACCA 5. The most common definition for quality maintenance, mentioned by 15% of respondents, included some type of inspections or testing. Contractors also mentioned doing a job the "right way," mentioned by 12% of survey respondents, and this was echoed in the field observations. Data gathered from the field observations corroborate the finding that quality maintenance is not a concept with a generally agreed-upon meaning. In many cases, the answer to the question indicated that quality maintenance is what the observed technicians had just performed, and non-quality maintenance would be what "other technicians" do.

Understanding and Protocols for Conducting Installation, Maintenance, and Service

Surveyed contractors tend to agree that there are many benefits of proper HVAC maintenance and installation. Over 80% of respondents indicated that proper maintenance and installation can improve air quality, increase customer comfort, increase energy savings/reduce electric bills, prolong the system's lifespan, prevent the need for repairs, and improve reliability.

Installation

Roughly two-thirds of contractors reported that they have formal policies for conducting installations and/or formal policies for following up with customers after installations. Nearly 70% of surveyed contractors stated that their companies have formal policies or guidelines that technicians are required to follow for installations.

A majority of contractors believe that the primary barrier to implementing high quality installation services is that customers are not willing to pay for it, while almost one-third reported a lack of contractor or technician knowledge. When asked about barriers to implementing high quality installation services, 62% of the contractors indicated that their customers simply did not want to pay for it. Additional barriers included that technicians lack the knowledge of what is necessary (29%) and that contractors/owners lack the knowledge of what is necessary to implement high quality installation (28%).

Almost two-thirds (64%) of contractors indicated that they have formal policies for following up with customers after an installation job. Phone calls were the most frequent means of following up with customers (29%), especially residential and small commercial customers. Maintenance agreements (22%) and maintenance follow-ups (19%) were the next most common ways of following up after an installation job.

Maintenance

Contractors tend to recommend more frequent maintenance check-ups for commercial customers. When asked how often their company recommends maintenance check-ups for their customers' HVAC systems, the average response was 3.1 check-ups per year for small commercial customers, 4.3 check-ups per year for large commercial customers, and 1.6 check-ups per year for residential customers. This difference is expected, given that commercial HVAC systems can potentially be used more frequently and equipment breakdowns are a financial risk to the company.

While roughly two-thirds of contractors have formal policies for conducting maintenance procedures, it is unclear how many of these involve ACCA/ASHRAE standards. Sixty-four percent of surveyed contractors stated that their companies have formal policies or guidelines that technicians are required to follow for maintenance procedures. These respondents were asked in an open-ended format what their policies or guidelines included, and 41% stated that they use a checklist (without specifying what is contained in the list). Only 1% reported that their formal policies or guidelines include ACCA/ASHRAE standards. However, it is possible that the checklists and specific tasks are part of the ACCA maintenance standard, but contractors generally did not mention the standard by name.

Service

Service contractors feel that cost and age of HVAC units are key customer concerns when considering whether to repair or replace their HVAC unit. When asked to rank factors that influence customers' decision-making of whether to replace or repair an HVAC unit, survey respondents indicated that they most often view financial cost (67% ranked this factor in the top two) and age of the unit (53% ranked this factor in the top two) as top customer considerations. Similarly, when asked to report what triggers their company to recommend replacement rather than repair for their customers, survey respondents reported that high repair costs, the existence of old systems, and the existence of inefficient systems were the most common triggers. Although there is some evidence that contractors recommend replacing inefficient systems, these finding generally suggest that the focus is on minimizing customer costs and replacing older equipment, rather than on optimizing efficiency.

Conducting Inspection, Diagnostics, and Remediation

Overall, technical performance of the field-observed technicians providing typical "maintenance" services was below the standards of ACCA 4, utility "quality maintenance" program goals, and industry best practices as judged by the expert technician. During field observations, almost all of the technicians attempted some of basic maintenance tasks, such as checking the thermostat, inspecting filters, inspecting the metering device, and inspecting refrigerant line insulation, but few performed the tasks correctly. None of the technicians successfully carried out the following tasks: searching for duct leaks, cleaning the condenser coil, assessing the refrigerant charge level, measuring motor amps, looking for evidence of biological growth, or cleaning the evaporator coil. Performance level was not related to the technician's certifications, training, years on the job, nor participation in utility programs. Some of the most important tasks for energy efficiency, such as ensuring registers are open, measuring static pressure and temperature differences across the evaporator coil, and checking refrigerant charge, were frequently not attempted. Interestingly, *no* technician observed in the field study attempted evaporator cleaning, although 68% of surveyed contractors stated that the evaporator coil is inspected and cleaned/adjusted as necessary during a typical residential maintenance visit. This provides evidence of a disconnect between contractors' stated practices and technicians' practices in the field.

Results of the field observations suggest that the requirements of conducting "quality maintenance" often conflict with other demands that technicians face. Technicians face demands from both their company (or their own monetary goals if sole practitioners) and from their customers. These include time constraints placed on each visit, and the perception that customers have two primary priorities: making sure their system is functioning (however effectively) and spending as little money as possible.

A number of noteworthy tasks were left off contractors' lists when they reported what their technicians perform during a typical installation or maintenance visit. At least 80% of contractors indicated that their technicians perform most of the tasks listed in the survey during a typical installation or maintenance visit. The most infrequently reported installation tasks included calculating correct sizing for equipment using Manual J, testing ductwork to determine maximum system size, installing new refrigerant lines, and providing the customer with documentation of installation procedures. Contractors were least likely to state that maintenance technicians measure airflow across heat exchanger/coil, inspect ductwork for biological growth, or inspect the integrity of all accessible ductwork.

While surveyed contractors indicated that digital refrigeration gauges are often used in the field, this conflicted with results of the field observations. For installations, 89% of survey respondents stated that technicians measure refrigerant charge, and for maintenance visits, 77% of survey respondents stated that technicians measure refrigerant charge. Furthermore, surveyed contractors reported that digital refrigeration gauges are the most used tools for diagnostic tests. However, none of the observed technicians used a refrigeration system and airflow analyzer (refrigeration gauge). Interestingly, a greater percentage (57%) of surveyed contractors reported that they *need* digital refrigeration gauges, compared to the percentage of contractor respondents who reported that they are in the top three tools *used* by their technicians to perform diagnostic tests (44%). This may reflect a discrepancy between the tools that contractors believe their technicians use in the field and what actually takes place in the field. This supports the possibility that technicians may lack digital refrigeration gauges, and this could be why they were not used during the field observations.

Selling Maintenance Services

The survey responses and field observations conflicted with respect to how frequently technicians sell maintenance services directly to customers. Overall, approximately 50% of surveyed contractors

stated that they rely on their technicians to sell maintenance services directly to residential customers; this is contrasted with the field observations, during which only three of the thirteen technicians (23%) offered maintenance agreements without being prompted to do so. The field observation interviews indicated that the observed technicians promoted maintenance agreements when it was required by their company but did not offer a maintenance agreement if they were not required to do so.

Respondents whose companies do not actively sell maintenance services indicated that the primary reason for not doing so is the perception that customers do not want to pay extra money for regular maintenance. A primary barrier indicated by the field observations was that technicians do not want to seem "pushy," especially if customers can care for equipment that is in relatively good condition themselves. The basis for the assumption that homeowners are able and willing to conduct maintenance tasks on their own is unclear.

When communicating the benefits of proper HVAC maintenance to customers, technicians often only present basic explanations, as opposed to providing concrete reports of benefits and costs or examples with customer-specific data. Contractors reported that when selling maintenance service to customers, technicians most often provide a "basic explanation of benefits" resulting from proper HVAC maintenance, reported by 70% of contractors whose technicians sell directly to customers. Forty-one percent indicated that technicians are explicit with how maintenance addresses each benefit (e.g., energy savings, electric bills, and indoor air quality). Contractors did not frequently report that technicians write up a service report that addresses benefits and costs (indicated by only 18% of respondents) nor did they frequently report that technicians show the customer data gathered with diagnostic tools to demonstrate how much money they can save (indicated by only 10% of respondents). Field observations found that technicians usually emphasized the "perks," such as discounts and priority service, rather than the services themselves or the maintenance benefits.

Contractor Business Models

Typically, maintenance contracts stipulate multiple technician visits per year, rather than a single visit. Eighty-two percent of survey respondents indicated that they typically stipulate a contract with multiple maintenance visits. The duration of maintenance contracts is typically one year, with generally more visits per year for commercial customers (most commonly four visits) than for residential customers (most commonly two visits).

Pricing of maintenance contracts varies by sector and system type. Forty-three percent of respondents indicated that the customer pays for maintenance based on a rate that is specific to customer sector. Roughly one-third stated that the customer pays based on a rate specific to the type of system. Contractors were more likely to report that contracts with commercial customers were more likely to be based on the size of the unit, compared to contracts with residential customers.

Service calls are also priced somewhat differently depending on sector. In pricing service calls, the most common pricing scenario in the commercial sector is to base cost on a technician's hourly rate, noted by 65% in the small commercial sector and 81% in the large commercial sector, but only 48% in the residential sector. Residential contractors were more likely to report that service pricing is most often based on the number and type of repairs performed (51%), compared to small commercial (36%) and large commercial (29%) contractors

Training

Contractors are very interested in receiving training from both manufacturers and from utilities. About three-quarters of respondents indicated they were either "interested" or "very interested" in training from these sources. Surveyed contractors overwhelmingly reported that they perceive on-the-job training to be the most effective for teaching quality installation skills. Contractors rated online courses as least effective.

Post-observation interviews indicated high levels of technician pride in their training and ongoing education. Observed technicians generally viewed themselves as well-trained, expert professionals, regardless of actual performance.

Considerations for HVAC Stakeholders

The HVAC activities that the CPUC, California utilities, and industry stakeholders such as ACCA, ASHRAE, NATE, HVAC training organizations, and others desire to promote are at odds with many of the elements prevalent in current contractor business models. Although the results of the field observations are not generalizable due to the small sample size, the field results were quite consistent; despite a clear request to dispatchers over the phone and technicians on-site, "quality maintenance" was not provided. While it is not definitive whether most technicians are capable of executing best practice tasks, it is more apparent that the prevailing contractor business model is a barrier to conducting quality maintenance. The field observations and the survey results suggest that contractors and technicians may focus more heavily on price-driven customers by providing the minimum possible service for the lowest possible price than on quality-driven customers by providing quality service at the applicable price.

Utilities, the CPUC, and industry proponents of achieving energy efficiency through enhanced HVAC contractor and technician behavior appear to face an uphill climb with respect to transforming the market. However, research indicates that there are strategies these market actors can explore in the near-term to begin this process. Below, the research team presents four key considerations with specific recommendations for each market actor group. Rather than treat these as isolated considerations, they should be considered together and prioritized to overcome the barriers presented by current contractor business models. That is, pursuing an isolated recommendation without considering how it fits with current contractor business models will likely not be fruitful.

1. **Educate technicians and contractors on the specifics of the ACCA/ASHRAE installation and maintenance standards.** Although surveyed contractors reported that standards are often implemented in the field, none of the observed technicians were knowledgeable of ACCA 4, and technicians stated that they did not use it as a guideline in their work. Linking the national industry standards with technicians' knowledge and skill sets may help technicians perceive the performance of high quality maintenance and installation within a larger industry context that could increase technicians' motivation to perform to that level and increase the sense of pride associated with the skills.
    a. **Utilities:**
        i. One way to begin to accomplish this is to more actively advertise the ACCA/ASHRAE standards on utility HVAC program websites and through related outreach materials.

   b. **Utilities, Industry Stakeholders:**
      i. Technician training programs should consider placing more emphasis on the standards and the standards' names, what they represent, the specific tasks and approaches involved, and how to perform the tasks correctly.
      ii. Encourage contractors to help link technicians' performance with the national standards by incorporating the standards into the expectations and policies set for their technicians. This includes educating technicians on the value proposition of quality maintenance and quality installation.

2. **Investigate how industry standards are communicated to technicians and how contractors follow up with technicians to ensure that standards are enacted in the field.** Survey results showed that a great majority of contractors aware of the standards reported that most or all of the standard's specifications are used in the field. However, this conflicted with field observation results.
   a. **CPUC, Utilities:**
      i. Future research could examine if and how contractors request that their technicians follow the specifications, and whether such contractors have procedures in place to check that their technicians are complying with these requests. This additional research could examine how company policy gets translated into fieldwork, and how contractors ensure that policies are followed.

3. **Determine how "Quality Installation" and "Quality Maintenance" programs should be branded, and what the primary message should be based upon.** When asked how they define "quality maintenance" or "quality installation," very few survey respondents and none of the observed technicians cited a utility program or ACCA/ASHRAE standards, and over half of those who had not participated in utility QI or QM programs were not aware that such programs exist. It is unclear whether the issue is that: ACCA and ASHRAE have been unable to widely establish the names and nicknames of Standards 4, 5, and 180 as "Quality Installation" and "Quality Maintenance"; whether the utility programs based on the standards have not been effectively marketed; or whether the terms may compete with other pre-existing and well established meanings (e.g. maintenance is avoiding failure, quality work is "what we do").
   a. **CPUC, Utilities:**
      i. Investigate whether the terms "quality installation" and "quality maintenance" are terms that technicians can readily differentiate from "good" maintenance, as it is regularly understood.
      ii. Investigate whether program names could be altered to include references to "standards-based" maintenance or "ACCA/ASHRAE-based" maintenance to more clearly link quality practices with the standards themselves.
   b. **Industry Stakeholders:**
      i. Provide insight to the CPUC and utilities as to how best to address the QI and QM branding issue.
   c. **All Stakeholders**:
      i. Pursue additional market research with contractors and technicians in order to collect data regarding the fluency with which the utility program names can be linked with standards-based practices, as well as specific data on the effectiveness of the current marketing strategies for these programs.

4. **Develop sales and technical training for contractor firm staff.** Survey results and field observations revealed that, when selling maintenance services, technicians do not frequently provide concrete evidence of benefits and costs or provide examples using customer-specific data. Furthermore, almost one-third of survey respondents reported a lack of contractor or

technician knowledge as barriers to implementing high quality installation services. Survey results indicate that contractors are interested in receiving technical training from utilities, particularly if it is "on-the-job" training.

a. **CPUC, Utilities**:
    i. Research best practices in sales training processes/approaches specific to HVAC services and then synthesize these best practices in a manner useful to contractors, technicians, dispatchers, and salespeople.

Additional considerations for technician and contractor training and influencing the sales of maintenance services include:

b. **All Stakeholders:**
    i. **For training initiatives, carefully consider not just the skills of technicians, but also the goals of the contracting firms and the perceived goals of customers.** Companies need to fulfill their monetary goals, and field observations and survey results suggest this is often accomplished by offering low-price and brief-visit maintenance services. Customers may be perceived as interested only in functional equipment with minimal time and financial investments.
        1. To increase the implementation of ACCA/ASHRAE standards, technicians will likely need to see the goals of quality technical performance as consistent with the goals of their employers and their customers.
        2. Contractors and technicians will need to learn to see customers as a heterogeneous group, where some are interested in the more traditional goals of saving money and avoiding failure, but others may be looking for opportunities to optimize energy savings and explore advanced technologies.

    ii. **Develop analysis tools that help persuade customers about quality installation and quality maintenance.** Contractors, as well as the technicians that were observed for this study, hold the perception that customers are primarily interested in minimizing costs. Therefore, a way to quantify savings that can be expected from maintenance and installation activities that are performed according to industry standards will help contractors, technicians, and customers to see the benefits of quality maintenance and quality installation. Although quantification of savings may be difficult and perhaps not even possible, it is worth undertaking this effort, because quantifying savings is a key route to justifying programs based on the standards. Quantification of savings will help convince contractors and technicians that quality maintenance and quality installation are compelling products/services to recommend, and quantified savings will provide customers with a compelling reason to implement quality maintenance or quality installation.
        1. Explore the feasibility and value of providing stakeholders with easy-to-use energy savings estimating software that would make it possible for technicians, salespeople, contractors, and end-users to determine the approximate energy and monetary savings from quality installation and

quality maintenance in specific buildings. One way to do this is to coordinate with stakeholders currently working on closely-related issues outside of the utilities.[1] In addition, estimates could be developed for savings associated with specific tasks called for by industry standards, and these can then be rolled up to provide a range of savings that can be expected at the customer level.[2,3]

5. **Undertake a field observation study similar to that conducted for this research that examines the behavior of technicians of contractors that currently participate in utility HVAC programs.** The field observations completed for this research observed a limited number of technicians from SCE Program participant companies. One of these three technicians told the research team that "SCE Maintenance" would achieve the same result but would take much longer to complete. A field observation study that focuses on program participating contractors could examine the extent of this sentiment or behavior in the field.
    a. **CPUC, Utilities:**
        i. A systematic study of maintenance behavior of technicians from participating contractors could shed light on the circumstances under which technicians and contractors promote the utility HVAC programs.

[1] An example of coordinated research includes the International Energy Agency "Annex 36 Quality Installation/Quality Maintenance Sensitivity Studies." In 2010, the International Energy Agency (IEA) established a collaborative international effort to investigate the impact of quality installation and quality maintenance on HVAC performance. Participating countries are France, Sweden, United Kingdom, and the United States. On behalf of the U.S., the Air Conditioning Contractors of America (ACCA) is serving as a co-Operating Agent for the Annex 36 initiative with the U.S. National Institute of Standards & Technology (NIST) as well as with Oak Ridge National Laboratory (ORNL).

[2] One example of an "estimator" for a measure is the Demand Control Ventilation Savings Estimator developed at academic institutions and made publicly available. See http://customer.honeywell.com/Business/Cultures/en-US/Products/Applications+and+Downloads/Economizer+Logic+Module+%28W7212%29+Simulator+and+Demand+Control+Ventilation+Savings-Estimator.htm

[3] Another example of a savings estimator that addresses a measure that contributes to quality installation and/or quality maintenance include the "Rooftop Unit Comparison Calculator" developed at Pacific Northwest National Laboratory. This calculator simulates the energy usage of both a high efficiency and a standard efficiency air conditioner and then compares their energy and economic performance. See http://www.pnl.gov/uac/costestimator/main.stm

1. INTRODUCTION

This report presents findings from the California HVAC Contractor & Technician Behavior Study undertaken by Energy Market Innovations, Inc. (EMI), Western Cooling Efficiency Center (WCEC), Verified, Inc., and Better Buildings, Inc. (BBI), on behalf of Southern California Edison (SCE) and Pacific Gas & Electric (PG&E). In addition, the study's scope and budget was expanded to collect data to inform the statewide HVAC Market Effects Study. The purpose of the study was to gain a greater understanding of the HVAC market and to inform future California IOU HVAC program design. This project addresses the behavioral research area, Phase II, as recommended by Phase I, of the "HVAC Maintenance Energy Efficiency Study."

Through early conversations with key stakeholders, the research team identified the following research objectives to guide the research:

- To document contractors' and technicians' understanding of HVAC maintenance, installation, and service, and the protocols that exist within their companies for each.
- To identify contractors' and technicians' knowledge and use of industry standards such as ASHRAE/ACCA Standard 180 and Standard 4 (defined by the industry as "quality maintenance") and ACCA Standard 5 (defined as "quality installation") used by the California IOUs.
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Organization of Report

This report is organized into eight chapters. The next chapter reviews the data collection methodology in detail. Chapter 3 describes the results of the incidence study, and Chapter 4 summarizes the characteristics of the online survey respondents. Chapter 5 provides results of the online contractor survey and the field observation study with respect to HVAC maintenance, Chapter 6 provides results with respect to service, and Chapter 7 provides results with respect to installation. Chapter 8 provides conclusions and recommendations.

Eight appendices accompany this report. Appendix A contains the criteria that surveyed contractors used to define the residential, small commercial, and large commercial sectors. Appendix B contains the incidence study survey instrument, and Appendix C contains the online contractor survey instrument. Appendix D provides a description of characteristics for each of the subsamples assigned to the residential, small commercial, and large commercial online survey modules. Appendix E provides the technical observation checklist used during each of the field observations, and Appendix F defines the correct implementation of technical tasks for residential HVAC maintenance used in evaluating the field observations. Appendix G contains the recommended repairs provided by the observed technicians. Under separate cover is Appendix H, which is the data for the online contractor survey. The data are publicly available in both Excel and SPSS format; any identifying information, including open-ended responses, has been deleted to maintain respondent confidentiality.