California HVAC Contractor & Technician Behavior Study

Final Report

CALMAC Study ID SCE0323.01

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September 14, 2012

Energy Market Innovations, Inc., Western Cooling Efficiency Center (WCEC), Verified, Inc., and Better Buildings, Inc. (BBI) would like to thank Brett Close, Southern California Edison Project Manager, for providing leadership and direction throughout this project. We also would like to thank Derek Jones, Pacific Gas & Electric Project Manager, for his support and insight during to this project. Finally, we would like to acknowledge contributions from Ed Vine, Ralph Prahl, Lynn Hoefgen, and Rohit Vaidya to the success of this project.

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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.
- 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 these 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 C-20 licensed 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.

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.

2. METHODOLOGY

This chapter of the report provides the methodological details for each of the three specific research efforts conducted for this study: (1) the incidence study telephone survey, (2) the online contractor survey, and (3) the field observations and follow-up interviews.

2.1. Incidence Study Methodology

The incidence study telephone survey was conducted during April and May 2012. Calls were made during weekday business hours (7 am to 5 pm, Pacific Daylight Time). Surveys lasted approximately 10 minutes each. The research team aimed to complete surveys with C-20 license holders representing 260 unique contractor firms (hereafter referred to as "contractors") that were actively working in the HVAC industry, and who also agreed to provide their email address for participation in the online contractor survey. Surveys were terminated at various points in the survey if a respondent indicated they did not hold a C-20 license, they were not currently working in the industry, or if they preferred not to provide their email address.

The sample frame for the incidence study was developed from the list of contractors contained in the California Contractors State License Board (CSLB) active C-20 list, obtained on December 17, 2011 from the CSLB.[4] The C-20 database was considered the appropriate starting point for developing the sample frame because HVAC contractors are required to be licensed to conduct business in California.[5] Because the research team wanted only one response per contractor firm, the list of 10,806 C-20 contractors was de-duplicated by both company address and phone number. This process resulted in 10,486 unique contractors with phone numbers. Phone calls were made to a randomly selected sample of 2,850 of these contractors.

Of the 2,850 contractors contacted for the survey, 496 agreed to take the survey, representing a response rate of 17%. Of the 496 who agreed to take the survey, 260 completed it in its entirety (9% completion rate) and 236 were either terminated (either due to not working in the HVAC industry, not holding a C-20 license, being unable to answer key questions, or answering all survey questions but not willing to provide their email address for the follow-up telephone survey) or refused to complete the survey at some point. Of the 236 respondents that did not complete the entire survey, 187 respondents provided enough information to inform the estimates for the incidence study (i.e., they answered key questions regarding activity in the HVAC industry and C-20 licensure).[6] Thus, of the 2,850 initial calls, a total of 447 cases (260 completes + 187 partial completes) provided enough information to inform the incidence study. Call dispositions for the incidence study are shown in Table 2-1.

[4] This file did not include contractors with suspended licensees. These cases were removed by the CSLB prior to EMI receiving the data file.

[5] Although "underground" contractors could be working while unlicensed, there was no reliable method for identifying such contractors. Thus, the study focused on contractors included on the C-20 list.

[6] Using these 187 responses was considered appropriate by the research team because these respondents agreed to the telephone survey, and there is no reason to suspect that their responses are any less valid.

Table 2-1: Incidence Study Call Dispositions

Call Disposition	Frequency	Percent
Call completed or partially completed	447	16%
Not reached (call back later, answering machine, etc.)	1,427	50%
Refusal	587	21%
Unreachable - disconnected, wrong number, or never answered	367	13%
Language barrier	14	<1%
Reached, but terminated/refused prior to answering industry/licensure questions	8	<1%
Total	**2,850**	**100%**

One notable finding from Table 2-1 is that 367 phone numbers were found to be disconnected, wrong numbers, or never answered. On the one hand, these cases may represent contractors no longer in business – legitimate adjustments to the incidence rates; on the other hand, the contact phone numbers provided to the research team might have had typographical errors, the phone number might have been changed, or some other issue may have existed to prevent phone contact even though the company was still in business – not legitimate adjustments to the incidence rates. Because this was a notable proportion of the sample (13%) the research team examined this issue further by taking a sample of 58 cases (which provides 90% confidence and +/-10% relative precision[7] to extrapolate findings to the 367 cases) with no valid phone number and conducted Internet searches based on company names and contact names to attempt to locate valid numbers.

As shown in Table 2-2, of the 58 cases examined, alternate contact information was found for 16 contractors (28%); no valid contact information was found for the remaining 42 cases (72%). Also shown is that the original 367 unreachable cases were reclassified using the proportions found from the 58 sampled cases, with 266 still being classified as unreachable (i.e. "not in business") and 101 cases considered "in business."[8] In order to derive more accurate estimates of the actual incidence of HVAC contractors in the state of California – and not overstate the proportion of contractors no longer in business – the research team incorporated the added information gained from this follow-up of initially unreached contractors. These results are incorporated into the final population incidence estimates as shown in Chapter 3 (Table 3-1) of this report.

[7] Calculated precision levels apply specifically to results reported as proportions.

[8] Although the research team did try to call the follow-up cases for which we found new contact information to determine industry/licensure status, the response rates were similar to the larger sample and not enough cases with complete data resulted from this effort.

Table 2-2: Follow-Up Call Status for Initially Unreachable Phone Numbers

Follow-up Status	Frequency	Percent [A]	Initial Call Status Unreachable [B]	Cases Reclassified [A] x [B]	Classification
No phone number located	42	72%	367	266	Not in business [(a)]
Phone number located	16	28%		101	In business
Total	**58**	**100%**		**367**	

(a) The research team felt reasonably confident that the contractors for whom no valid number could be located were no longer in business. This assertion is based on the premise that a working phone number is required in order to procure business, and contractors actively working in the HVAC industry would thus be motivated to answer their telephone, provide means to leave a voice message, or provide a new phone number if the old phone number had been changed

2.2. Online Contractor Survey Methodology

The online contractor survey was conducted during May and June of 2012. The sample frame for the online contractor survey was assembled from a variety of sources, as follows.

- Incidence study respondents (from CSLB C-20 list)[9]
- HVAC-related union members in California:
  - SMACNA (Sheet Metal and Air Conditioning Contractors' National Association)
  - MCAA (Mechanical Contractors Association of America)
  - MSCA (Mechanical Service Contractors of America)
- CSLB C-20 license holder list
- PG&E QI/QM program participants
- NATE (North American Technician Excellence) C3 certified contractor list
- HVACR Business Magazine subscriber list
- Dun & Bradstreet listings with an SIC code of 1711

The entire list of contacts was de-duplicated by company name, address, and phone number, which left 11,917 cases[10]; however, email addresses were available for only 3,495 of these contacts. De-duplicating by email address resulted in a total sample frame of 3,482 unique contractor contacts with email addresses. The research team classified these contacts as shown in Table 2-3. Roughly half of those that completed the incidence study telephone survey completed the online survey. The completion rate among the union sample (5%) was lower than that among the C-20 email list (12%), and the reason for the lower completion rate among the union sample is not clear. However, the fact that some companies in the union sample were not HVAC contractors (e.g., some companies manufactured sheet metal) likely contributed to the lower completion rate.

[9] Although generally considered the most comprehensive list of HVAC contractors in the State, the CSLB C-20 list contained only phone numbers and no email addresses. Respondents to the incidence study telephone survey were asked for their email address as part of the survey.

[10] This number is somewhat greater than the 10,486 unique contractors contained on the C-20 list due to the number of additional data sources.

Table 2-3: Online Survey Sample Frame and Completion Rate

Sample Source	Sample Size	Number of Completes	Completion Rate
Incidence study respondents (from C-20 list) [(a)]	260	129	49.6%
Union members with email addresses	347	18	5.2%
C-20 list, minus incidence study completes, with email addresses	1,400	172	12.3%
Contractors with email addresses, not on the C-20 list	1,475	24	1.6%
Total	**3,482**	**343**	**9.9%**

Note. "Sample Size" provides the number of unique contractors for which an email address was available. Many additional contacts could not be used for the online survey because no email address was available.
(a) Five of the 260 incidence study respondents were union members. All of the 260 incidence study respondents were C-20 license holders.

An email invitation with the survey link was sent to all 3,482 contacts in a staggered fashion. Respondents were offered a $75 gift card as an incentive to complete the survey. All sample contacts were sent four periodic email reminders, with the exception of the contractors with email addresses not on the C-20 list, who were sent two reminders. This is because the first invitation to this group was sent two weeks before the study closing, and thus it did not make sense to send this group more than two reminders. In total, 343 respondents completed the survey. The 343 completed responses were inspected for any duplicates by company name, but no duplicates were identified. All 343 respondents were sent a $75 gift card.

Table 2-4 shows the distribution of the online contractor survey respondents in terms of the positions they hold in their companies. The vast majority of all respondents (85%) indicated they were the owner of their company (63%) or the President/CEO (22%). Almost one-half of the remaining respondents (7% of total) were General Managers. None of the other positions accounted for more than 2% of the respondents.

Table 2-4: Employment Positions of Online Survey Respondents

Position	Percent (n = 343)
Owner	63%
President/CEO	22%
General Manager	7%
Service Manager	2%
Technician	2%
* Vice president	1%
* All of the above	1%
Other	2%
Total	**100%**

Note. Asterisks (*) indicate coded open-ended responses.

A more detailed characterization of the contractor respondents is presented in Section 4 of this report.

Assigning Online Survey Respondents to Survey Modules

The online survey presented different modules based on both the sector within which contractors work (Residential, Small Commercial, or Large Commercial) and the types of jobs regularly performed by contractors (Service, Maintenance, and Installation). The screening portion of the survey (conducted over the phone for incidence study respondents and online for all others) determined the modules to which the contractors were assigned.

All respondents were assigned to all three job-type modules, provided that at least one percent of their work included each job type. Job-type modules were presented in random order. Due to length of the survey, each contractor was assigned to only one sector; survey questions were very similar across the three sector types. Respondents were asked the percentage of jobs that their company completes in each sector and were assigned to answer questions for one sector based on their responses. Any contractor respondents who indicated that 10% or more of their jobs were in the large commercial sector were assigned to that sector. Respondents who indicated that large commercial jobs were less than 10% of their work and small commercial jobs entailed 20% or more of their work were assigned to the small commercial sector. The remaining respondents, all of whom conduct work in the residential sector, were assigned to the residential sector for purposes of completing the online survey. This strategy was used to ensure a roughly equal distribution of completes for each of the three sectors and to account for the fact that firms working in the large commercial sector are less common. The particular cut-off numbers were chosen based on preliminary results of the incidence study. Table 2-3 shows how the 343 respondents were assigned to each of the sector and job-type modules.

Note that the overall sample size of 343 respondents provides +/- 5.2% relative precision at the 95% confidence level. The size of each of the sub-samples shown in Table 2-5 is adequate to provide better than +/- 10% relative precision at the 90% confidence level. These precision levels apply to the reporting of proportions and do not apply to the reporting of means.

Table 2-5: Online Survey Completes by Sector and Job Type

Job Type	Residential (n = 126)	Small Commercial (n = 119)	Large Commercial (n = 97)	Total (n = 343)
Service	123	119	93	335
Maintenance	109	110	92	311
Installation	116	114	97	327

The strategy used to assign respondents to survey modules necessarily meant that those assigned to the residential module conducted a large percentage of their business in the residential sector. Table 2-6 shows the mean percentage of jobs performed in each of the sectors for respondents assigned to each of the three modules. As expected, those assigned to the residential module tend to perform a majority of their work in the residential sector, whereas those assigned to the small commercial and large commercial modules perform a relatively large amount of their work in other sectors. An acknowledged potential limitation of this study is that responses to the residential module are not representative of contractors that perform a substantial amount of work in other sectors; rather they tend to perform the majority of their work in the residential sector. Additional descriptions of the subsamples assigned to the three survey modules is provided in Appendix D.

Table 2-6: Mean Percentage of Jobs in Each Sector, by Survey Module Assignment

Survey Module Assignment	Percentage of Jobs Worked in Each Sector		
	Residential Mean (*SD*)	Small Commercial Mean (*SD*)	Large Commercial Mean (*SD*)
Residential (n = 126)	93.1% (5.2)	6.6% (4.9)	0.3% (1.0)
Small Commercial (n = 119)	60.3% (22.4)	39.2% (22.3)	0.4% (1.4)
Large Commercial (n = 97)	22.8% (23.5)	36.3% (21.9)	40.9% (27.4)

2.3. Field Observation Methodology

The field observations consisted of two main components: (1) the observation of technicians conducting a service or maintenance call on a system with an intentionally-implemented fault where technicians were unaware that researchers were observing them, and (2) a semi-structured interview with the observed technicians. A total of 16 field observations were conducted, but only 13 technicians provided consent to use their observations in this study and only 9 of these consented to a follow-up interview. 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. The Institutional Review Board at the University of California, Davis, approved the research methods used in conducting the field observations.

The research was conducted at the home of a research ally, in Corona, CA, over the course of three weeks in May 2012. A master HVAC technician tuned-up and conducted in-depth diagnostics of the HVAC system so that its performance was well understood both before the study as well as between technician visits. The master technician then imposed two controlled faults so that the unit's performance was degraded in a known way. Both faults (three closed air-supply registers, and fan control wires switched to be set on low speed instead of high speed) had the effect of decreasing evaporator airflow, which has a dramatic effect on capacity and energy efficiency. The airflow in the system was measured to be 250 cfm/ton, which is about 38% too low.[11] The artificially introduced faults gave the research team the opportunity to see how technicians diagnosed a problem with the system and how they used their diagnosis to offer repairs, offer maintenance services, and explain their work to customers. The intent of the study was not to have the flaw actually repaired, and the researchers halted the technician before this occurred.[12]

The research team identified a population of 138 HVAC service companies that could be contacted for services in the area of Corona, CA. The list was crafted collecting information from yellow page searches

[11] Low airflow of less than 350 cfm/ton is a common fault occurring in HVAC systems See Parker, D., Sherwin, J., Raustad, R., Shirey, D., "Impact of Evaporator Coil Air Flow in Residential Air Conditioning Systems," Florida Solar Energy Center (FSEC), FSEC-PF-321-97. Available at http://www.fsec.ucf.edu/en/publications/html/FSEC-PF-321-97/index.htm. [Accessed August 1, 2012.]

[12] As discussed in Chapter 5, only four technicians detected that the air-supply registers were closed, and only two technicians detected that the airflow was too low. Despite this, many observed technicians made recommendations for repairs; see Appendix G.

for areas adjacent to Corona, Google searches for HVAC companies in areas adjacent to Corona, SCE program participating contractor lists, and recommendations from expert consultants on this study.

To ensure the study was able to observe technicians from a variety of contactor firms with different qualifications and involvement with the industry, researchers originally targeted a sample of 16 companies, including:

- Four companies that were participants in SCE programs.
- Four companies that mentioned NATE (North American Technician Excellence) certification on their websites.
- Four companies that had websites but did not mention SCE programs or NATE certification.
- Four companies that did not have websites and could only be contacted by phone.

After categorizing the 138 companies into these four groups, companies were contacted randomly within each group. A total of 34 companies were contacted in order to reach a final sample of 16 observations. Of the other 18 companies, 3 did not service the Corona territory, 3 had inaudible or outdated voicemail messages (e.g., "Merry Christmas!"), 2 said they would call back for scheduling but did not call, 4 did not conduct the type of service the study required (residential/maintenance), and the other 6 were either wrong numbers or stated the company was out of business.

HVAC companies were recruited using one of four scripts. Scripts varied in the description of the state of the units and the request of the technicians. The goal was to develop requests that regular homeowners would plausibly make, and also to ensure that researchers would observe a range of different service levels. The four recruitment scripts used were:

1. **Service/Maintenance**: *"I will be moving into this house in June,[13] and I would like you to send someone to make sure the AC is running well. I would rather not have any surprises when the summer comes, and I hear that the AC is not cooling as well as it used to. I would like to check if anything is wrong."*
2. **Maintenance**: *"I will be moving into this house in June, and I would like you to send someone to do maintenance on the AC, to make sure that it is running well. I would rather not have any surprises when summer comes. I don't know of any problems, but would like to know if there are any."*
3. **Thorough Maintenance + Energy:** *"I will be moving into this house in June, and I would like someone to conduct a thorough maintenance of my AC. I plan to use it a lot and want to know what I can do to have it perform at its best, and be the most energy efficient it can be. I would like to get a full inspection, to get it to work the best it can."*
4. **Thorough Maintenance + Energy + Utility:** *"I will be moving into this house in June, and I would like someone to conduct a thorough maintenance of my AC. I plan to use it a lot and want to know what I can do to have it perform at its best, and be the most energy efficient it can be. I would like to get a full inspection, to get it to work the best it can. I have a friend that works in the utilities and he has told me that there are different kinds of maintenance, and I want the best, that goes beyond what people usually get."*

[13] For all observations, one observer posed as the homeowner who already lived at the house, and the other observer posed as a friend of the homeowner who would soon be moving into the house.

In order to stage the most realistic scenario possible, and to gain reliable, unbiased results, each observation was conducted by a social scientist (behavioral observer) and a master technician (technical observer) who posed as the current and future homeowners. The two researchers interacted with the technicians in a realistic manner, asking them what they were doing along the way. The observers took mental notes on what the technicians were doing, both from technical and behavioral perspectives. The observers paid particular attention to whether the technicians used a maintenance checklist, how the technicians diagnosed the system, what diagnostic tools they used, and how the technicians interacted with the "homeowners" in a sales/service capacity. Immediately upon completion of each visit, the master technician completed a predefined checklist of tasks that the technician might perform in the occupied space, attic, and outside at the condensing unit. This checklist was excerpted from ACCA Standard 4 (the residential HVAC maintenance standard), and included all of the typical tasks that the researchers agreed a skilled technician should undertake (see Appendix E). In addition, the master technician also indicated whether or not the technician correctly diagnosed the two intentionally imposed faults.

Once the maintenance call was completed and paid for, the researchers revealed to the technician that he was observed as part of a research study. At this point, technicians were asked if they consented to their observation being included in the research study results. Technicians were given an explanation about the goals of the study, were guaranteed the protection of their confidentiality, and were asked to participate in a post-observation interview to take place immediately or at a later time (i.e., on the phone at a time the technician was not "on-the-clock"). The post-observation interview was used to assess why the technicians conducted the maintenance call as they did and what factors they considered in making the decisions about system diagnostics, recommendations, and sales offers for maintenance agreements. Technicians were provided with a $100 cash incentive upon completion of the interview.

The final sample of 13 companies whose technicians consented to participate comprised:

- Four SCE Program participant companies that were also NATE C3-certified.
- Three companies that were NATE C3-certified (and not SCE participants).
- Two companies that did not have websites.
- Four companies that had websites but did not claim NATE certification or SCE programs.

Of the 13 technicians who consented to having their observations included in our analysis, 11 also accepted to participate in a post-observation interview. However, 2 of them were unable to schedule the interview due to schedule conflicts. The sample of 9 interviewed technicians comprised:

- Three technicians from SCE Program participant companies that were also NATE C3-certified (two were NATE certified technicians; one of the technicians was not NATE certified).
- Three technicians from companies that were NATE C3-certified (and not SCE participants).
- One technician from a company that did not have a website.
- Two technicians from companies that had websites but did not claim NATE certification or SCE programs.

It is worth noting that the requirement to be a NATE C3-certified company is that 50% of the technicians are NATE certified, which means that it was possible to be assigned a non-NATE certified technician from one of these companies. Two of the technicians sent from SCE/NATE companies were not NATE certified. On the other hand, three of the technicians who came from the contractors that did not mention

NATE certification on their websites, or did not have websites, were NATE certified. In two of these cases, the NATE certified technicians owned their own small companies.

Due to the low sample size of the field observations, the results of the field observations cannot be used on their own to generalize to the entire population of HVAC technicians in California; however, the results of the field observations can be used to provide additional "in-the-field" evidence for findings of the larger surveys which were undertaken with a statistically valid sample.

2.4. Analysis and Reporting

Results presented throughout this report are unweighted. The research team considered weighting results of the online survey by sector, but ultimately decided not to do so. Weighting is typically used to ensure the sample obtained is proportionally representative of the population under consideration. However, weighting by the number of respondents across the residential, small commercial, and large commercial sectors would not have accomplished this. This is because, due to the length of the survey, each respondent only completed a single sector module (i.e. residential, small commercial, ***or*** large commercial), even if they did business in more than one sector. Thus, even though a respondent may have completed the residential module, they may also have operated in the small commercial and/or large commercial sectors. The research team felt that this would have made the influence of any weights misleading. Additionally, it is worth noting that the research team did conduct some analyses using possible weighting schemes, and no substantive differences were found.

Results for the online survey are generally reported by sector, which reflects the organization of the survey and shows how responses might be similar or different according to the type of customer the contractor is serving. One other possibility was to examine results by contractor size, as it is possible that the practices of larger firms differ from those of smaller firms; however, this was not within the scope of this project, and thus results by size are not reported.

Findings and interpretations of results are accompanied by statistical tests when possible. In many cases, in order to conduct valid chi-square tests of independence (i.e. meeting the assumptions of no expected cell counts of 0, and no more than 20% of expected cell counts less than 5), the data were restructured from what is shown in tables and figures. Because some categories or responses had cell counts that were too small, in some cases they were collapsed with other categories or responses to allow for valid tests; in some other cases, no logical collapsing was feasible and some categories or responses were not tested. The results of all statistical tests are provided in the text, and when restructuring or the elimination of categories or responses occurred, footnotes describe the nature of the restructuring or elimination. In addition, some results simply did not have enough cases in total to allow for valid statistical tests. With these results, notable differences are discussed, but the limited number of responses is also noted.

Note that percentages shown in tables may not add to 100% due to rounding.

3. INCIDENCE STUDY RESULTS

This chapter of the report provides the results from the incidence study. Overall, the objectives of the incidence study were as follows.

1. Estimate the incidence of C-20 contractors who are actively working in the HVAC industry.
2. Estimate the incidence of C-20 contractors who offer installation, maintenance, and/or service.
3. Estimate the incidence of residential, small commercial, and large commercial contractors.
4. Collect email addresses and recruit contractors who are: (1) active and (2) offer installation and/or maintenance services for the online contractor survey.

3.1. Incidence of C-20 Contractors Actively Working in the HVAC Industry

Respondents to the telephone survey were asked whether their company was currently working in the HVAC industry and if they personally held a C-20 license in the state of California. There were a total of 447 responses to these two questions, including partial completes and those who terminated later in the survey. However, in order to get an accurate estimate of the population of C-20 contractors currently working in the HVAC industry in California, it was important to also consider the call dispositions for the entire sample of 2,850 contacts telephoned for participation in the study. Of the 2,850 total calls made for this study, 2,036 were not completed but the final call disposition did provide enough information to determine that the contractor was still in business. Initially, 367 other calls resulted in dispositions including disconnected numbers, wrong numbers, and calls that were never answered even though at least five attempts were made during normal business hours. These latter dispositions suggest that perhaps some telephone numbers included in the C-20 list represent contractors that are no longer in business. This assertion is based on the premise that a working phone number is required in order to procure business, and contractors actively working in the HVAC industry would thus be motivated to answer their telephone, provide means to leave a voice message, or provide a new phone number if the old phone number had been changed. However, by conducting follow-up Internet searches by company name and contact name, the research team was able to estimate that of the 367 initially unreachable phone numbers the actual number of out-of-business contractors was likely closer to 266 (see Table 2-2 above).[14]

Table 3-1 shows the incidence study results extrapolated to the population. Overall, a total of 2,850 contractors were called for the study and of this, industry activity and C-20 licensure status was determined for 447 contacts based on completed or partially completed calls (Columns A and B). Additionally, after careful assessment of the unreachable phone numbers as discussed above, a total of 266 cases (or 9% of the total population) were deemed out of business. Column C shows that of the

[14] Briefly, the follow-up analysis of initially unreachable contractors was conducted by taking a sample of 58 of the 367 cases (to provide 90% confidence +/-10% relative precision for results reported as proportions) with no initially valid phone number and conducting an Internet search to determine if a functional phone number could be found. Of the 58 total cases, the research team was able to locate 16 (28%) updated phone numbers, but was unable to find new information for the remaining 42 cases (72%). The updated status of this sample of 58 cases was then extrapolated to the total 367 cases.

contractors in the C-20 list that were deemed in business (447), 86% were found to be currently working in HVAC and holding a C-20 license; 2% were currently working in the HVAC industry with no C-20 license, and 11% were no longer working in the HVAC industry. Column D of Table 3-1 shows the allocation of the remaining 2,137 cases deemed still in business to the industry/licensure statuses proportional to the sample findings. These 2,137 cases consist of the 2,036 additional calls that were attempted but the final call status did not provide enough information to determine industry/licensure status (i.e. answering machine, refusals, language barrier, callback scheduled but not completed, or otherwise terminated), along with the estimated 101 cases that were initially unreachable but for which the follow-up analysis allowed the research team to determine the contractor was still in business (see Footnote 14). Column E and F represent the "adjusted" frequencies and percentages for each industry/licensure status after incorporating the information on the still in business cases. Overall, the research team estimated that 78% of the C-20 list contractors are currently working in the HVAC industry and hold a C-20 license, 2% are currently working in the industry but do not hold a C-20 license, 10% are not currently working in the HVAC industry, and 9% are no longer in business. However, it is worth noting that the estimated proportions for the three categories accounting for in-business contacts may be slightly lower than indicated – and thus, the not-in-business proportion slightly higher – because the research team assumed that "refusals" and "terminates" were in-business contractors and were distributed in proportions equal to the three categories of sample contacts that were reached for the incidence study. In reality, some of these "refusals" and "terminates" may not be in business.

Finally, the estimated sample totals were then extrapolated to the population of unique contractors in the CSLB C-20 List (n = 10,486 after de-duplicating the list by both company address and phone number) to determine an estimate of the number of active C-20 licensed contractors in the state of California. Overall, based on the results presented in Table 3-1, the research team estimated that 78% of the contractors called for this study were active in the HVAC industry with C-20 licenses, which corresponds to a statewide population of contractors of roughly 8,210 unique firms (90% confidence interval = 8,045 to 8,313).

Table 3-1: Survey Respondents' Activity in HVAC Industry and C-20 Licensure and Estimated Population Size

Industry/Licensure Status	Incidence (Surveyed Contractors) Frequency [A]	Incidence (Surveyed Contractors) Percent [B]	Percent of Subtotal [a] [C]=[A]/447	Estimated allocation of not-completed calls [b] [D] = [C] x 2,137	Adjusted Sample Totals [c] Frequency [E] = [A] + [D]	Adjusted Sample Totals [c] Percent [F]	Estimated Statewide Population Size [G] = [F] x 10,486 [d]
Currently Working in the HVAC Industry/Holds a C-20 License	386	54%	86%	1,845	2,231	78%	8,210
Currently Working in the HVAC Industry/No C-20 License	11	2%	2%	53	64	2%	234
Not Currently Working in the HVAC Industry (Indicated by Respondent)	50	7%	11%	239	289	10%	1,063
SUBTOTAL	**447**		**100%**	**2,137**			
Not Currently in Business (Unreachable - Phone Disconnected, Wrong Number, or Never Answered)	266	37%			266	9%	979
TOTAL	**713**	**100%**			**2,850**	**100%**	**10,486**

(a) The subtotal only considers the 447 cases that were reached for the survey and provided enough responses to determine industry and licensure status.

(b) A total of 2,137 cases are allocated to the population based on the proportions derived from the completed and partially completed calls (Column C). This consists of 2,036 calls that were made but not completed where the call disposition indicated the contractor was still in business (i.e., answering machine, refusals, language barrier, callback scheduled but not completed, or otherwise terminated), as well as the estimated 101 contractors from the follow-up analysis of initially unreachable phone numbers discussed earlier in section 2.1.

(c) Note that the estimated proportions for the three categories accounting for in-business contacts may be slightly lower than indicated, and the "Not Currently in Business" proportion may be slightly higher, because the research team assumed that refusals and terminates were in-business contacts and were distributed in proportions equal to three categories of sample contacts that were reached for the incidence study.

(d) 10,486 is the number of unique contractors after the list of 10,806 C-20 contractors was de-duplicated by both company address and phone number.

3.2. Incidence of C-20 Contractors Who Offer Service, Maintenance, and/or Installation

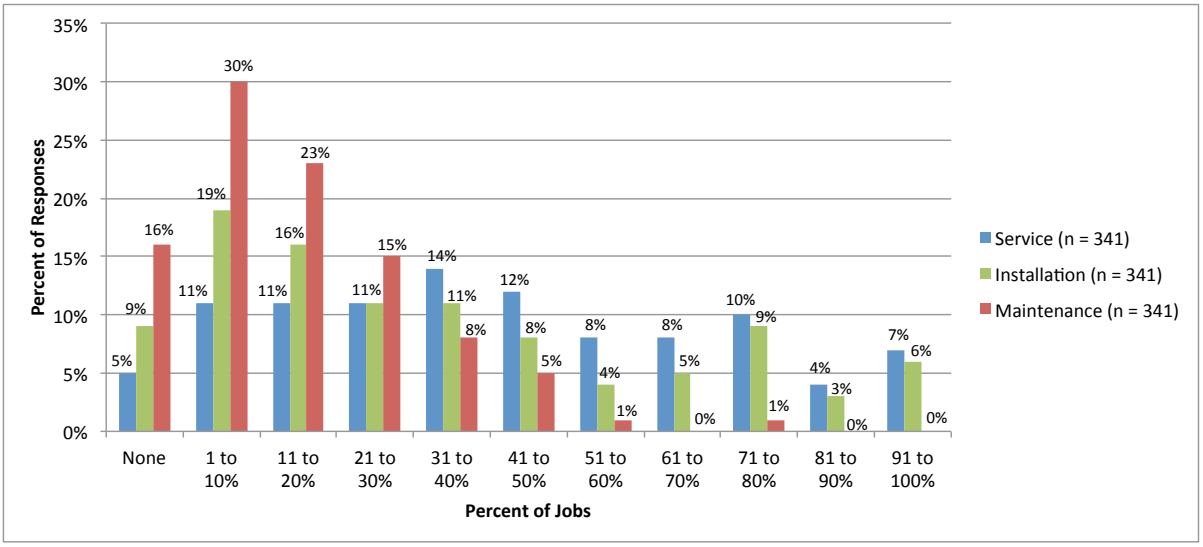
Incidence study survey respondents were asked to report the percentage of their company's business (based on the number of jobs completed) that comes from service calls, maintenance visits, and installation jobs. These types of jobs were defined in the survey as follows:

- Service calls: Appointments made to fix a fault in HVAC systems that either shut the system down or inhibit the system's operation to the point that the customer detects a problem.
- Maintenance visits: Checkups to inspect, test, measure, and preserve an HVAC system.
- Installation jobs: Projects where the primary purpose is to install new equipment or replace existing equipment.

Figure 3-1 shows responses to this question, received from 341 contractor respondents who hold a C-20 license (in addition to the 260 "completes," 81 partial respondents hold a C-20 license and answered this question). Most contractors reported that at least some of their jobs were in each of the categories, with 95% reporting that they do at least some service jobs, 91% reporting that they do some installation jobs, and 84% reporting that they do at least some maintenance jobs.

It is interesting to note that the overwhelming majority (97%) of respondents 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 respondents 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. Whereas maintenance and installation jobs are positively skewed, service jobs approach more of a normal distribution.

Figure 3-1: Installation, Maintenance, and Service as a Percentage of Jobs Among C-20 Contractors



Note. Responses were provided on a continuous scale from 0 to 100. Responses were categorized into groups of 10% each for the sake of brevity.

Table 3-2 shows the estimate of the population of C-20 licensed contractors in California that perform work in service, maintenance, and/or installation. The population estimate is based on the total estimated population of currently active C-20 licensed contractors computed in Table 3-2. Most of the estimated active population of C-20 contractors is expected to perform at least some work in each of the three job types.

Table 3-2: Incidence Estimates of C-20 Contractors Who Offer Service, Maintenance, and/or Installation

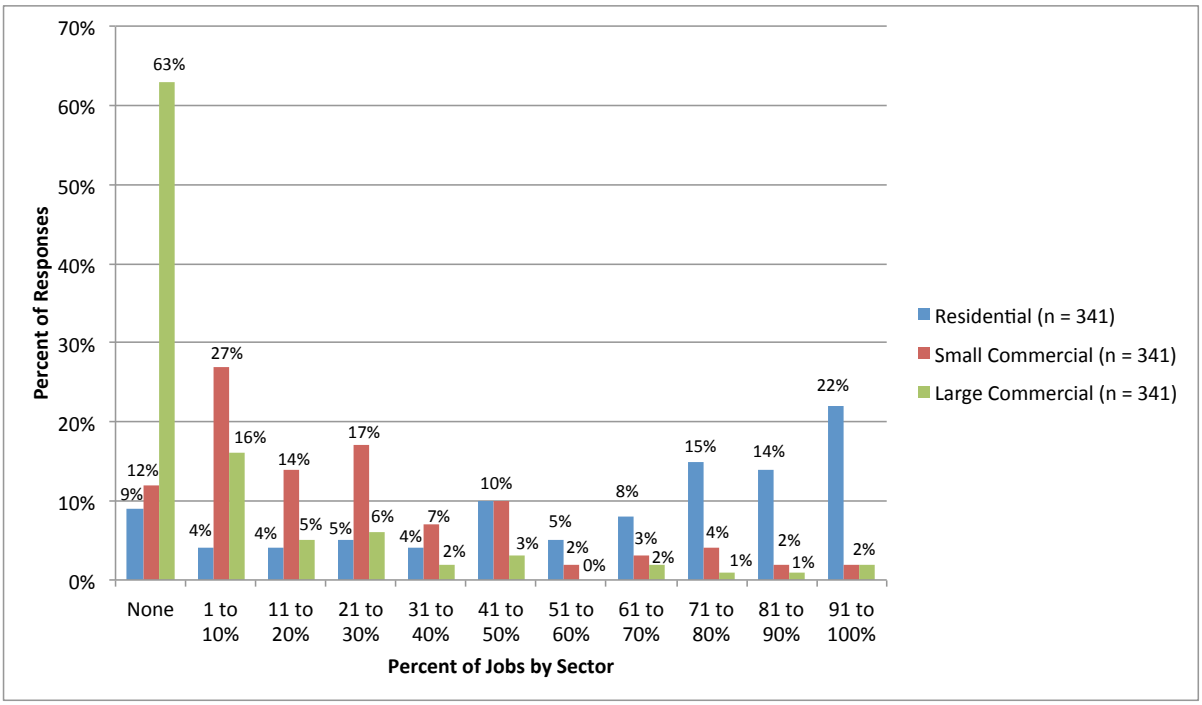
Job Type	Percent of Sample Performing At Least Some Work In Each Job Type (n = 341)	Extrapolated to Active C-20 Population (N = 8,210) [(a)]
Service	95%	7,800
Maintenance	84%	6,896
Installation	91%	7,471

Note. Numbers in each column are not mutually exclusive, as many contractors perform more than one type of job.
(a) See Table 3-1 for the computation of the Active C-20 Population.

3.3. Incidence of Residential, Small Commercial, and Large Commercial C-20 Licensed Contractors

Respondents were also asked to report the percentage of their company's work (based on the number of jobs completed) that is conducted in the residential, small commercial, and large commercial sectors. Most C-20 licensed contractors reported that at least some of their jobs were performed with customers in both the residential and small commercial sectors, with 91% reporting that they do at least some jobs with residential customer and 88% reporting that they do at least some jobs with small commercial customers. Only 37% reported that they do at least some jobs with large commercial customers. Figure 3-2 shows the frequency of responses across all 362 C-20 licensed respondents who answered this question. Whereas large commercial jobs are highly positively skewed, and small commercial jobs are somewhat positively skewed, residential jobs are negatively skewed.

Figure 3-2: Percentage of Company's Work by Sector Among C-20 Contractors



Note. Responses were provided on a continuous scale from 0 to 100. Responses were categorized into groups of 10% each for the sake of brevity.

Table 3-3 shows the estimate of the population of licensed C-20 contractors in California that perform work in the residential, small commercial, and/or large commercial sectors. Again, note that the numbers shown are not mutually exclusive, as many contractors perform work in more than one market sector. As expected, given the pattern seen in Figure 3-2, most C-20 contractors perform work in the residential and small commercial sector, and many fewer perform work in the large commercial sector.

Table 3-3: Incidence of C-20 Contractors Who Perform Work in the Residential, Small Commercial, and/or Large Commercial Sectors

Sector	Percent of Sample Performing At Least Some Work In Each Sector (n = 362)	Extrapolated to Active C-20 Population (N = 8,210)
Residential	91%	7,471
Small Commercial	88%	7,225
Large Commercial	37%	3,038

Respondents were also asked to state, in an open-ended format, how they define each of the three sectors, and these open-ended responses were coded and tallied. The full list of coded responses is provided in Appendix A. Table 3-4 shows a brief summary of responses for this question. Contractors most often

mentioned that they considered single-family buildings as residential, although 12% of comments specifically mentioned multifamily dwelling such as apartments, condos, or townhouses as a criteria, and 11% of comments mentioned "multifamily" as a criteria. Contractors most often defined the small commercial sector by describing aspects of the building's use or type of building (e.g., restaurant, strip mall). The commercial sectors were also frequently defined by describing equipment size or capacity. Contractors tended to define small commercial equipment capacity as "less than" a certain tonnage, whereas they tended to define large commercial equipment capacity as "greater than" a particular tonnage. For example, 19% of comments for defining the small commercial sector mentioned an equipment size of 10 tons or less, whereas 18% of comments for defining the large commercial sector mentioned an equipment size of 10 tons or greater.

Table 3-4: Summary of Criteria that Respondents Used to Define the Residential, Small Commercial, and Large Commercial Sectors

Most common responses	Percent of Comments - Residential (n = 231; 317 total comments)	Percent of Comments - Small Commercial (n = 217; 281 total comments)	Percent of Comments - Large Commercial (n = 97; 125 total comments)
Single family [(a)]	50%	-	-
Specific mention of condos, apartments, and/or townhomes	12%	2%	-
General multi-family comment	11%	-	-
Building/business type (e.g., restaurant, strip mall, high rise, etc.)	-	33%	28%
Equipment size of less than 10 tons [(b)]	3%	19%	-
Equipment size of greater than 10 tons [(c)]	-	1%	18%

Note. See Appendix A for full list of coded responses.
(a) This response was likely the most common because it was included as a prompt in the survey question.
(b) The "Equipment size of less than 10 tons" category groups all comments of less than 10 tons or less (e.g., includes responses of "less than 5 tons")
(c) The "Equipment size of greater than 10 tons" category groups all comments of greater than 10 tons or more (e.g., respondents who stated "greater than 15 tons" are included in this category).

3.4. Types of HVAC Systems That C-20 Licensed Contractors Work With

Finally, the incidence study asked contractors to report the percentage of their company's work that is performed on various types of HVAC systems. The number of respondents for this question was 254.[15] Table 3-5 shows the percentage of respondents who indicated that they do any type of work on each type of system. Also shown is the average response reported for the percentage of the company's work that is performed with each type of system. By far the most common type of system is a unitary system that is

[15] When the survey began, there was no requirement that the percentages across the types of systems add to 100. This was changed relatively early in the survey, and the 254 responses represent those for which the reported percentages add to 100%.

less than 20 tons. Ninety-five percent of contractors stated that they perform at least some work on these types of systems, and on average, 83% of their company's work was performed on these types of systems.

Those who stated that they conduct work with unitary systems less than 20 tons were asked whether these systems are most often integrated with sophisticated computer controls such as building energy management systems (EMS) or building automation systems (BAS). Twenty-one percent of respondents indicated that these systems were usually integrated with such controls.

Table 3-5: Percentage of Work Performed on Various Types of HVAC Systems

Type of System	Percent That Do Any Work With the Type of System (n = 254)	Average Percentage of Work Performed With This Type of System (n = 254) [(a)]
Unitary systems (split or packaged) that are less than 20 tons in capacity	95%	83%
Unitary systems (split or packaged) that are greater than or equal to 20 tons in capacity	40%	9%
Built-up Systems	28%	5%
Other types of HVAC systems	16%	3%

(a) The average is reported only for those who indicated they do some work on the type of system indicated (zeroes are not included).

Those who stated that they perform work on any "other" types of HVAC systems were asked to specify what the other types of systems were. These open-ended responses were coded and are shown in Table 3-6. The most common type of other system reported was chillers, followed by heat pumps and systems that are specifically designed for heating rather than cooling (e.g., furnaces, boilers, etc.).

Table 3-6: Other Types of HVAC Systems That Contractors Work On

Response	Frequency	Percent (n = 31)
Chillers	16	52%
Heat Pumps	13	42%
Heating	13	42%
Refrigeration	9	29%
Evaporative Coolers	6	19%
Hydronic Systems	5	16%
Exhaust	4	13%
Other	6	19%

Note. Multiple responses were accepted. Two respondents declined to answer this question, and this question was inadvertently skipped for eight respondents.

4. CHARACTERISTICS OF ONLINE SURVEY RESPONDENTS

This chapter summarizes the characteristics of the 343 online survey respondents, in terms of firmographics, a description of the tools commonly used by contractors to conduct diagnostics, and a description of survey respondents' participation in utility-sponsored HVAC programs.

4.1. Firmographics

Although there was variability across the respondents, overall, the "average" contractor had the following characteristics:[16]

- Has been in business for over 5 years (86%).
- Has an annual revenue of less than $1 million (74%).
- Works out of a single location (87%).
- Has fewer than 10 employees (82%).
- Employs staff that are not members of a union (92%).
- Does not belong to any industry associations (53%).
- Does not hold any certifications (56%).
- Works in the SCE (57%), SCG (45%), and/or PG&E (43%) service territories.
- Has an annual technician staff turnover rate of less than 5% (64%).
- Employs between one and four service/maintenance technicians (83%), between one and four installers (77%), between one and four design engineers (63%), and between one and four sales/estimators (84%). However, a single individual may fill one or more of these staff roles.
- In terms of hiring new technician staff, the following characteristics seem to matter (in rank order by percent that indicated the characteristic is "very important" or "important"): work ethic (96%), communication skills (94%), presentation (e.g., neat, dressed appropriately (92%), work experience (91%), formal HVAC education (75%), and union membership (11%).

The remainder of this section provides more detail on each of the individual characteristics.

Table 4-1 shows that of the 343 total contractor survey respondents, the great majority (86%) indicated that their company had been in business for greater than five years. Only 14% had been in business less than five years, while almost one-quarter (24%) had been in business 30 years or more.

[16] Overall, almost one-quarter of all respondents (24%) possessed all of the first seven characteristics shown in this list; roughly three-quarters (76%) possessed at least five of the first seven characteristics.

Table 4-1: Years in Business

Years in Business	Percent (n = 343)
Less than 5 years	14%
5 to 9 years	19%
10 to 19 years	22%
20 to 29 years	22%
30 years or more	24%
Total	**100%**

As shown in Table 4-2, the annual revenue of the majority of responding contractors was less than $1 million (74%); just under two-thirds of all respondents (61%) reported annual revenue of less than $500,000. However, almost one-quarter of all respondents (22%) indicated that their company generated at least $1 million a year.

Table 4-2: Company's Annual Revenue

Annual Revenue	Percent (n = 342)
Less than $100,000	20%
$100,000 to $249,999	22%
$250,000 and $499,999	18%
$500,000 and $999,999	13%
$1 million and $2,999,999	13%
$3 million and $7,999,999	4%
$8 million or more	4%
Prefer not to answer	4%
Don't know	1%
Total	**100%**

Note. One respondent did not answer this question.

Respondents were asked to characterize the facility where they worked. As shown in Table 4-3, the vast majority (87%) indicated that the facility where they work is their company's only location.

Table 4-3: Facility Type

Facility Type	Percent (n = 343)
Your company's only location	87%
The headquarters of a company with multiple locations	6%
A branch or franchise location of a company based in California	2%
A branch or franchise location of a company based outside California	1%
* Work in the field	2%
* My home	1%
Other	1%

Note. Multiple responses were accepted. Asterisks (*) indicate coded open-ended responses.

Table 4-4 shows that most responding contractors work at smaller firms, with roughly two-thirds (66%) having fewer than 5 employees. Only 8% of the respondents represented companies with 25 or more employees.

Table 4-4: Number of Employees

Number of Employees	Percent (n = 343)
1-4	66%
5-9	16%
10-24	10%
25-49	3%
50-99	3%
100 or more	2%
Total	**100%**

Only 29 of the 343 respondents (8%) indicated that employees at their company were members of a union. These 29 respondents were asked to which union(s) they belonged, and Table 4-5 shows that 79% were Sheet Metal Workers International Association (SMWIA) members, while 48% were United Association (UA) members.

Table 4-5: Contractors' Employees' Union Memberships

Union	Percent (n = 29)
Sheet Metal Workers International Association (SMWIA)	79%
United Association (UA)	48%
Don't know	7%
Other	14%

Note: Multiple responses were accepted.

Respondents were also asked to indicate if their company belonged to any of a number of HVAC industry associations. As shown in Table 4-6, over one-half (53%) of the respondents indicated that their company did not belong to any associations. Of those who did indicate that their company belonged to an association, the most common association membership was with Institute of Heating and Air Conditioning Industries (IHACI) (16%), Refrigeration Service Engineers Society (RSES) (13%), and Air Conditioning Contractors of America (ACCA) (11%).

Additional analysis was conducted to determine the extent of overlap among association memberships. Of those who indicated that their company belonged to an association, respondents reported that their company belonged to between one and four associations, with 70% reporting only one association membership, 17% reporting two association memberships, 9% reporting three association memberships, and 3% reporting four association memberships. Thus, it does not appear that contractors tend to join multiple associations.

Table 4-6: Contractors' Association Memberships

Association	Percent (n = 343)
No, my company does not belong to any associations	53%
Institute of Heating and Air Conditioning Industries (IHACI)	16%
Refrigeration Service Engineers Society (RSES) [(a)]	13%
Air Conditioning Contractors of America (ACCA)	11%
Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)	9%
Mechanical Service Contractors of America (MSCA)	3%
* ABC	1%
* ASHRAE	1%
* BPI	1%
* IGSHPA	1%
* NATE	1%
* NCI	1%
* PHCC	1%
* USGBC	1%
Other	3%
Don't know	2%

Note. Multiple responses were accepted. Asterisks (*) indicate coded open-ended responses.
(a) Note that only individuals, not companies, can be members of RSES. These respondents were thus referring to memberships held by individuals in their company.

Table 4-7 shows that over one-half (56%) of surveyed contractors indicated that their company had no HVAC-related certifications. Almost one-third (30%) said they were NATE C3-certified. No more than 3% of respondents mentioned any of the other certifications.

Table 4-7: Contractors' Certifications

Certification	Percent (n = 343)
Our company has none of these certifications	56%
NATE C3	30%
ACCA Quality Assured	3%
MSCA STAR	3%
National Balancing Council (NBC)	3%
Associated Air Balance Council (AABC)	2%
* BPI	2%
* EPA	1%
* HERS rater	1%
* NCI	1%
* RSES	1%
Other	3%

Note. Multiple responses were accepted. Asterisks (*) indicate coded open-ended responses.

Respondents whose firms conduct installation services were asked to report the percentage of their installation technicians that hold particular certifications. Table 4-8 shows that most commonly held certification among installation technicians is NATE. Next most common was HVAC Excellence, followed by RSES certification.

Table 4-8: Percentage of Installation Technicians with Certifications

Response	NATE (n = 264)	HVAC Excellence (n = 199)	RSES (n = 203)	UA STAR (n = 162)	PAHRA/ Industry Competency Exam (n = 181)	TABB (n = 180)
0-24%	56%	70%	71%	86%	78%	79%
25-49%	8%	4%	4%	0%	1%	2%
50-74%	9%	4%	2%	3%	2%	1%
75-100%	17%	9%	7%	2%	2%	2%

Note. "Don't know" responses are not shown and comprise the remaining responses.

Similarly, respondents whose firms conduct maintenance services were asked to report the percentage of their maintenance technicians that hold particular certifications. Again, as shown in Table 4-9, the most common was NATE. The next most common certifications were HVAC Excellence, RSES, and UA STAR.

Table 4-9: Percentage of Maintenance Technicians with Certifications

Response	NATE (n = 254)	HVAC Excellence (n = 193)	RSES (n = 194)	UA STAR (n = 194)	PAHRA/ Industry Competency Exam (n = 165)	TABB (n = 169)
0-24%	50%	68%	69%	69%	76%	78%
25-49%	6%	3%	6%	6%	3%	2%
50-74%	12%	6%	5%	5%	2%	1%
75-100%	24%	10%	7%	7%	2%	1%

Note. "Don't know" responses are not shown and comprise the remaining responses.

Table 4-10 shows that the service territory covered by the responding contractors covers the vast majority of the state of California. Over one-half (57%) operate in SCE territory, almost one-half (45%) operate in Southern California Gas (SCG) territory, 43% operate in PG&E territory, and almost one-third (30%) operate in Los Angeles Department of Water & Power (LADWP) territory.

Table 4-10: Service Territory

Response	Percent (n = 343)
Southern California Edison	57%
Southern California Gas	45%
Pacific Gas and Electric Company	43%
Los Angeles Department of Water & Power	30%
San Diego Gas and Electric	17%
Sacramento Municipal Utility District	11%
* Anaheim	1%
* Azusa Water & Power	1%
* Imperial Irrigation	1%
* Modesto Irrigation District	1%
* Pasadena Water & Power	1%
* Redding Electric Utility	1%
* Riverside	1%
* Roseville Electric	1%
* Southwest Gas	1%
* Turlock Irrigation District	1%
Other	3%
Don't know	1%

Note. Multiple responses were accepted. Asterisks (*) indicate coded open-ended responses.

Responding contractors were asked about the annual turnover in their technician staff. Table 4-11 shows that about two-thirds (64%) of responding contractors reported an annual turnover rate of 5% or less; almost three-quarters (74%) stated the annual turnover rate was less than 10%.

Table 4-11: Annual Technician Staff Turnover

Response	Percent (n = 336)
Less than 5 percent	64%
5 to 9 percent	10%
10 to 19 percent	7%
20 to 29 percent	4%
30 to 39 percent	2%
40 to 49 percent	2%
50 percent or more	2%
Prefer not to answer	6%
Don’t know	5%
Total	**100%**

Note. Seven contractors did not respond to this question.

The responding contractors were asked to report the number of employees in their company with the following roles: service/maintenance technician, installer, design engineer, and sales/estimator. Table 4-12 shows that the vast majority of contractors (83%) reported having between one and four service/maintenance technicians employed at their firm, just over three-quarters (77%) reported having between one and four installers, almost two-thirds (63%) reported having between one and four design engineers, and 84% reported having between one and four sales staff/estimators. Notable is that just over one-third (34%) of contractors indicated that they had no design engineers at their firm.

Table 4-12: Employees by Role

Role	0	1 to 4	5 to 9	10 or greater	Total
Service/Maintenance Technician (n = 333)	3%	83%	10%	4%	100%
Installer (n = 325)	3%	77%	11%	8%	100%
Design Engineer (n = 276)	34%	63%	1%	2%	100%
Sales/Estimator (n = 310)	10%	84%	4%	3%	100%

Note. Because some respondents skipped this question, the number of respondents varied for each role asked about.

The responding contractors were asked to rate the importance that their company placed on several characteristics when they seek to hire new technicians. Table 4-13 shows that 96% of respondents mentioned work ethic as "important" or "very important," while 94% mentioned communication skills as "important or "very important," 92% mentioned presentation (e.g., neat, dressed appropriately) skills as "important or "very important", and 91% mentioned work experience as "important or "very important." Interesting is the finding that formal HVAC education and certifications sit near the bottom of the list. Also notable is that two-thirds of all respondents (66%) indicated that union membership was "not at all important."

Table 4-13: Importance of Certain Characteristics When Hiring a Technician

Attribute	Very Important	Important	Somewhat Important	Not at all Important	No Opinion	Total
Work ethic (n = 336)	88%	8%	0%	1%	3%	100%
Communication skills (n = 336)	71%	23%	3%	0%	3%	100%
Presentation (e.g., neat, dressed appropriately) (n = 332)	66%	26%	5%	0%	2%	100%
Work experience (n = 340)	62%	29%	5%	0%	3%	100%
Formal HVAC education (n = 335)	39%	36%	19%	4%	3%	100%
Certifications (n = 332)	28%	40%	21%	7%	4%	100%
Union membership (n = 318)	8%	3%	7%	66%	16%	100%

Note. Some respondents skipped this question and the number of respondents varied for each role.

4.2. Contractors' Reports of Tools *Used* and *Needed* to Conduct Diagnostic Tests

In the survey, all contractors were provided a list of 15 diagnostic tools typically used when conducting diagnostic tests on HVAC systems and were first asked to rank the three tools they *use* most; the same list was then presented and the contractors were asked to rank the three tools they *need* the most to successfully perform diagnostic tests on HVAC system. The objectives were twofold. First, the research team wanted to get a general idea of what types of tools contractors are using in the field; second was to see if there are any gaps between what they typically use and what they deem as ideal. Figure 4-1 shows the results, presenting the percentage of contractor respondents who ranked each of the tools in the top-three for both questions.

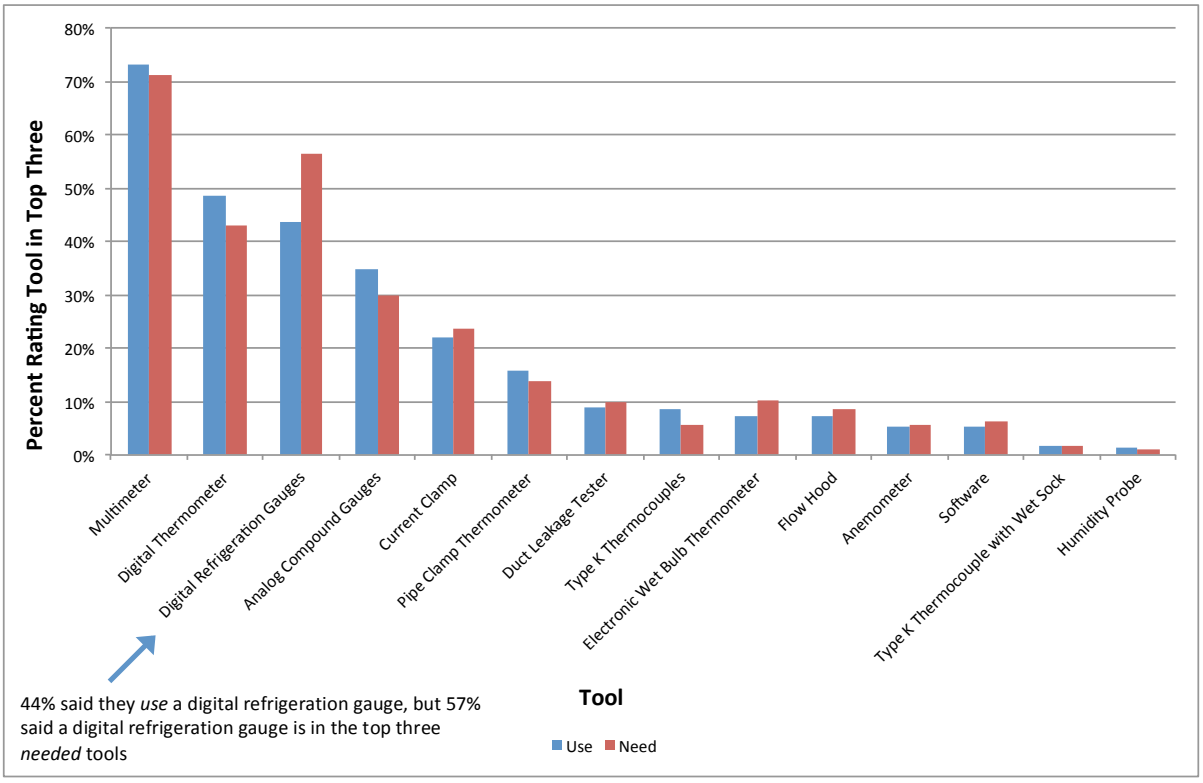
Figure 4-1 shows that multi-meters (73%), digital thermometers (48%), and digital refrigeration gauges (44%) were most often rated in the top-three used tools. These were also the most commonly needed tools. It is interesting to note that 7 of the 13 observed technicians used a multi-meter, and 12 used an air-

temperature thermometer, but none of the observed technicians used a refrigeration system and airflow analyzer (refrigeration gauge). This may reflect a discrepancy between what contractors believe that technicians use in the field and what actually takes place in the field. Tools that technicians used during the field observations are discussed in Chapter 5.

Also used by surveyed contractors, but less frequently rated in the top three, were analog compound gauges (35%), current clamps (22%), and pipe clamp thermometers (16%). All of the other tools were mentioned as being among the top-three used tools by less than 10% of the respondents.

When comparing the patterns of responses across the diagnostic tools contractors *use* and the tools they think they *need* to conduct successfully perform diagnostic tests, we see only one notable gap: while 44% of the contractors said they *used* a digital refrigeration gauge to conduct diagnostic tests, significantly more (57%) said they feel they *needed* these gauges to successfully perform diagnostic tests.

Figure 4-1: Percent of Contractors Rating Each Tool in Top-3 When Asked Which They Use Most and Which They Need Most



Note. Only one person indicated using flow plates and none indicated needing flow plates in the top three tools. Thus, for space purposes, flow plates were excluded from the figure.

4.3. Participation in Utility-Sponsored HVAC Energy Efficiency Programs

Contractor respondents who indicated that they conduct installation work were asked if they had ever participated in a utility-sponsored HVAC Quality Installation program, which promotes proper HVAC

installation practices.[17] Of the 297 installation contractors that completed the survey and conduct work in the residential sector,[18] only 81 (27%) indicated that they had participated in a quality installation (QI) program, 201 (68%) stated they had not, and 4% did not know. Of those who had ever participated, only 35% stated that they are currently participating.

There were some notable differences between contractors who indicated they had ever participated in a utility Quality Installation program and those who had not ever participated. Those who had participated in a QI program were significantly more likely to have at least 5 but less than 50 employees ($X^2 = 20.7$ ($df = 5$), $p < .01$). They were also generally more likely to report annual revenues of $500,00 or greater compared to those who had not participated ($X^2 = 23.9$ ($df = 8$), $p < .01$). Those who stated that they belong to any associations were more likely to have participated in a QI program (36%) compared to those who stated that their company did not belong to any associations (20%). Specifically those who were members of ACCA were significantly more likely to have participated in a QI program (53%) compared to those were not members of ACCA (24%) ($X^2 = 12.1$ ($df = 1$), $p < .01$). Those who were members of RSES were also significantly more likely to have participated in a QI program (47%) compared to those were not members of RSES (25%) ($X^2 = 7.6$ ($df = 1$), $p < .01$).

Those who reported that they had any certifications were also more likely to report that they had participated in a utility QI program (33%) compared to those who reported that their company had no certifications (23%). Specifically those who were NATE C3-certified were significantly more likely to have participated in a QI program (40%) compared to those who were not NATE C3-certified (21%) ($X^2 = 11.4$ ($df = 1$), $p < .01$).

Of the 201 contractor respondents who stated their company had not participated in a Quality Installation program, Table 4-14 shows that over one-half (57%) said this was because they were not aware that electric utilities had HVAC Quality Installation programs and 14% stated it was because they had never thought about it. Seventeen percent felt these programs were too much hassle. Notably, 12% stated that they felt their customers would not care if they participated, and only 7% felt participation would not benefit their business.

[17] Quality installation criteria include correct sizing and correct refrigerant charge, and new residential system installations are also required to satisfy duct leakage requirements.

[18] The California IOUs currently do not offer a commercial quality installation program; thus 30 respondents who only perform work in the small commercial and/or large commercial sectors were not included in this analysis.

Table 4-14: Reasons for Not Participating in a Utility HVAC Quality Installation Program

Response	Percent (n = 201)
I was not aware that electric utilities have HVAC quality installation programs	58%
Too much of a hassle	17%
Never thought about it	13%
Our customers would not care if we participated	12%
Utilities' HVAC quality installation programs would not benefit our business	6%
Prefer not to answer	4%
Don't know	4%
* Did not qualify	2%
* Could not find information on program	2%
* In the process of enrolling in the program	1%
* Too far to travel	1%
* Not equipped to participate	1%
Other	2%

Note. Multiple responses were accepted. Asterisks (*) indicate coded open-ended responses.

The 81 installation contractor respondents who indicated that their company had participated in a utility-sponsored HVAC Quality Installation program were asked what they thought were the advantages to participating in such a program. Table 4-15 shows that four advantages dominated the responses with roughly one-half of the contractors mentioning each: customers get incentives, which makes them happier with us (61%), it drives customers directly to us (49%), it allows us to approach new customers (49%), and our company's technician staff have benefited from the program's training opportunities (49%). Only 15% felt their company had experienced no significant advantages from participation, so it is unclear why only 35% of those that have participated are currently participating in a QI program.

Table 4-15: Perceived Advantages of Participating in a Utility HVAC Quality Installation Program

Response	Percent (n = 81)
Customers get incentives, which makes them happier with us	61%
It drives customers directly to us	49%
It allows us to approach new customers	49%
Our customers get incentives to do maintenance correctly, which makes them more apt to hire us	49%
Our company's technician staff have benefited from the program's training opportunities	49%
There have been no significant advantages	15%
* Not familiar enough with the program to comment	3%
Other	5%

Note. Multiple responses were accepted. Asterisks (*) indicate coded open-ended responses.

Surveyed maintenance contractors were asked to report if they had ever participated in an HVAC Quality Maintenance program offered by a California electric utility. Quality maintenance practices improve the efficiency of existing residential and commercial HVAC systems. Of the 296 maintenance contractor respondents who answered this question, 75 (25%) indicated that they had participated in a quality maintenance (QM) utility program, and of these, almost one-half (45%) stated that they are *currently* participating in such a program.

There were some notable difference between contractors that had participated in a utility QM program and those who had never participated. Those who had participated in a QM program were also significantly more likely to have five or more employees ($X^2 = 14.7$ ($df = 5$), $p < .05$). Respondents who stated that their company belongs to any associations were more likely to have participated in a QM program (30%) compared to those who stated that their company did not belong to any associations (18%). Specifically companies whose employees were members of RSES were also significantly more likely to have participated in a QM program (38%) compared to those whose employees were not members of RSES (22%) ($X^2 = 4.5$ ($df = 1$), $p < .05$).

Contractors that had any certifications were also significantly more likely to report that they had participated in a utility QM program (37%) compared to those who reported that their company had no certifications (13%) ($X^2 = 23.6$ ($df = 1$), $p < .001$). Specifically companies that were NATE C3-certified were significantly more likely to have participated in a QM program (43%) compared to those were not NATE C3-certified (16%) ($X^2 = 26.2$ ($df = 1$), $p < .001$).

Those whose companies had never participated in an electric utility's HVAC Quality Maintenance program were asked to indicate why their company had never participated. Table 4-16 shows that 58% of those who had never participated were not aware that utilities offer these types of programs.

Table 4-16: Reasons for Not Participating in a Utility HVAC Quality Maintenance Program

Reason	Percent (n = 221)
I was not aware that electric utilities have HVAC quality maintenance programs	58%
Never thought about it	18%
Too much of a hassle	15%
Utilities' HVAC quality maintenance programs would not benefit our business	9%
Our customers would not care if we participated	8%
Prefer not to answer	4%

Note. Multiple responses were accepted.

Those respondents whose companies had participated in a Quality Maintenance program were asked to report the main advantages for their company' participation. As shown in Table 4-17, respondents most commonly reported that the incentives make customers more likely to hire the contractor (61%) and also make customers happier with the contractor (57%). Again, only 15% of respondents indicated that there have been no substantial advantages, so it is unclear why more than half of those who have participated are not currently participating in a QM program.

Table 4-17: Perceived Advantages of Participating in a Utility HVAC Quality Maintenance Program

Response	Percent (n = 75)
Our customers get incentives to do maintenance correctly, which makes them more apt to hire us	61%
Customers get incentives, which makes them happier with us	57%
It allows us to approach new customers	53%
Our company's technician staff have benefited from the program's training opportunities	52%
It drives customers directly to us	47%
There have been no significant advantages	15%

Note. Multiple responses were accepted.

Additional future analysis could examine any differences between contractors who dropped out of a QI or QM program and those who are currently participating. However, these subsamples are relatively small (e.g., 34 respondents stated that they are currently participating in a utility QM program, and 41 indicated that they have participated in the past but dropped out), and such an analysis was not one of the objectives of the current research.

In addition to utility sponsored HVAC QI and QM programs, contractor respondents who conduct work in the residential sector (n = 313) were also asked if they had ever participated in a "Whole House" program that includes the building envelope, lighting, or appliances, in addition to HVAC. One in ten respondents (10%) indicated they had. However, of the respondents who indicated they had not participated in a "Whole House" program (n = 273), one-half (50%) indicated they would potentially be interested in participating in such a program in the future, and 12% indicated they were not sure.

The research team examined characteristics of contractor firms for the respondents who reported that they were interested in or had participated in Whole House programs to determine if there were any differences compared to those who had not participated and were not interested. Respondents whose companies have certifications were more likely to report that they were interested in or had participated in Whole House programs (60%), compared to those who stated that their company has no certifications (47%). Specifically, those from companies that were NATE C3-certified were significantly more likely to state that they were also interested in or had participated in Whole House programs (62%) compared to those who were not NATE C3-certified (48%) ($X^2 = 5.1$ ($df = 1$), $p < .05$).

5. MAINTENANCE

This chapter of the report focuses on HVAC maintenance. Woven into this chapter's thematic organization are key results from the two different data collection efforts: results of maintenance contractors' responses to the online contractor survey, and results of the onsite field observation that involved covertly watching 13 technicians perform maintenance duties. Note that quotation marks are used when quotes are verbatim from an interview. Italics without quotation marks indicate paraphrasing from the field observations, which were not electronically recorded.

In most cases, the results of the field study corroborate the survey findings, but in some cases the results seem to conflict. These areas are discussed in detail below. It is important to consider that there are multiple potential explanations for any differences identified: (1) the differences could represent real differences that exist between contractor's policies/beliefs/awareness, and technicians' performance and reports in the field, (2) the differences could be due to the sample of technicians and the sample of contractors representing different populations – however an examination of the data showed that 4 of the 13 observed technicians were from contracting firms that had completed the online survey suggesting the populations are similar, (3) the differences could be due to survey respondents' intentional misreporting – but the research team does not have evidence of this occurring. Given the low sample size of the field observations, additional research is needed to verify that any differences represent real differences between contractors and technicians.

5.1. Awareness and Implementation of Maintenance Standards

Table 5-1 shows surveyed maintenance contractors' awareness of industry standards, namely ACCA Standard 4 and ASHRAE/ACCA Standard 180. ACCA Standard 4 concerns the maintenance of residential HVAC systems, while ASHRAE/ACCA Standard 180 concerns the maintenance of commercial HVAC systems. Awareness of the two standards was identical, at 45%. Stated differently, greater than one-half of the sample was not aware of the ACCA/ASHRAE standards.

Table 5-1: Maintenance Contractor Awareness of ACCA/ASHRAE Standards

Standard	Percent
ACCA 4 [(a)]	45%
ASHRAE/ACCA 180 [(b)]	45%

(a) Asked only of Residential contractors (n = 109).
(b) Asked only of Small Commercial and Large Commercial contractors (n = 201; one respondent skipped this question).

For both standards, the majority of maintenance contractor respondents who were aware of the standard indicated that they adhere to either the majority or all of the standard's specifications. Table 5-2 shows that of those aware of ACCA Standard 4 and ASHRAE/ACCA Standard 180, 42% and 40% reported that they adhere to the majority of the standard's specifications. Almost a quarter of those aware of ACCA 4 stated that they adhere to all of the standard's specifications, while roughly one-third of those aware of ASHRAE/ACCA 180 reported that their firm adheres to all of the standard's specifications.

Table 5-2: Maintenance Contractor Implementation of ACCA/ASHRAE Standards, Among Those Aware of the Standards

Implementation of ACCA 4 [(a)]	Percent (n = 48)
Aware of standard but do not adhere	4%
Adhere to some of standard's specifications	31%
Adhere to the majority of the standard's specifications	42%
Adhere to all of the standard's specifications	23%
Total	**100%**
Implementation of ASHRAE/ACCA 180 [(b)]	**Percent (n = 86)**
Aware of standard but do not adhere	1%
Adhere to some of standard's specifications	26%
Adhere to the majority of the standard's specifications	40%
Adhere to all of the standard's specifications	34%
Total	**100%**

(a) One respondent who indicated that they are aware of ACCA 4 did not answer this question.
(b) Four respondents who indicated that they are aware of ACCA 180 did not answer this question.

With respect to the field observation study, post-observation interviews indicated that technicians were not knowledgeable about ACCA Standard 4, and none of the 13 observed technicians stated that they use the standard in their regular work. Five of nine interviewees did say that the standard's name seemed familiar, but emphasized that they were not fully acquainted with it and it was not used systematically as a guideline. The other four interviewees said they had never heard about the standard.

When the interviewers explained that ACCA 4 was a standard for maintenance of residential HVAC systems, including a checklist of anything that should be done in a quality maintenance visit, technicians suggested that it probably corresponded to the primary elements of their company's checklist.

It is possible that the observed technicians were familiar with the contents of ACCA Standard 4, just not by name. Technical education, or the firm's checklist, for example, might include all the tasks and skills required by ACCA 4 but might not emphasize that the tasks and skills correspond to a national industry standard.

5.2. Definition of Quality Maintenance

Surveyed contractors were asked, in an open-ended format, to report how they define "quality maintenance" for jobs with residential, small commercial, and large commercial customers. Coded responses are shown in Table 5-3. Overall, the most common response was that quality maintenance included some type of inspections or testing. Contractors also mentioned doing a job the "right way," and this was mentioned by 12% of respondents overall. Inspecting air filters was also a common component of quality maintenance, but only for residential and small commercial customers. Only 1% of respondents indicated that standards such as ACCA 4, ACCA 180, or BPI (Building Performance Institute) were what they used to define quality maintenance. This evidence suggests that there may be a disconnect between contractors' reported awareness and implementation of ACCA/ASHRAE standards and the extent to which they are associated with "quality maintenance."

Three statistically significant differences were detected across sectors and these were associated with: inspecting air filters ($X^2 = 18.474$ ($df = 2$), $p < .001$), checking refrigerant charge ($X^2 = 11.408$ ($df = 2$), $p < .01$), and inspecting condensing coil ($X^2 = 9.260$ ($df = 2$), $p < .01$). In all these cases, the large commercial contractors provided this response less frequently than both the residential and small commercial contractors.

Table 5-3: Contractors' Definitions of "Quality Maintenance"

Task	Residential (n = 109)	Small Commercial (n = 110)	Large Commercial (n = 92)	Total (n = 311)
General Mention of Inspections/Testing	13%	21%	11%	15%
'Complete' or 'Proper' - Doing a Job the 'Right Way'	7%	14%	15%	12%
Inspecting Air Filters	14%	11%	1%	9%
Using a Checklist	9%	10%	7%	9%
Communicating Findings to the Customer	9%	8%	8%	8%
Peak/Optimum Performance	7%	8%	9%	8%
Inspecting Ductwork	10%	9%	2%	7%
Checking Refrigerant Charge	13%	5%	1%	7%
Customer is Satisfied	9%	5%	8%	7%
Inspecting Electrical Components	10%	6%	1%	6%
Inspecting Condensing Coil	10%	7%	0%	6%
Manufacturer Specifications	5%	4%	7%	5%
Cleaning the System	6%	8%	1%	5%

Note. Only shows responses for criteria mentioned by at least 5% of respondents. Multiple responses accepted.

Similarly, data gathered from the field observations suggests that quality maintenance is not a concept with a generally agreed-upon meaning. The request to differentiate quality from regular maintenance seemed to confuse most of the interviewed technicians, with many of them concluding that what they had performed during the observation was "quality maintenance."

Throughout the observations of the technician visits, the phrase "quality maintenance" was never used by any of the technicians observed unless the researchers prompted it, nor was it used by any of the dispatchers or administrative staff that researchers contacted on the phone to schedule the service/maintenance calls. Only one technician made unprompted references to the difference between the maintenance practices he was engaging in, which included systematic measurements, compared to those of other technicians, but he still did not label it as "quality maintenance." This technician stated that:

> *"Systems should not be checked the old bubba way, where they just put their hands on the pipe and if it is beer-can cold it's ok… many technicians don't make any pressure measurements, but those are key."*

Throughout the post-observation interviews, when asked what differentiates regular maintenance from quality maintenance, technicians had difficulty understanding what the researchers were referring to. The concept of "quality maintenance" did not seem to be part of their technical vocabulary. In many cases, the answer to the question indicated that quality maintenance was what they had just performed, and non-quality maintenance would be what "other technicians" sometimes do. Technicians pointed to the better aspects of their own (and their company's) performance, and identified that as "quality."

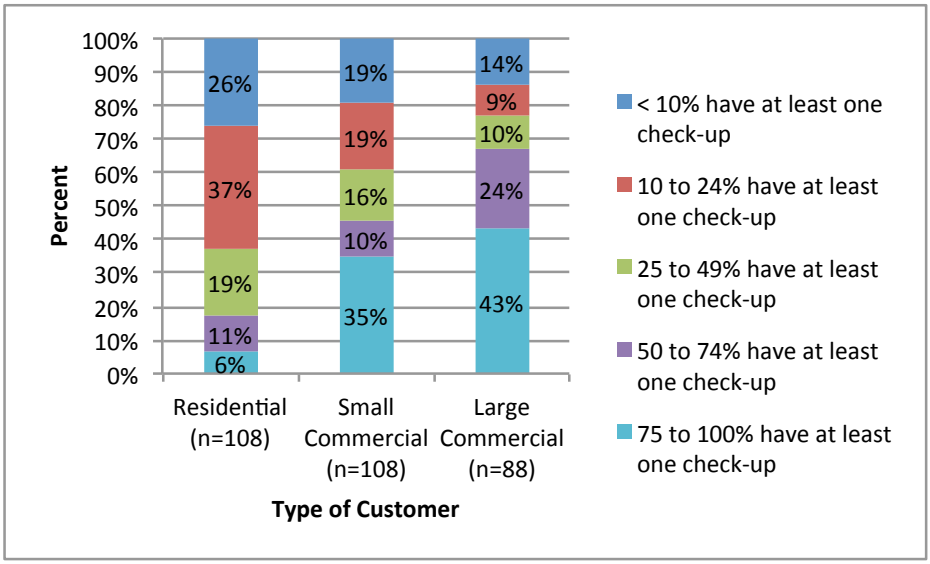
When asking for definitions of regular vs. quality maintenance, technicians often fell back to giving a personal definition. For example: *"I consider residential maintenance, uh…solving problems before they happen; being able to diagnose a problem before its arrival, in a nutshell."*

Of the companies recruited for the observation study, four were current participants in the SCE Quality Maintenance Residential Program. Of these four, only one offered, on the phone, to conduct maintenance that, according to them, might qualify for a $50 rebate from SCE. It was offered only when researchers asked for thorough maintenance and energy savings, plus added a reference to a "friend in the utilities" who mentioned that quality maintenance can be different than regular maintenance. The company did not refer to it as "quality maintenance" but rather as "SCE maintenance," and it was defined by the person on the phone as *a thorough maintenance visit that examines the whole system's performance, a performance evaluation.* In this one case, the "SCE Maintenance" was also described as being *the same service that we would offer as a performance evaluation, but it takes twice as long because we have to use a computerized system to enter the data and have the service qualify for the SCE rebate.*

5.3. Conducting Maintenance

Surveyed maintenance contractors were asked to report the percentage of their residential, small commercial, and large commercial customers who have at least one maintenance check-up per year on their HVAC systems. As shown in Figure 5-1, contractors reported that small commercial and large commercial contractors are more likely to have maintenance check-ups on their HVAC systems (X^2 = 59.131 (df = 8), p < .001). For example, 67% of respondents reported that at least half of large commercial customers have at least one maintenance check-up per year, while only 17% of respondents reported that at least half of residential customers have at least one maintenance check-up per year.

Figure 5-1: Maintenance Contractors' Reports of the Percentage of Customers Who Have at Least One HVAC Check-Up Per Year



Surveyed maintenance contractors were also asked how often their company recommends that their residential, small commercial, and large commercial customers have maintenance check-ups for their HVAC systems. As shown in Table 5-4, contractors tend to recommend more frequent maintenance

check-ups for commercial customers (small commercial mean = 3.1 check-ups/year; large commercial mean = 4.3 check-ups/year) compared to residential customers (mean of 1.6 check-ups/year) (F=16.691 (df=2), p<.001).[19] Roughly two-thirds of respondents (66%) stated that they recommend four maintenance check-ups per year to large commercial customers, but only one percent of respondents stated that they recommend four maintenance check-ups per year to 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.

Table 5-4: How Often Contractors Recommend Customers Have HVAC Maintenance Check-Ups

Recommendation	Residential (n = 108)	Small Commercial (n = 110)	Large Commercial (n = 92)	Total (n = 308)
Every other year	6%	0%	0%	2%
Once a year	29%	5%	3%	13%
Twice a year	56%	28%	17%	35%
Three times a year	2%	13%	3%	6%
Four times a year	1%	49%	66%	37%
More than four times a year	0%	0%	3%	1%
Varies	4%	4%	6%	4%
We do not recommend that our customers schedule maintenance appointments	3%	1%	2%	2%

Contractors were asked to indicate whether they agreed that regular, proper HVAC maintenance provided the benefits shown in Table 5-5, for residential, small commercial, and large commercial customers. For each benefit, respondents indicated whether they strongly disagreed, disagreed, felt neutral, agreed, or strongly agreed. The table shows the percentage who indicated that they agree or strongly agree with each benefit. There is very little variation in responses, with 80% to 90% of respondents agreeing with each statement, indicating that contractors generally agree that HVAC maintenance has multiple benefits. No statistically significant differences were detected across sectors at the $\alpha = .05$ level of significance.

[19] The 3% of large commercial cases included in Table 5-4 that are listed as "More than four times a year" actually included the following: "weekly" (n = 1), "monthly" (n = 1), and "bi-monthly" (n = 1). These were coded as 52, 12, and 24, respectively, in order to calculate the means presented above. Respondents that indicated that the recommendations "vary" and "we do not recommend that our customers schedule regular maintenance appointments" were not included in the mean calculations.

Table 5-5: Maintenance Contractors' Perceived Benefits of Proper HVAC Maintenance

Benefit	Residential (n = 109)	Small Commercial (n = 110)	Large Commercial (n = 92)	Total (n = 311)
Improve air quality	83%	88%	90%	87%
Increase customer comfort	88%	89%	90%	89%
Increase energy savings and reduce electric bills	92%	91%	91%	91%
Prolong a system's operational lifespan	92%	93%	92%	92%
Prevent expensive repairs	91%	87%	92%	90%
Improve a system's reliability	92%	93%	91%	92%

Table 5-6 shows that 64% of survey respondents indicated that their company has a formal policy or set of guidelines that technicians are required to follow for maintenance procedures. The percent of maintenance contractor respondents who stated that they have such guidelines for small commercial customers was somewhat less, at 59%, than those for residential (66%) or small commercial customers (68%). No statistically significant differences were detected across sectors at the $\alpha = .05$ level of significance.

Table 5-6: Percent of Companies That Have Formal Policies or Guidelines That Technicians Are Required to Follow for Maintenance Procedures

Response	Residential (n = 105)	Small Commercial (n = 108)	Large Commercial (n = 91)	Total (n = 304)
Yes	66%	59%	68%	64%
No/ Don't know	34%	41%	31%	36%
Total	**100%**	**100%**	**100%**	**100%**

Table 5-7 shows respondents' descriptions of their companies' guidelines for implementing maintenance procedures with residential, small commercial, and large commercial customers. Forty-one percent of respondents indicated that they have a checklist that technicians follow for maintenance procedures, while 14% of respondents mentioned specific tasks that technicians complete. Only 1% of respondents specifically mentioned that it is their company policy to follow ACCA standards for maintenance visits. Again, 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.[20]

[20] Most categories had an insufficient number of responses to conduct valid statistical tests. No testing was conducted for this question.

Table 5-7: Description of Contractors' Formal Policies/Guidelines for Implementing Maintenance Procedures

Company Guidelines	Residential (n = 69)	Small Commercial (n = 64)	Large Commercial (n = 62)	Total (n = 195)
Use a checklist	45%	42%	34%	41%
Specific tasks described (i.e., change filters, wash coil, check thermostat)	16%	6%	19%	14%
Company manual or list of procedures	0%	8%	8%	5%
Manufacturer's specifications	0%	14%	2%	5%
Address customer concerns	7%	5%	0%	4%
Procedures customized depending on the system	4%	0%	3%	3%
Procedures customized depending on the customer	3%	0%	3%	2%
Perform a system inspection	1%	3%	0%	2%
Per the maintenance agreement	3%	3%	0%	2%
Prepare a report for customer	0%	2%	3%	2%
Use ACCA standards	0%	2%	2%	1%
Other	1%	3%	8%	4%

Table 5-8 shows the number of technicians who used each type of instrument in the field observations. The number of technicians using specific types of each instrument are shown in boxes just to the right of the description, and the total number of technicians using the tool in general are in the right-most column.

Almost all observed technicians used a current clamp, refrigerant pressure manifold, and air and pipe temperature measuring instruments. Most refrigerant pressure manifolds were analog, while most air temperature measurements devices were digital. Clamp-on sensors were most frequently used for pipe temperature measurements. The two technicians who completed the maintenance tasks most completely had a higher quality set of instruments.

Technicians in the field study consistently reported that they were required to purchase and maintain their own tools. Most said that their contracting companies provided purchasing plans for them to buy quality tools, but it is the responsibility of the technician to keep himself up to date with tools and to pay for them.

Table 5-8. Number of Observed Technicians Who Used Each Type of Instrument

Device								Total Used
D1	Duct Pressurization Tester							1
D2	Current Clamp							11
D3	Multi-meter	Amps	Volts	MF	RMS			3
		2	1	0	0			
D4	Refrigerant Pressure Manifold	Digital	Analog					11
		4	7					
D5	Static Pressure Manometer	Digital	Analog					5
		3	2					
D6	Airflow Measurement	Hood	Grid	Anemometer	Pitot Tube			2
		1	0	0	1			
D7	Pipe Temperature	RTD	TC	Digital	Analog	Strap-on	Clamp-on	11
		0	1	2	0	0	8	
D8	Air Temperature	RTD	TC	Digital	Analog			12
		0	2	10	0			
D9	Refrigeration System and Airflow Analyzer							0
D10	Humidity	Digital	Analog					3
		3	0					

Note. The number of technicians using specific types of each instrument are shown in boxes just to the right of the description, and the total number of technicians using the tool in general are in the right-most column. MF = microfarads. RMS = root mean squared (real power) meter. RTD = resistance temperature device. TC = thermocouple.

Table 5-9 shows tasks performed by technicians during a typical maintenance visit, as reported by survey respondents. The most commonly performed tasks were inspecting the blower motors, condensing coils, and filters. Less common tasks include inspecting the integrity of ductwork, checking ductwork for moisture accumulation or biological growth, and measuring airflow across the heat exchanger/coil. Only two statistically significant differences were detected across sectors: (1) significantly fewer residential contractors indicted that they inspect evaporator coils and clean/adjust as needed (68%), as compared to small commercial (90%) and large commercial contractors (82%) ($X^2 = 16.8$ ($df = 2$), $p < .001$), and (2) far fewer residential contractors indicated that they inspect economizers (35%) than small commercial contractors (78%) and large commercial contractors (84%) ($X^2 = 65.7$ ($df = 2$), $p < .001$).

Table 5-9: Tasks Performed During a Typical Maintenance Visit

Task	Residential (n = 109)	Small Commercial (n = 110)	Large Commercial (n = 92)	Total (n = 311)
Inspect blower motors for proper operation	94%	92%	92%	93%
Inspect condensing coil and clean/adjust as needed	91%	95%	93%	93%
Inspect filters for particulate accumulation and clean/replace as needed	90%	96%	92%	93%
Inspect all electrical components for proper operation	91%	90%	91%	91%
Inspect condensate drains (and traps) for proper operation	86%	94%	93%	91%
Visually inspect heat exchanger for signs of corrosion, fouling, structural problems (e.g., cracks, perforations, bulges)	91%	91%	83%	88%
Test system controls' modes of operation and control sequences	87%	86%	86%	86%
Inspect accessible refrigerant lines, joints, and coils for oil leaks	77%	86%	87%	83%
Inspect evaporator coil and clean/adjust as needed	68%	90%	82%	80%
Inspect air filter housing integrity and air seal	76%	78%	83%	79%
Measure refrigerant charge	81%	78%	73%	77%
Inspect cabinet, cabinet fasteners, and cabinet panels	72%	73%	77%	74%
Inspect grilles, registers and diffusers for dirt accumulation	66%	68%	63%	66%
Inspect economizers	35%	78%	84%	65%
Inspect integrity of all accessible ductwork insulation	64%	52%	55%	57%
Inspect the integrity of all accessible ductwork including: duct strapping, hangers, sections, joints, and seams	57%	50%	49%	52%
Inspect all accessible ductwork for areas of moisture accumulation or biological growth	51%	50%	55%	52%
Measure airflow across heat exchanger/coil	50%	41%	47%	46%

Survey respondents who indicated that their company's technicians measure refrigerant charge during a typical maintenance visit were asked how technicians determine that the refrigerant charge is correct. Responses are shown in Table 5-10. Contractors most commonly reported that technicians check the temperature split across the coil before using gauges, reported by 62% of respondents. Also noteworthy is that contractors indicated that technicians are comparing measurements with manufacturer recommendations: 59% of respondents indicated that they check subcooling for TXV and compare this with manufacturer's recommendations, and 51% said they check superheat for fixed orifice and compare this with the manufacturer's recommendations. No statistically significant differences were detected across sectors at the $\alpha = .05$ level of significance.

Table 5-10: How Technicians Determine the Correct Refrigerant Charge in HVAC Units During a Typical Maintenance Visit

Response	Residential (n = 88)	Small Commercial (n = 86)	Large Commercial (n = 67)	Total (n = 241)
Check temperature split across coil before using gauges	68%	57%	60%	62%
Check subcooling for TXV and compare with manufacturer's recommended subcooling [(a)]	63%	55%	60%	59%
Check both superheat and subcooling (regardless of metering device)	48%	60%	63%	56%
Check superheat for fixed orifice and compare with manufacturer's recommended superheat	55%	51%	45%	51%
Check subcooling for TXV and compare with a generic table (e.g., T24)	45%	37%	36%	40%
Check superheat for fixed orifice and compare with a generic table (e.g., T24)	36%	31%	34%	34%
Don't know	1%	1%	7%	3%
Other	1%	6%	3%	3%

Note. Multiple responses were accepted. Asterisks (*) indicate coded open-ended responses.
(a) This was inadvertently termed "manufacturer's recommended superheat" in the survey. It is likely that respondents recognized this mistake and correctly assumed the intended meaning of the question.

The field observations offer additional perspective by providing information on technicians' onsite performance. Table 5-11 summarizes the number of tasks completed by each technician in the field observation. This table differentiates between an "attempt" to carry out a task (empty circle) and a task that is carried out "correctly" (filled circle). If the technician made any attempt at all, it was recorded as an attempt. Technicians were considered to have performed task "correctly" if they followed industry best practices, from ACCA, CEC and other sources, as described in Appendix F. The master technician on the research team used his judgment along with these criteria to determine if a task was fully completed and completed correctly.

Regarding the imposed faults, only four technicians discovered the closed supply air registers and opened them. One technician checked registers but did not open the closed registers or indicate they were closed verbally or on the invoice paperwork. These results were surprising—closed registers are easy to find, so it was expected to be one of the first things that a technician would check. Diagnosing low airflow is important to optimizing efficiency. Only two technicians detected that the airflow was too low, and only one of these technicians diagnosed correctly that the fan wires were switched. Despite the fact that most of the technicians did not discover the imposed faults, many of the technicians made recommendations for repairs; these repairs are listed in Appendix G.

Nine of the thirteen observed technicians attempted inspecting the air filter, electrical components, line and duct insulation, and ductwork. No technician observed in the field study attempted evaporator cleaning, possibly because of the configuration of the unit. The evaporator coil was difficult to reach; however, this may be common in residential systems. This is contrasted with the fact that 68% of surveyed contractors stated that the evaporator coil is inspected and cleaned/adjusted as needed during a typical residential maintenance visit (see Table 5-9).

Of the tasks in the research team's field observation checklist that were attempted by the technicians, very few were conducted to the level of quality that would be expected if industry standards were followed.

Only two technicians investigated the system successfully enough to detect that the airflow was far too low for efficient operation. Nine of the thirteen technicians did not open all the air registers before running tests. Five measures were attempted frequently, but never completed correctly (inspecting ducts, cleaning condenser coils, checking refrigerant charge, measuring motor amps, and looking for evidence of biological growth). The task most commonly completed correctly was checking the thermostat. None of the technicians successfully carried out the following tasks: searching for duct leaks, cleaning condenser coil, assessing the refrigerant charge level, measuring motor amps, looking for evidence of biological growth or cleaning the evaporator coil.

It is noteworthy that two technicians provided lists of maintenance items (containing between 40 and 60 points) that were checked-off as being performed on the invoice, but the items were not all performed or were performed improperly. In some cases, maintenance items were not checked off as being performed even though the technicians performed some of the maintenance services properly.

Table 5-11: Tasks Attempted (○) and Completed Correctly (●) by each Observed Technician

Task Description	Number of Techs. Correct	Number of Techs. Attempt	Technicians												
			1	2	3	4	5	6	7	8	9	10	11	12	13
Thermostat	5	6	●		●		○			●		●			●
Registers	4	5		●				●			●			○	●
Air Filter [(a)]	2	9	○		○		●	○	○	●		○	○		○
Electrical	2	9	○		●		○	○	○	○	○	●		○	
Temp Split	2	6	○	○	●						○		○		●
Furnace	2	5			●					○		○	○	●	
Line and Duct Insulation	1	9	○					○	○	○	○	○	○	●	○
Motor Amps	1	7	○		●		○		○		○	○		○	
Ext. Static	1	2			●										○
Airflow	1	2			●										○
Ducts	0	9			○			○	○	○	○	○	○	○	○
Condenser Coil	0	7					○		○	○	○	○	○	○	
Biologicals	0	6					○	○		○		○		○	○
Refrig. Charge	0	5			○		○				○	○			○
Evaporator Coil	0	0													
Total Attempts			**6**	**2**	**10**	**0**	**7**	**6**	**6**	**8**	**8**	**10**	**6**	**8**	**10**
Total Correct			**1**	**1**	**7**	**0**	**1**	**1**	**0**	**2**	**1**	**2**	**0**	**2**	**3**

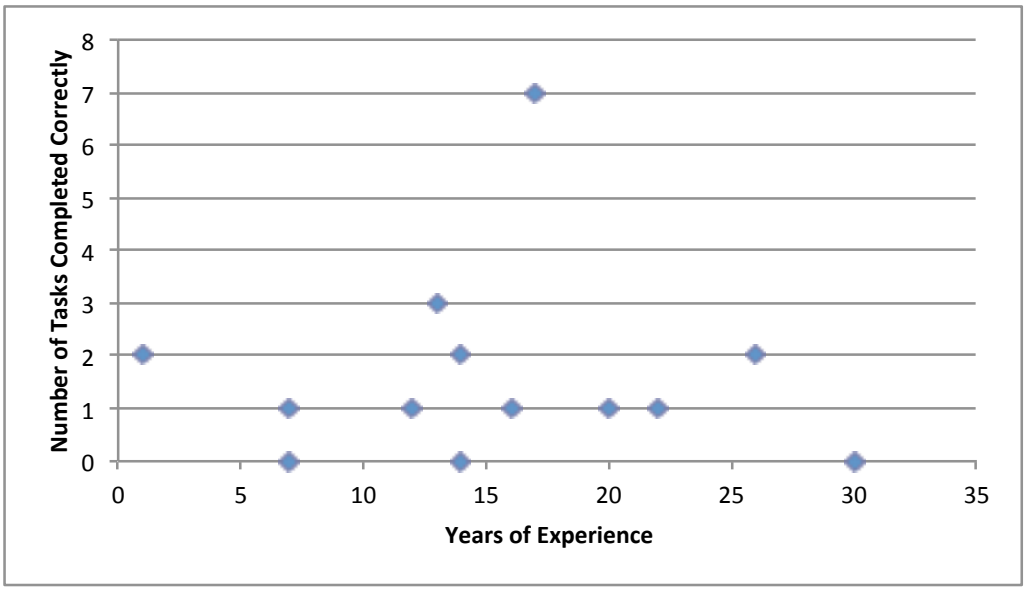
Note. Tasks listed are evaluated as executed correctly (filled circle), attempted but executed incorrectly (empty circle), or not attempted.

(a) The air filter was visibly dirty and technicians were told that it had been longer than three months since it had been replaced; however only two technicians recommended replacing the air filter.

Some companies of the observed technicians conducted follow-up feedback calls. These mostly sought feedback on whether the technician had been clean, polite, and "listened to the concerns of the customer." None of the feedback calls involved evaluating satisfaction with the technician's technical service or solutions provided. This is notable because if technicians know they are being evaluated on informal characteristics, rather than on technical performance, it is possible that they may focus more on these informal elements and give technical elements a lower priority.

The research team also explored observed technician characteristics to determine whether they were associated with maintenance technician performance. Figure 5-2 shows the impact of a technician's years of experience—keeping in mind that the small sample size prevents generalizability. The data show that there is not much of a relationship between a technician's years of experience and his ability to correctly perform maintenance tasks. Those who had completed two or more tasks correctly had a range of experience, from 1 year to over 25 years, while those who had completed no tasks correctly also had a wide range of experience, from seven and 30 years. It is notable that the one technician who completed seven tasks correctly had 18 years of experience. Appendix F contains the best practice criteria (based on both ACCA Standard 4 and the experience of the master technician) against which tasks were judged.

Figure 5-2: Number of Field Tasks Performed Correctly in Relation to Technicians' Years of Experience



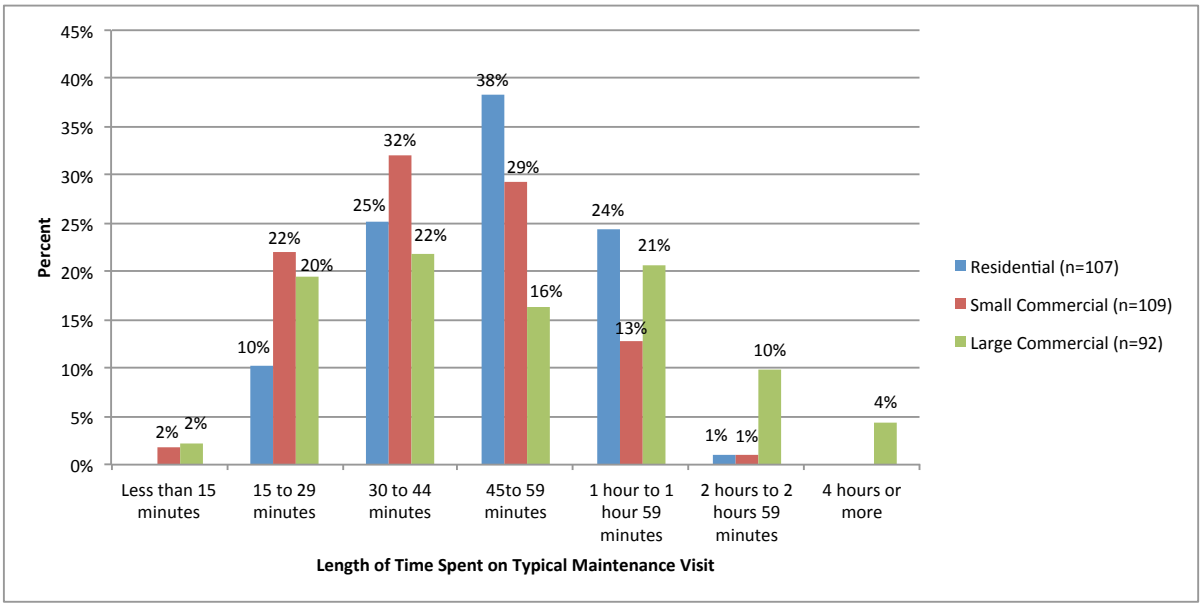
During the field observations, the main constraint on implementing high quality maintenance service that researchers observed was time. Having too little time allotted for a service/maintenance call resulted in technicians taking shortcuts, including not writing down measurements or not taking measurements with instruments, and instead using heuristics to detect whether the system was running well. The fact that some technicians are proud of the fact that their experience in the field allows them to do this may be an obstacle to implementing high quality maintenance. Physical obstacles to routine maintenance (in this case, for example, the evaporator coil was difficult to access) usually meant skipping the task, because there was no time scheduled to complete time-consuming tasks. Other obstacles the research team found were the perception that customers might not be interested in spending lengthy periods of time (up to four hours) supervising quality maintenance services, and that they might not want to spend more money, which lengthier maintenance services would require.

Most of the observed technicians had very little control over the time available for a visit. Scheduling was often determined from a central office that provided the technician with very little information about the details of each upcoming maintenance request. During the call time, the technician was then expected to detect customers' priorities, conduct the maintenance and explain and sell repairs and maintenance agreements. Technicians knew that this is part of their job but they could not spend too much time on any of the tasks, since they often have another job to run to. The results, as observed in the field, were that the

customers' priorities and requests were attended to perfunctorily at the beginning of the call, maintenance was conducted as quickly as possible, and maintenance agreement offers were rushed through and explained in terms of monetary perks rather than performance benefits.

Surveyed contractors were asked to report the length of time technicians generally spend working on an HVAC unit during a typical residential, small commercial, and large commercial visit. Contractors reported a wide range of times that technicians typically spend on maintenance visits. As shown in Figure 5-3, respondents most commonly reported that technicians spend between 45 and 59 minutes during typical residential maintenance visits. For small commercial visits, technicians commonly spend somewhat less time, between 30 and 44 minutes. There was more variety in length of visits reported for large commercial units, and respondents were more likely to report that technicians spend over two hours with large commercial units than with residential or small commercial units; 10% of respondents indicated that technicians spend between two and three hours, and an additional 4% indicated that technicians spend four hours or longer with a typical large commercial maintenance visit ($X^2 = 22.887$ ($df = 6$), $p < .001$).[21]

Figure 5-3: Reported Length of Time Technicians Spend During a Typical Maintenance Visit



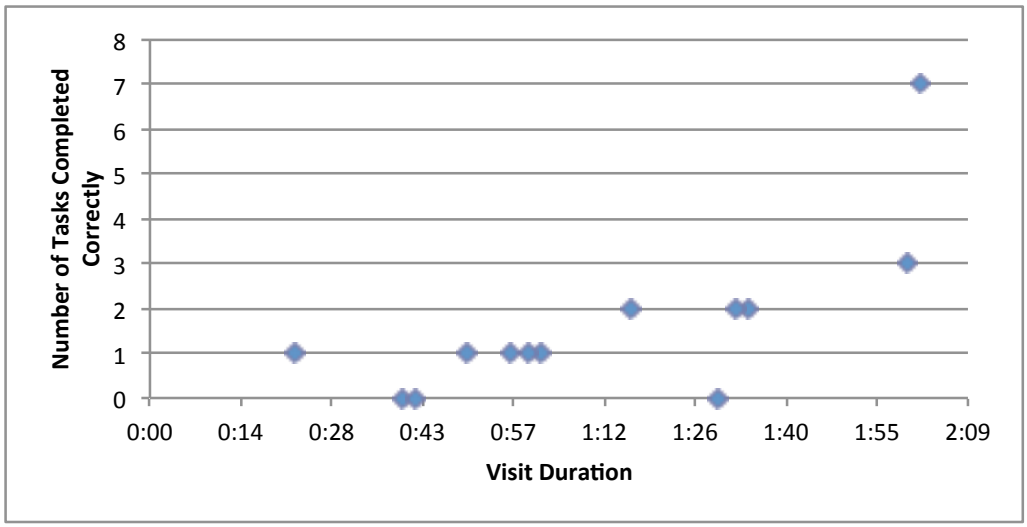
Note. No respondents indicated that technicians spend between 3 hours and 3 hours 59 minutes.

The field observation study corroborated the wide distribution of maintenance visit times shown in the survey. Researchers were also able to cross-reference the amount of time spent onsite with the number of key maintenance tasks performed correctly, as shown in Figure 5-4. There appears to be a trend toward longer visits associated with a greater number of correctly performed maintenance tasks. All of the

[21] In order to meet the requirements for the chi-squared test of independence, the first two categories were collapsed into "less than 30 minutes" and the last two categories were collapsed into "2 hours or more" to ensure all cells had adequate counts.

technicians who performed at least two tasks correctly spent at least an hour onsite, and those who performed the most tasks correctly spent the most time, up to two hours. It is unclear whether performing more tasks correctly might lead to a longer visit, or if a longer allotted time for the visit might lead to performing more tasks correctly.

Figure 5-4. Number of Field Tasks Performed Correctly in Relation to the Duration of Maintenance Visit



Throughout the field observations, requests for technician visits were increasingly escalated so that the researchers were eventually explicitly asking for "the best kind of maintenance" that is thorough and prioritized energy efficiency. Typical responses to the researchers' inquiries about energy efficiency and energy efficiency optimization were:

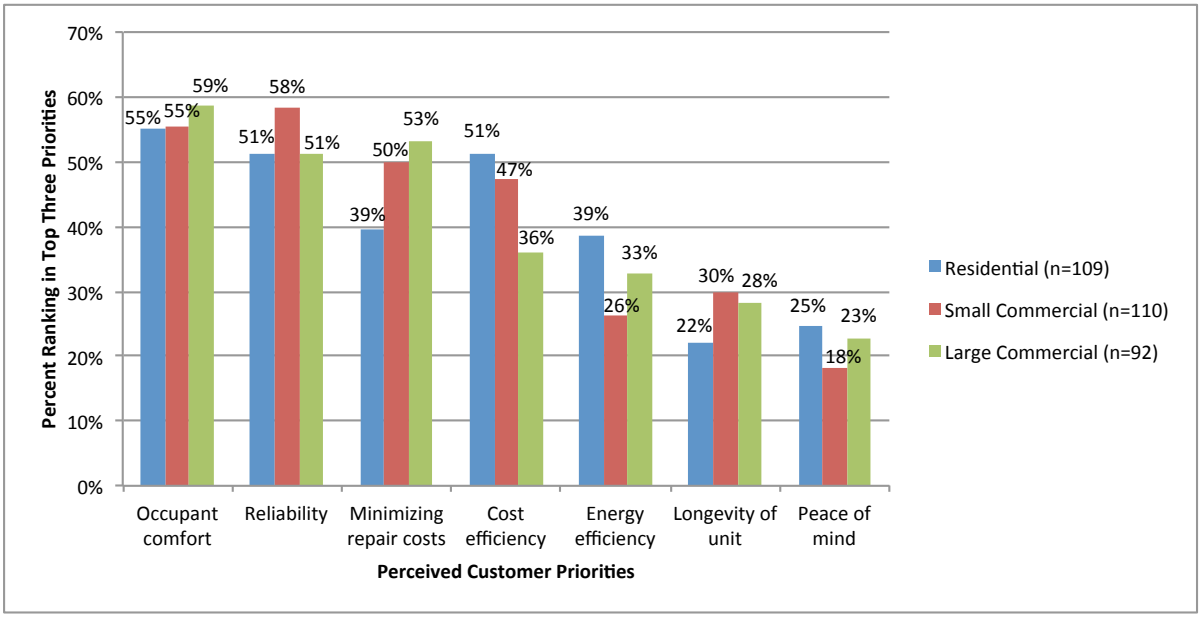
- Recommending easy DIY (do-it-yourself) behavioral solutions such as keeping the thermostat at a steady set-point so that equipment does not have to work harder when the resident comes home (and house is at 95 degrees F), using a cheap filter that allows for easier air flow, and washing coils so that equipment does not have to work as hard.
- Offering non-HVAC technology or maintenance solutions: "If you really want to be energy efficient you would be better advised to install solar panels" or "Rather than get more efficient systems, you should insulate your attic."
- Expressing resignation: "It will just always be warmer upstairs, so it will be expensive to run the system there."

In general, environmental and energy efficiency issues were perceived by the observed technicians as completely absent from customers' concerns, and they reported that they do not bring these topics up unless the customers ask for it. In the case of energy efficiency, it is brought up only in the context of monetary savings. Some technicians expressed environmental concerns of their own, but they usually related these concerns to waste (toxic refrigerant, recycling of old units) rather than to carbon emissions or energy usage. Multiple technicians conveyed skepticism about climate change, while at the same time expressing concern for the state of the environment.

Figure 5-5 shows contractors' perceptions of customers' priorities for their HVAC systems. Respondents were asked to rank the seven benefits according to residential, small commercial, and large commercial

customers' priorities when it comes to their HVAC systems. Shown in the figure is the percentage of respondents who ranked each benefit in the top three in terms of perceived customer importance. In general, respondents reported that occupant comfort was most important to customers, followed by reliability. Minimizing repair costs and cost efficiency (i.e., overall costs that could include energy costs, potential productivity losses, etc.) were seen as the next most important factors. Next was energy efficiency, which was ranked in the top three by about one-third of respondents. No statistically significant differences were detected across sectors at the $\alpha = .05$ level of significance.

Figure 5-5: Contractors' Ranking of Customers' Priorities with Respect to their HVAC Systems—Maintenance Contractors



Note. Respondents ranked all seven benefits. Shown is the percentage of respondents who included each benefit in the top three customer priorities.

The field observations found that observed technicians perceived customers primarily as interested in two things: the equipment working when needed, and spending as little as possible to achieve that goal. Technicians spent little time gauging whether specific customers deviate from this general rule. The undercover researchers never exhibited any interest in reducing the cost of repairs, retrofits or installation, and focused instead on asking for optimization opportunities, energy efficiency and even environmental aspects. All these requests were ignored, and most technicians still used their maintenance cost-minimization strategies to offer repairs and agreements, and to attempt to establish trust. This may be an indication that technicians do not have the time, motivation or expectation to explore different motivations in different customers.

5.4. Selling & Pricing Maintenance

Surveyed contractors were asked to report if their company actively tries selling or marketing HVAC maintenance services to their customers. As shown in Table 5-12, contractors are somewhat more likely to sell or market maintenance services to their small commercial and large commercial customers ($X^2 = 7.49$ ($df = 2$), $p < .05$). Overall, 75% stated that their company actively sells maintenance services, with 66% stating that their company actively sells maintenance contracts to residential customers. This is

somewhat greater than what was observed during the residential field observations when researchers were offered maintenance agreements by only 6 of the 13 (46%) represented companies (three over the phone and three on site by the technician).

Table 5-12: Percentage of Maintenance Contractors Who Actively Sell Maintenance Services

Response	Residential (n = 105)	Small Commercial (n = 107)	Large Commercial (n = 89)	Total (n = 299)
Yes	66%	81%	80%	75%
No/Don't know	34%	19%	22%	25%
Total	**100%**	**100%**	**100%**	**100%**

Survey respondents who reported that their company does not actively sell or market maintenance services were asked what reasons they have for not actively selling these services. Table 5-13 shows that the most common reason is that contractors feel that customers do not want to pay extra money for regular maintenance. Respondents who indicated that their company does not actively sell maintenance services also frequently felt that customers do not understand the value of maintenance (especially for commercial customers), are not interested in regular maintenance (especially for residential customers), and are not willing to make long-term commitments.[22]

[22] Statistical tests were not conducted for this question because of the rather small number of responses (i.e., no sector had more than 36 cases).

Table 5-13: Reasons That Maintenance Contractors Do Not Actively Sell Maintenance Services to Customers

Response	Residential (n = 36)	Small Commercial (n = 20)	Large Commercial (n = 17)	Total (n = 73)
Customers do not want to pay extra money for regular maintenance	50%	40%	41%	45%
Customers do not understand the value of maintenance	22%	40%	47%	33%
Customers understand the value of maintenance, but are not interested in having maintenance performed on a regular basis	42%	25%	24%	33%
Customers are not willing to make long-term commitments	36%	30%	29%	33%
We don't make enough money on maintenance contracts	19%	20%	12%	18%
Our technicians need more 'soft skills' training, such as communication skills, to be able to sell maintenance contracts to customers	17%	15%	24%	18%
*Customers cannot afford/do not want to pay for it	3%	0%	18%	5%
There is no value in doing maintenance	6%	0%	6%	4%
Our technicians need more technical training to be able to perform regular maintenance	0%	5%	12%	4%
*Customers do their own maintenance	0%	0%	18%	4%
Other	19%	30%	18%	22%

Note. Asterisks (*) indicate coded open-ended responses.

All respondents were asked to report what they see as the primary barriers to their company selling maintenance services to their residential, small commercial, or large commercial customers.[23] Table 5-14 shows that the most common response (indicated by 55% of respondents) was that customers do not want to pay extra money for maintenance, especially small commercial customers. Fifty-one percent of respondents indicated that customers do not want to pay extra money unless someone can show them evidence of how much money they can save. Interestingly, 14% of respondents stated that there are no barriers to regular maintenance, with fewer residential respondents indicating that there were no barriers (6%) as compared to small commercial (11%) and large commercial (27%) respondents ($X^2 = 19.2$ ($df = 2$), $p < .001$).

Bivariate correlations were calculated to assess whether contractor respondents that reported any particular barrier were likely to report other specific barriers.[24] This analysis revealed that this was not the case, as all of the barriers were positively correlated, with the exception of the barrier "technicians need more technical training to be able to perform maintenance." This barrier was unrelated to "customers know about the benefits of maintenance, but do not want to pay extra money for it," "customers know about the benefits of maintenance, but do not want to pay extra money for it unless someone can show them evidence of how much money they can save," and "equipment warranties make certain customers

[23] Answers to this question are somewhat different from the previous question, because all maintenance contractors were asked to report barriers to selling maintenance services (shown in Table 5-13), whereas the results shown in Table 5-12 show reasons that contractors who do not actively sell maintenance services do not do so.

[24] Open-ended responses were not included in this analysis.

less willing to have maintenance performed on their HVAC units." Especially highly and positively correlated were "customers do not know that maintenance can improve the performance and longevity of their cooling system" and "customers do not know that maintenance can reduce their electric bills" ($r(309) = .59$, $p < .001$).

The fact that 39% of surveyed contractors suggested that technicians lack "soft skills" needed to sell maintenance services to residential customers is in contrast with findings from the field observations in which observed technicians were very conversationally skilled. Technicians enjoyed teaching and explaining how the HVAC system works, how to use it, and how to maintain it. Many technicians used analogies to explain air conditioning, including comparisons to the human body's heart and lungs and to sucking air through narrow or wide straws. Almost all observed technicians engaged in relational non-technical conversations about family, health, weather and even their economic and financial problems. In many cases, they viewed this as a way to earn customer trust and create a rapport that can lead to continuous service.

Table 5-14: Maintenance Contractors' Self-Reported Barriers to Selling HVAC Maintenance Services

Barrier	Residential (n = 109)	Small Commercial (n = 110)	Large Commercial (n = 92)	Total (n = 311)
Customers know about the benefits of maintenance, but do not want to pay extra money for it	52%	64%	48%	55%
Customers know about the benefits of maintenance, but do not want to pay extra money for it unless someone can show them evidence of how much money they can save	58%	52%	42%	51%
Technicians need more 'soft skills' training, such as communication skills, to be able to sell maintenance to customers	39%	39%	27%	35%
Customers do not know that maintenance can reduce their electric bills	36%	38%	28%	34%
Customers do not know that maintenance can improve the performance and longevity of their cooling system	37%	37%	28%	34%
Equipment warranties make certain customers less willing to have maintenance performed on their HVAC units	27%	18%	23%	23%
Technicians need more technical training to be able to perform maintenance	14%	17%	11%	14%
*Customers cannot afford/do not want to pay for it	4%	3%	1%	3%
*Other barrier	7%	1%	2%	4%
There are no barriers, all our customers have maintenance performed on their HVAC systems regularly	6%	11%	27%	14%

Note. Asterisks (*) indicate coded open-ended responses.

Overall, the field observations suggested that a substantial barrier to the offer of maintenance agreements is the perception that the equipment is in good enough condition that customers can get the best "bang-for-the-buck" by caring for the equipment themselves. Under these circumstances, offering a maintenance

agreement is seen as pushy and it diminishes trust-building with the customer. Technicians repeatedly and explicitly stated that "they are not trying to sell anything." Several technicians reported they did not want to be pushy on maintenance agreements, since there is a perception that customers do not like to sign contracts in general. Table 5-15 indicates the relationship between characteristics of customers, business, and equipment and factors that were found to promote or discourage the offer of a maintenance agreement to a customer, through the post-observation interviews. Technicians often indicated that they would definitely offer maintenance agreements to older customers and older equipment. It is unclear whether a younger customer with relatively good equipment could expect a maintenance agreement offer even if they are asking for it, but evidence from this anecdotal study suggests it would occur infrequently.

Table 5-15. Characteristics that Encourages and Discourage an Offer of a Maintenance Agreement

Characteristic	Encourages Offer	Discourages Offer
Customer Characteristic	• Customer is perceived to be unable to conduct basic maintenance because of old age, disability • Customer is perceived to be disinclined to do their own basic maintenance • Customer is perceived as willing to pay to have things done for them • Customer asks about maintenance agreements • Customer is interested in energy savings	• Has rejected an offer on phone contact • Seems young or able to do basic maintenance on his/her own • Shows interest in doing basic maintenance on his/her own • Is unclear about the living situation (e.g., renter, shares space), possibly making financial situation unclear
Business Characteristics	• Technician has enough time to discuss a maintenance agreement with customer • Technician diagnoses repairs that would become substantially cheaper by making use of discounts	• Technician constrained for time because of allotted time for the service • Customer is upset because technician arrived late, is taking too long, or has found that expensive repairs are needed
Equipment Characteristics	• Equipment is more than 20 years old • Equipment or parts of it are hard to access for cleaning or changing filters • Equipment is diagnosed as in need of repairs	• Equipment is/looks "new" (in this case, it was 12 years old) • Equipment is located in a clean, well insulated area • Equipment is diagnosed as being in good running conditions

There were a variety of sales strategies observed in the field observations. For three of the observed technicians, the researchers were offered maintenance agreements on the phone when the research team contacted the company for a technician visit. Because the researchers rejected the agreements over the phone, they were not re-offered by the technician during the visit. Of the remaining 10 technicians observed, 3 offered maintenance agreements without researchers having to ask for them, 3 offered them after researchers inquired about them, and 4 did not offer them at all (three companies did not have maintenance agreements as a product offering and one technician was short on time).

In the three cases where technicians offered a maintenance agreement without the researchers asking, the technician offered the agreement after they finished inspecting the system and as they were preparing the

invoice. The main selling point was that it was going to save the homeowner money immediately and in the long-run, because of repair discounts and priority service. Two of these companies had different agreement "levels" that did not differ on the services provided, but rather on the discount percentages on potential repairs (10% or 15%), and on the priority service levels (same day vs. 24 hours).

In the three cases where technicians offered agreements after researchers asked for them, the offer tended to be less detailed. In two of the cases, the technicians told the researchers to call the company's office if they were interested in the agreements. In the third case, a document describing the agreement was provided, with the request to call the office. In all of these cases, technicians explained that the visit's service would be discounted if the "homeowner" decided to move forward with the agreements.

Seven technicians provided documents describing their maintenance agreements, with the implication that researchers could call the company later if they decided to sign up for the maintenance service and that agreement discounts would then be credited to the customer. Maintenance agreements often had names that alluded to energy (e.g., "energy savings program" or "energy saver"), but documents offered no explanation for how the agreements save energy or how much energy they save. If asked, technicians stated that maintenance agreements would indeed save energy by ensuring smooth operation of the equipment, but they rarely brought it up unless prompted.

Table 5-16 summarizes the number of checkpoints (tasks to be performed) and benefits offered for each of the seven maintenance agreement document offers that researchers collected. These documents offer a good comparison between contractors' explicit guidelines to promote maintenance and the technicians' actual behavior in the field.

Technical checkpoint tasks included things like: check airflow, clean condenser coil, tighten electrical connections, check refrigerant charge, etc. Other checkpoints that the research team considered non-technical were things like: place company sticker on outdoor unit, bid for replacement of system at no charge, schedule next seasonal tune up, etc.

Technical and contractual benefits were often presented in the same list within a document. Technical benefits included things like: lower energy bills, extended equipment life, and breakdown prevention.[25] Contractual benefits were things like: 10% discount on repairs, no overtime charges, 24 hour service, and priority service in case of an emergency.

Most of the agreements researchers reviewed included more contractual than technical benefits. This is in line with what was observed in the field: that technicians sell the agreements based on the "perks" rather than the technical services and benefits.

[25] The research team attempted to separate the benefits into sub-categories, such as efficiency/cost savings and failure prevention, but this was not possible, as some tasks (e.g., cleaning condenser coils) have both energy-saving and failure-prevention implications.

Table 5-16. Summary of Checkpoints and Benefits for Maintenance Agreements

Document	Total Listed Tasks	Technical Tasks	Total Benefits Listed	Technical Benefits	Contractual Benefits
1	13	11	9	4	5
2	37	36	7	2	5
3	1	1	1	0	1
4	3	3	8	3	5
5	12	12	11	6	5
6	12 [(a)]	8	4	7	4
7	13	13	11	5	6

Note. "Total Listed Tasks" is the number of tasks that the document lists as part of the maintenance agreement (M.A.). "Technical Tasks" is the subset of those that correspond to a technical inspection checkpoint. "Total Benefits Listed" is total number of benefits that the customer is promised to receive from the M.A. "Technical Benefits" are benefits to the operation of the HVAC system. "Contractual Benefits" are perks and financial incentives that are achieved from signing the M.A. (e.g., discounts, priority service).

(a) One company offered a "37-point" maintenance, but only 12 of these were listed in their maintenance agreement document.

Surveyed contractors who indicated that their company actively sells HVAC maintenance services to their residential, small commercial, or large commercial customers were asked if the *technicians* at their company sell maintenance services. Responses are shown in Table 5-17. Overall, 53% stated that their technicians sell maintenance services directly to their customers. Contractors were significantly more likely to report that their technicians sell maintenance services directly to residential customers (76%) than to small commercial (55%) or large commercial (33%) customers ($X^2 = 30.609$ ($df = 4$), $p < .001$). Respondents indicated that their large commercial technicians most often refer their customers to a sales person. Only 8% of respondents stated that technicians play no role in selling maintenance services.

Because the field observations took place at a residence, comparing survey results with the field observations requires looking at contractors' survey responses with respect to residential customers only. Of the 105 respondents whose companies work with residential customers and completed the residential module of the survey, 66% (n = 69) actively sell maintenance services to their *residential* customers (see Table 5-12 above). Of these, 76% stated that their *technicians* sell maintenance services directly to their residential customers; this means that overall, approximately 50% of contractors rely on their technicians to sell maintenance services directly to residential customers. However, during the field observations, only three of the thirteen technicians (23%) offered maintenance agreements without being prompted to do so.

Table 5-17: Do the Technicians at Your Company Sell HVAC Maintenance Contracts?

Response	Residential (n = 66)	Small Commercial (n = 86)	Large Commercial (n = 70)	Total (n = 222)
Yes, our technicians sell maintenance services directly to customers	76%	55%	33%	53%
Our technicians recommend that customers purchase maintenance services, but then refer the customer to a sales person	14%	38%	60%	37%
No, our technicians play no role in the maintenance service sales process	11%	7%	7%	8%
Total	**100%**	**100%**	**100%**	**100%**

Note. This question was asked only of maintenance contractor respondents who indicated that their company actively sells or markets HVAC maintenance services.

Surveyed contractors whose technicians sell maintenance services directly to their customers were asked how technicians communicate the benefits of proper air conditioner maintenance versus the cost, to residential, small commercial, and large commercial customers. Table 5-18 shows that 70% stated that their technicians provide a basic explanation of benefits, while 41% stated that they provide an explicit explanation of benefits, although this was somewhat less common with small commercial customers. The only statistically significant difference detected across sectors was that respondents were more likely to indicate that they write up a service report for large commercial customers (39%) than either residential (14%) or small commercial (13%) customers ($X^2 = 8.244$ ($df = 2$), $p < .05$).

Table 5-18: How Technicians Communicate the Benefits of Proper HVAC Maintenance

Response	Residential (n = 50)	Small Commercial (n = 47)	Large Commercial (n = 23)	Total (n = 120)
Our technicians provide a basic explanation of benefits from proper maintenance	66%	72%	74%	70%
Our technicians are explicit with how maintenance addresses each benefit (e.g., energy savings, electric bills, indoor air quality)	46%	34%	43%	41%
Our technicians write up a service report that addresses benefits and costs	14%	13%	39%	18%
Our technicians show the customer data gathered with diagnostic tools to demonstrate how much money they can save through maintenance	12%	6%	13%	10%

The research team observed a variety of strategies in offering maintenance agreements during the field observations. Some companies required that their technicians offer the maintenance agreements every time they conduct a service or maintenance call. Technicians acknowledged this as part of their job, but reported during interviews that it is a burden on their time, so they often provide documents and do not spend much effort attempting to persuade customers to sign the agreement. Maintenance agreements seem not to be standard practice. Other companies leave it to the technician to decide whether an agreement should be offered or not. In these cases, technicians offer agreements when they are requested or when customers are older and perceived as unable to perform basic maintenance tasks themselves. Finally, there

are situations in which the offer and sales of agreements is left to dispatchers or administrative assistants at the office, who offer the agreements when a call is made.

Surveyed contractors whose technicians sell maintenance services directly to their customers were asked if they provide technician staff with sales training that encourages residential, small commercial, or large commercial customers to purchase maintenance services. As shown in Table 5-19, fewer contractors reported that they provide technicians with sales training that encourages small commercial customers to purchase maintenance services (31%) as compared to residential customers (57%) and large commercial customers (55%) ($X^2 = 7.096$ ($df = 2$), $p < .05$).

Table 5-19: Does Your Firm Provide Technician Staff with Sales Training for Selling Maintenance Services?

Response	Residential (n = 49)	Small Commercial (n = 45)	Large Commercial (n = 20)	Total (n = 114)
Yes	57%	31%	55%	46%
No	43%	69%	45%	54%
Total	**100%**	**100%**	**100%**	**100%**

Respondents who indicated that their company provides its technician staff with sales training for selling maintenance services were asked to indicate which selling points are covered in the training. As shown in Table 5-20, roughly 90% of contractors reported that their training covers the impact of maintenance on system longevity, energy savings/electric bills, and system reliability.[26] Customer comfort and indoor air quality were somewhat less frequently covered.

Table 5-20: Selling Points Covered by Technician Training for Encouraging the Purchase of Maintenance Services

Response	Residential (n = 28)	Small Commercial (n = 14)	Large Commercial (n = 11)	Total (n = 53)
The impact of maintenance on system longevity	93%	100%	82%	92%
The impact of maintenance on energy savings and electric bills	86%	100%	82%	89%
The impact of maintenance on system reliability	86%	93%	91%	89%
The impact of maintenance on customer comfort	82%	64%	73%	75%
The impact of maintenance on indoor air quality	71%	57%	82%	70%
Other	4%	0%	0%	2%

Note. Multiple responses were accepted.

During the field observations, maintenance services were primarily offered as an opportunity to have the "peace of mind" that comes from knowing the equipment will not fail, and were not connected strongly in technicians' minds with energy efficiency. During recruitment, contractors did not promote lower costs, added value, or guaranteed performance. It may be that the dispatchers did not feel there was a need to

[26] Statistical tests were not conducted for this question because of the rather small number of responses (i.e., no sector had more than 28 cases).

sell their maintenance service, because researchers were already attempting to schedule an appointment with them.

Apparently, it is left to each technician to decide how to promote the agreement. The observations indicate that most technicians choose to promote these agreements in terms of discounts, priority services, and other contractual perks rather than in terms of technical and performance benefits of a well maintained system. The SCE quality maintenance service was discouraged because it would take four hours and achieve similar results.

It is interesting to note that although some maintenance agreement documents emphasized energy benefits in the titles of the agreements, energy benefits were never reviewed when technicians were explaining the agreements. Again, this may be a function of available time.

In several cases, when there were different levels of maintenance agreements, technicians suggested that the "homeowner" get the "basic" rather than the "premium" version, because the equipment was in good enough shape that it did not merit more expensive protection. Technicians explained that this was the version of the agreement that "made more sense for us."

Observed technicians focused primarily on avoidance and prevention of failure as the main benefits of maintenance, suggesting that this was best accomplished by checking and replacing parts. They also noted energy benefits stemming from clean and unrestrictive filters and unclogged systems. Energy benefits were attributed to the system running smoothly, and not using more energy than it had to. Indoor air quality and equipment life were addressed only once each. Comfort, somewhat surprisingly, was not emphasized directly as a benefit of system optimization, but rather as the side effect of the equipment not failing.

Contractor survey respondents who indicated that their company actively sells HVAC maintenance services were asked to report their company's sales and marketing strategies for finding new residential, small commercial, or large commercial customers to purchase their maintenance services. As shown in Table 5-21, overall, almost two-thirds of contractors (68%) stated that they rely on recommendations from customers, while 44% stated that they sell maintenance services to existing/former customers, and this was especially the case with large commercial contractors (59%) compared to small commercial (36%) or residential (39%) contractors ($X^2 = 9.2$ ($df = 2$), $p < .05$). Contractors were more likely to report using online advertising with residential customers (32%) than with small commercial (16%) or large commercial (21%) customers ($X^2 = 7.6$ ($df = 2$), $p < .05$). Finally, a greater proportion of residential contractors indicated they utilize direct mailing (33%) than either small commercial (7%) or large commercial (16%) contractors ($X^2 = 18.737$ ($df = 2$), $p < .001$). No other statistically significant differences were detected across sectors.[27]

[27] Four of the categories did not have large enough cell counts to conduct valid statistical tests: (1) advertising in newspapers, (2) advertising in magazines, (3) advertising on the radio, and (4) advertising on television.

Table 5-21: Sales and Marketing Strategies for Finding New Customers to Purchase Maintenance Services

Response	Residential (n = 69)	Small Commercial (n = 87)	Large Commercial (n = 70)	Total (n = 227)
Recommendations from current customers	68%	61%	64%	64%
Our main strategy is to transition existing/former customers that have received other services into purchasing maintenance work	39%	36%	59%	44%
Recommendations from other contractor firms	22%	31%	36%	30%
Online advertising	32%	16%	21%	22%
Visibility through utility HVAC installation and maintenance programs	25%	13%	23%	19%
Direct mailing	33%	7%	16%	18%
The phone book	25%	13%	16%	17%
Our company does not have a marketing strategy for finding new customers to purchase maintenance services	14%	22%	9%	15%
Online postings including social media	22%	7%	19%	15%
Advertising in newspapers	14%	9%	6%	10%
Advertising on the radio	7%	3%	4%	5%
Advertising in magazines	3%	3%	6%	4%
Advertising on television	3%	1%	1%	2%

Contractor respondents who indicated that their company actively sells HVAC maintenance services were asked to report their company's practice for bidding various maintenance approaches to residential, small commercial, or large commercial customers. Responses are shown in Table 5-22. For residential and small commercial customers, respondents were most likely to report that they offer only one level of maintenance ($X^2 = 8.936$ ($df = 2$), $p < .05$). Large commercial contractors were more likely to state that they have multiple tiers of maintenance with different price points (53%) than either residential (36%) or small commercial contractors (31%) ($X^2 = 8.151$ ($df = 2$), $p < .05$). Finally, large commercial contractors were also more likely to state that they bid different prices for different market segments (43%) than both residential (13%) and small commercial (30%) contractors ($X^2 = 15.162$ ($df = 2$), $p < .001$).

Table 5-22: Approaches to Bidding Maintenance Contracts

Response	Residential (n = 69)	Small Commercial (n = 87)	Large Commercial (n = 70)	Total (n = 227)
We only have one level of maintenance	46%	47%	26%	40%
We have multiple tiers of maintenance (e.g., basic and premium) and each has a different price point	36%	31%	53%	39%
We bid different prices for different market segments	13%	30%	43%	29%
We offer performance contracts	14%	6%	16%	11%
We guarantee the lowest cost maintenance contracts	1%	5%	9%	5%

Respondents at contractor firms that sell HVAC maintenance services were asked if the individuals in their company who sell maintenance agreements to residential, small commercial, or large commercial

customers have a formal set of questions that they ask customers to determine how to bid a maintenance agreement. As shown in Table 5-23, just over one-third of residential (38%) and small commercial (37%) contractors stated that they have a set of formal set of questions for bidding maintenance agreements, while almost one-half (49%) of large commercial contractors said they did, although this was not statistically different at the α =.05 level of significance.

Table 5-23: Does Your Company Have a Formal Set of Questions to Aid Bidding Maintenance Agreement?

Response	Residential (n = 68)	Small Commercial (n = 82)	Large Commercial (n = 65)	Total (n = 215)
Yes	38%	37%	49%	41%
No	62%	63%	51%	59%
Total	**100%**	**100%**	**100%**	**100%**

Table 5-24 shows how contractors that actively sell HVAC maintenance services price maintenance contracts with residential, small commercial, and large commercial customers. 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. The only statistically significant difference across sectors was that contracts with commercial customers were more likely to be based on the size of the unit (small commercial = 21%; large commercial = 16%), compared to those with residential customers (6%) (X^2 = 7.061 (df = 2), $p < .05$).[28]

Table 5-24: Pricing of Maintenance Contracts

Response	Residential (n = 69)	Small Commercial (n = 87)	Large Commercial (n = 70)	Total (n = 226)
The customer pays based on a rate specific to customer type (e.g., residential, small commercial, large commercial)	48%	45%	37%	43%
The customer pays based on a rate specific to system type (cooling capacity, design of HVAC unit, etc.)	27%	31%	44%	34%
The customer pays an hourly rate based on the time a technician spends working on site during each visit	22%	22%	37%	27%
The customer pays based on a rate specific to size of the unit	6%	16%	21%	15%
The customer pays based on the square footage of home or facility	0%	1%	4%	2%

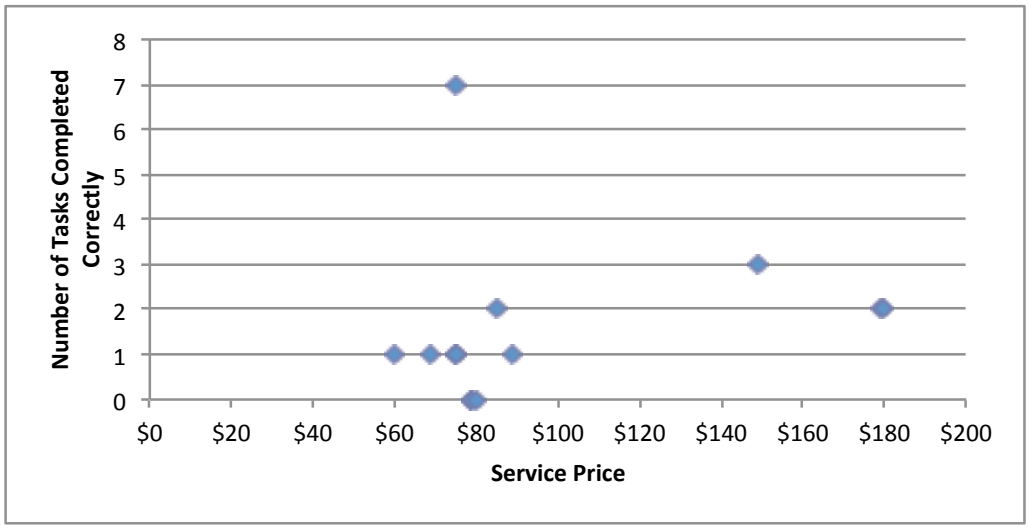
Note. Multiple responses were accepted.

The field observation portion of the study found that prices paid for a single maintenance visit ranged from $60 to $180, although the best performing technician in terms of the number of tasks completed

[28] "The customer pays based on square footage" was not tested due to an insufficient number of cases.

correctly (with 7 correct key tasks) charged a modest $75 for the visit. Figure 5-6 demonstrates that the cost of a maintenance visit had virtually no association with a technician's ability to correctly perform maintenance tasks.

Figure 5-6: Number of Field Tasks Performed in Relation to Cost of Maintenance Visit



The observations and interviews with technicians did not shed much light on why the services were priced at a certain level, but there were indications that cost was expected to increase if the visit was too long, and in one particular case it was made clear that the price of service was charged by the hour. This seemed to be an anomaly, though, as most prices were arranged in advance.

Ten of the thirteen observed technicians recommended repairs on the system. Technicians usually provided written estimates for repairs when they involved replacing parts. Prices for each repair or part were in the hundreds of dollars range, with final estimates ranging from $129 to $1,236, depending mostly on how many repairs or part replacements were being recommended. When a recommendation to work on ducts was included, which involved prices in the thousands, they provided ballpark estimates or no estimate at all, and instead recommended further diagnostics to produce accurate pricing.

There appears to be a set of questions that dispatchers/technicians ask from customers to determine what type of service they are requiring, either when the customer calls in to schedule the service, or as the technician arrives at the customer's home. These are very basic questions regarding the kind of equipment and the problems that may be present. Researchers did not find any clear evidence that technicians were screening customers in order to bid maintenance agreements.

Researchers thought that in most visits, technicians missed the opportunity to offer more quality service and diagnostics than were originally requested. The main rationale provided was that the unit in the study did not necessitate expensive services since it was in good enough shape and the economics would not make sense.

Respondents whose firms actively sell maintenance services were asked whether they stipulate a contract with multiple maintenance visits or single maintenance visits when selling to residential, small commercial, or large commercial customers. As shown in Table 5-25, respondents were overall more

likely to report using contracts, and this was especially the case with large commercial customers; single maintenance visits occur more frequently with residential customers than with commercial customers (X^2 = 17.046 (df = 2), $p < .001$).

Table 5-25: Are Typical Maintenance Services Contracts or Single Visits?

Response	Residential (n = 67)	Small Commercial (n = 85)	Large Commercial (n = 69)	Total (n = 221)
Contracts	69%	82%	96%	82%
Single visits	31%	18%	4%	18%
Total	**100%**	**100%**	**100%**	**100%**

Table 5-26 shows survey respondents' reported percentage of existing maintenance contracts that fail to renew each year, with residential, small commercial, or large commercial customers. It appears that fewer contracts fail to renew with commercial customers, compared to residential customers; that is, commercial customers are perceived to be more likely to renew their contracts. Across the different customer types, almost half (47%) of respondents stated that less than 5% of their customers fail to renew their maintenance contracts each year. No statistically significant difference was detected across sectors at the $\alpha = .05$ level of significance.[29]

Table 5-26: Percent of Existing Maintenance Contracts That Fail to Renew Each Year

Response	Residential (n = 61)	Small Commercial (n = 75)	Large Commercial (n = 66)	Total (n = 202)
Less than 5 percent	33%	49%	58%	47%
5 to 9 percent	26%	19%	15%	20%
10 to 19 percent	20%	20%	9%	16%
20 to 29 percent	10%	5%	5%	6%
30 to 39 percent	3%	3%	3%	3%
40 to 49 percent	2%	0%	5%	2%
50 percent or more	7%	4%	6%	5%
Total	**100%**	**100%**	**100%**	**100%**

As shown in Table 5-27, the structure of maintenance contracts in terms of number of visits per year varies by customer type.[30] For residential customers, maintenance contracts most often stipulate two visits per year. For small and large commercial customers, the most common response was four visits per year.

[29] In order to conduct the chi-square test, the last three categories were collapsed into a single "30 percent or greater" category.

[30] Cell counts were too small and no logical regrouping was evident to conduct a valid statistical test for this question.

Table 5-27: Structure of Maintenance Contracts—Visits Per Year

Response	Residential (n = 63)	Small Commercial (n = 83)	Large Commercial (n = 64)	Total (n = 210)
1 visit per year	11%	1%	2%	4%
2 visit per year	65%	17%	5%	28%
3 visit per year	0%	13%	8%	8%
4 visit per year	3%	59%	66%	44%
5 visit per year	0%	2%	2%	1%
6 visit per year	0%	1%	3%	1%
12 visits per year	2%	1%	8%	3%
Over 12 visits per year	13%	2%	5%	6%
Varies	6%	2%	3%	4%
Total	**100%**	**100%**	**100%**	**100%**

As shown in Table 5-28, most maintenance contracts are for a term of one year, for all three types of customers.[31]

Table 5-28: Structure of Maintenance Contracts—Duration

Response	Residential (n = 64)	Small Commercial (n = 75)	Large Commercial (n = 61)	Total (n = 200)
12 months	69%	75%	80%	75%
Greater than 12 months	9%	9%	8%	9%
Contracts are open-ended	3%	8%	8%	7%
Less than 12 months	8%	3%	3%	5%
No Contract	6%	3%	0%	3%
Varies	5%	3%	0%	3%
Total	**100%**	**100%**	**100%**	**100%**

5.5. Training and Certification – Maintenance Contractors and Technicians

The interviews completed for the field observations indicated that often technicians were more knowledgeable than their technical performance scores would suggest. This does not mean that all of them could have performed up to ACCA or "Quality Maintenance" standards, but that all of them could have performed better than they did.

Most observed technicians evaluated the HVAC industry as dynamic, and acknowledged the need to continuously seek new training, learn more skills, and get up to speed on new technologies. In general, technicians expressed that they like this characteristic of the industry, and they prized their educational credentials and certificates when they had them.

[31] Cell counts were too small and no logical regrouping was evident to conduct a valid statistical test for this question.

The observations also revealed a tension between technicians' perceptions that their job is dynamic ("every system is different, I never find the same thing") and a sense that experience allows technicians to diagnose based simply on past experience ("I know by touching the pipes if it is running well" or "I know these houses' construction, so I know this is a duct problem"). Some technicians stated that their field experience allows them to conduct their work through shortcuts that rookies should not use ("a new guy should take all measurements and write them down; I don't need to do that anymore").

Surveyed contractors were asked to rate ten different training methods in terms of how effective they are for teaching someone the technical skills needed to perform quality maintenance on residential, small commercial, or large commercial HVAC systems. Because these results were very similar for the three different types of customers, Table 5-29 presents these results in aggregate. These results are also very similar to those reported for the effectiveness in teaching quality installation reported earlier. Contractors reported that on-the-job training is by far the most effective type of training for teaching quality installation skills. Sixty-seven percent of respondents reported that training offered by an electric utility is effective for teaching quality maintenance skills. Online training was viewed as least effective for teaching quality maintenance skills.

Table 5-29: Perceived Effectiveness of Training Methods for Teaching the Technical Skills Needed to Perform Quality Maintenance

Training	Very Effective	Effective	Somewhat Effective	Not at All Effective	No Opinion	Not Familiar with Training
On-the-Job Training (n = 305)	76%	18%	2%	1%	2%	1%
Technical or Trade School (n = 303)	37%	38%	19%	1%	3%	2%
Manufacturer Training (n = 305)	36%	41%	18%	1%	2%	2%
Certification Training (n = 301)	35%	42%	15%	2%	4%	3%
Union Apprenticeship (n = 295)	28%	28%	12%	6%	11%	15%
Training Offered by Electric Utility (n = 303)	28%	35%	19%	2%	6%	10%
Private Training Institute (n = 300)	26%	38%	19%	1%	7%	9%
Distributor Training (n = 301)	23%	40%	31%	3%	2%	1%
Community College (n = 299)	17%	40%	29%	4%	6%	3%
Online HVAC Course (n = 298)	7%	28%	41%	8%	6%	10%

All contractors were asked to rate their company's level of interest in six different training methods. Table 5-30 shows responses to this question among contractor respondents whose firms conduct maintenance. These results are very similar to those reported earlier among installation contractors because in many cases they overlap (i.e., those that conduct installation tend to also conduct maintenance). Maintenance contractors are most interested in manufacturer and utility training, with 79% and 75% stating that they were either interested or very interested in manufacturer training and utility training, respectively.

Table 5-30: Interest in Training Opportunities—Maintenance Contractors

Rating	Very Interested	Interested	Somewhat interested	Not at all Interested	No Opinion	Not Familiar with Training
Manufacturer training (n = 282)	45%	34%	10%	6%	4%	1%
Utility training (n = 287)	42%	33%	12%	7%	3%	2%
Distributor training (n = 300)	36%	32%	18%	9%	4%	1%
IHACI training (n = 290)	32%	32%	14%	9%	6%	8%
Online HVAC course (n = 294)	23%	29%	21%	18%	5%	4%
Private training institute (n = 287)	20%	23%	23%	24%	6%	4%

Respondents whose companies conduct maintenance jobs were asked to rate their perceived level of effectiveness for six HVAC industry certifications in terms of how well they prepare technicians to perform quality maintenance. Table 5-31 shows that contractors most often reported that the NATE certification process was very effective in preparing a technician to perform quality maintenance.

Table 5-31: Perceived Effectiveness of the Certification Process for Preparing a Technician to Perform Quality Maintenance

Rating	Very Effective	Effective	Somewhat effective	Not at All Effective	No Opinion	Not Familiar with Certification
NATE (n = 287)	37%	25%	11%	8%	7%	11%
RSES (n = 258)	17%	21%	12%	8%	13%	29%
HVAC Excellence (n = 259)	16%	18%	9%	7%	14%	36%
TABB (n = 243)	8%	17%	11%	8%	16%	40%
UA STAR (n = 247)	8%	15%	11%	9%	15%	43%
PAHRA/Industry Competency Exam (n = 248)	5%	17%	9%	8%	16%	44%

Technicians observed in the field study expressed pride in all the levels of training they have completed and certifications they have earned, and made an effort to distinguish their field of work from the perception that "anybody could do this." During field interviews, technicians stated clearly that they need and enjoy continuous education and training, and they understand that the direction of the industry is towards professional certification. The technicians explained that they felt pressure to obtain training and certifications if they do not have them, and that they find value in the training and certifications they obtain. That said, technicians did not seem to think that presenting their certifications to customers was an important part of the job—they rarely hear customers ask for certifications and they do not think that customers know what these certifications mean. However, they do view SCE programs as having an impact on contracting companies pushing technicians to achieve NATE certification.

As observed by the field study, certified technicians performed more maintenance and service tasks, and executed them correctly more often. However, certifications were not a guarantee of better maintenance performance. NATE certified technicians did not always perform better than non-certified technicians.

The two best performing technicians were NATE and NCI (National Comfort Institute) certified, but there was one NATE certified technician among the worst performers as well.

6. SERVICE

This chapter focuses on data collected from service contractors. Service is defined as a contractor/technician visit that was initiated based on a perceived symptom in the HVAC system, which may be diagnosed as requiring a small fix, a major repair, or the installation of a new system. There were fewer service-focused survey questions asked of contactors, compared to installation and maintenance. Questions were asked regarding service to inform the role that service calls play in terms of installation and maintenance work.

6.1. Replacement vs. Repair of HVAC Systems

The contractor survey included a set of questions unique to the service module that focused on the dynamics involved with customers' decisions to replace or repair existing HVAC systems after a service diagnosis. Respondents were asked to rank factors that they believe influence customers' decision-making of whether to replace or repair an HVAC unit. Table 6-1 shows the percentage of respondents that ranked each factor in the top two. For all three sectors, financial cost was clearly identified as the most important factor, followed by the age of the unit. A contractor's recommendation to a customer was the third highest factor influencing repair-or-replace decisions. No statistically significant differences were detected across sectors at the $\alpha = .05$ level of significance.[32]

Table 6-1: Percent of Contractors Rating Each Factor in Top-2 Factors That Influence Customers' Decision-Making of Whether to Replace or Repair an HVAC Unit

Factor	Residential (n = 123)	Small Commercial (n = 119)	Large Commercial (n = 93)	Total (n = 335)
Financial cost	66%	73%	62%	67%
Age of unit	54%	55%	48%	53%
Our company's recommendation of whether to replace or repair	42%	36%	39%	39%
Speed with which unit can be made operational	18%	23%	23%	21%
SEER rating of unit	8%	11%	12%	10%
Other	4%	0%	1%	2%

Note. Multiple responses were accepted.

Similar findings are apparent in Table 6-2, which displays results from a survey question that asked contractors to indicate what would trigger their company to recommend replacement rather than repair for a customer's HVAC unit. Overall, the most frequent two responses were that "repair cost is high relative to replacement cost" (94%) and the "system is old" (73%). Unlike Table 6-1, however, Table 6-2 indicates a different third most common response: the "system is inefficient." At 72% across all sectors, this may be an important finding for California IOUs, since it suggests that there is a perceptible energy

[32] The 'Other' response was not tested due to insufficient cell counts.

efficiency component of new unit recommendations. No statistically significant differences were detected across sectors at the $\alpha = .05$ level of significance.[33]

Table 6-2: What Would Trigger Recommending Replacement Rather than Repair

Response	Residential (n = 123)	Small Commercial (n = 119)	Large Commercial (n = 93)	Total (n = 335)
Repair cost is high relative to replacement cost	96%	94%	92%	94%
System is old	79%	70%	71%	73%
System is inefficient	77%	66%	73%	72%
System is under capacity	51%	58%	62%	57%
System is over capacity	36%	26%	30%	31%
Don't know	2%	0%	0%	1%
Other	4%	1%	3%	3%

Note. Multiple responses were accepted.

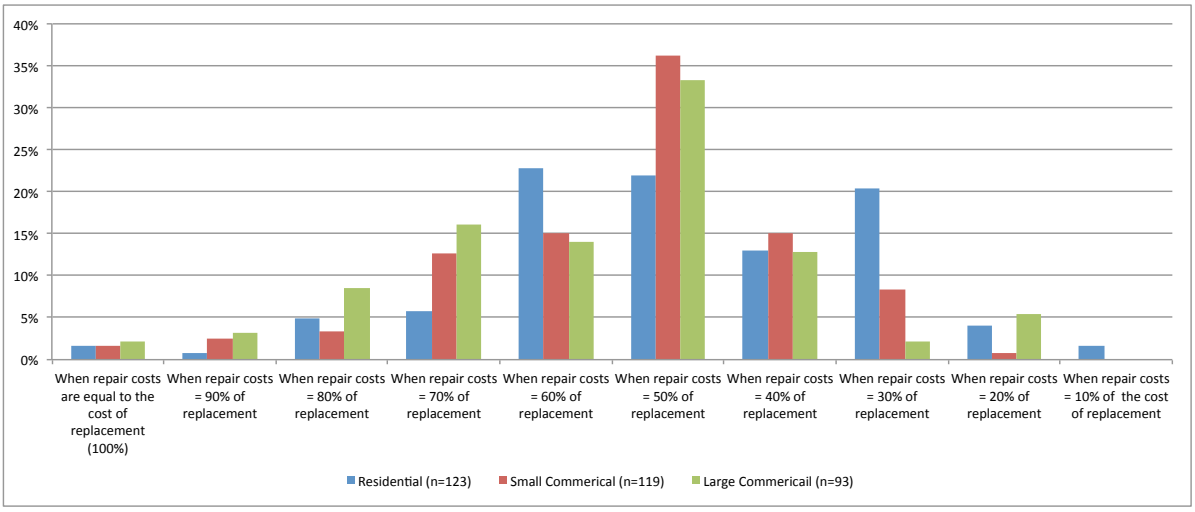
Researchers anticipated that contractors would identify the financial element as heavily impactful on customers' decision to replace or repair their unit and thus included a survey question that would analyze this dynamic in a bit more detail. The question posed was, "At what percentage of replacement cost does your company recommend replacement instead of repair for residential customers?" Figure 6-1 shows that there is a fairly normal distribution of responses with 30% of all respondents stating that customers would likely replace over repair when repair costs are about 50% of the cost of replacement. For residential customers, contractors were somewhat more likely to state that they would recommend replacement when repair costs represent 60% of replacement costs. ($X^2 = 37.740$ ($df = 12$), $p < .001$).[34]

Note that many of the observed technicians made recommendations for repairs; see Appendix G.

[33] The 'Don't know' and 'Other' categories were not tested due to insufficient cell counts.

[34] In order to conduct a valid chi-square test and ensure adequate cell counts, the first three categories were collapsed into "When repair costs are more than about 80% of replacement," and the last two categories were collapsed into "When repair costs are less than about 20% of replacement."

Figure 6-1: At What Percentage of Replacement Cost Do Contractors Recommend Replacement Instead of Repair?—Service Contractors



6.2. Pricing Service

For the field observations, there appeared to be a set of questions that dispatchers/technicians ask from customers to determine what type of service they are requesting, either when the customer calls in to schedule the service, or as the technician arrives at the customer's home. These were very basic questions regarding the kind of equipment and the problems that may be present.

For the field observations, prices for the one-time service/maintenance visit were always provided on the phone in advance, with the caveat that they could change if repairs were offered and accepted by the researchers at the time of the visit. Prices paid for service/maintenance visits ranged from $60 to $180. The observations and interviews with technicians did not shed much light on why the services were priced at a certain level, but there were indications that cost was expected to increase if the visit was too long, and in one particular case it was made clear that the price of service was charged by the hour.

Estimates and pricing for recommended repairs were more varied. Technicians usually provided written estimates for repairs when they involved replacing parts. In these cases prices for each repair or part were in the hundreds of dollars range, with final estimates ranging from $ 129 to $1,236, depending mostly on how many repairs or part replacements were being recommended. When a recommendation to work on ducts was included, which involved prices in the thousands, they provided ballpark estimates or no estimate at all, and just recommended further diagnostics to produce accurate pricing.

Surveyed contractors where asked to report how they price service calls. As shown in Table 6-3, 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 ($X^2 = 24.4$ ($df = 2$), $p < .001$). 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 ($X^2 = 11.9$ ($df = 2$), $p < .01$). Residential contractors were also more likely to report that service calls were based on a flat rate (10%), compared to small commercial (3%) and large commercial (3%) contractors ($X^2 = 6.1$ ($df = 2$), $p < .05$).[35]

Table 6-3: Pricing Service Calls—Service Contractors

Response	Residential (n = 123)	Small Commercial (n = 119)	Large Commercial (n = 93)	Total (n = 335)
The customer pays an hourly rate based on the time a technician spends working on site	48%	65%	81%	63%
The customer pays based on the number and type of repairs performed	51%	36%	29%	40%
The customer pays based on the type of HVAC equipment in his/her home	6%	8%	10%	7%
* Flat rate	10%	3%	3%	6%
* Time and materials	2%	3%	2%	2%
* Other	4%	2%	4%	3%

Note. Multiple responses were accepted. Asterisks (*) indicate coded open-ended responses.

6.3. Training – Service Contractors

All contractors were asked to rate their company's level of interest in six different training methods. Table 6-4 shows responses to this question among contractors that conduct service. At least 64% of respondents stated that they were either "very interested" or "interested" in training offered by manufacturers (78%), utilities (75%), distributors (69%), or IHACI (64%). Eighteen percent of respondents noted that they were "not at all interested" in online HVAC courses.

Table 6-4: Interest in Training Opportunities—Service Contractors

Training	Very Interested	Interested	Somewhat Interested	Not at All Interested	No Opinion	Not Familiar with Training
Manufacturer training (n = 317)	44%	34%	10%	6%	4%	1%
Utility training (n = 324)	42%	33%	12%	7%	3%	3%
Distributor training (n = 313)	36%	33%	17%	8%	4%	1%
IHACI training (n = 311)	33%	31%	13%	9%	6%	8%
Online HVAC course (n = 310)	23%	29%	21%	18%	5%	4%
Private training institute (n = 305)	19%	22%	23%	24%	7%	5%

[35] "Time and materials" and "Other" were not tested due to insufficient cell counts.

7. INSTALLATION

This chapter of the report presents the results from the respondents given the installation module of the online contractor survey. It is arranged in four sections: (1) awareness and implementation of ACCA Standard 5, (2) definition of "quality installation," (3) the installation process, and (4) training.

7.1. Awareness and Implementation of ACCA Standard 5

Survey respondents representing residential and small commercial contractors that perform installation work were asked if they were aware of ACCA Standard 5 specifications, which are the specifications for residential and commercial HVAC installation. Just over one-third (39%) indicted they were aware of ACCA 5.[36] The 90 respondents who indicated they were aware of the standard were also asked how they used ACCA Standard 5 in their work, and Table 7-1 shows their responses. Over one-half of aware contractors (55%) indicated that they adhere to the majority, but not all, of the specifications of the standard. Just over one-quarter (28%) indicated they adhere to the standards completely; only 5% said they were aware but do not adhere to the standard.

Table 7-1: Installation Contractor Implementation of ACCA Standard 5, Among Those Aware of the Standard

Implementation of ACCA 5 [(a)]	Frequency	Percent
We adhere to the majority of the standard's specifications on a job, but not all of the specifications	48	55%
We adhere to all of the standard's specifications on a job	25	28%
We adhere to some of the standard's specifications on a job, but not all of the specifications	11	13%
We are aware of the standard but do not adhere to it on a job	4	5%
Total	**88**	**100%**

(a) Two respondents who indicated that they are aware of ACCA 5 did not answer this question.

7.2. Definition of Quality Installation

Contractor respondents who were presented the installation module were asked, in an open-ended format, to report how they define "quality installation" for jobs with residential, small commercial, and large commercial customers. Coded responses are shown in Table 7-2. Across sectors, the most common criterion used to define quality installation was complying with city or state codes, such as California Title 24 (18% total). Other more commonly provided definitions included "correct" system and duct sizing (13%), and duct sealing (12%). Interestingly, standards (i.e., ACCA 5, BPI, NCI, IHACI, SMACNA, and LEED) were only mentioned by 2% of the respondents. This evidence suggests that there

[36] This question was inadvertently not asked of large commercial contractors.

may be a disconnect between contractors' reported awareness and implementation of ACCA standards and the extent to which they are associated with "quality installation."

Also as shown in Table 7-2, there were some slight differences across sectors, and the greatest distinctions tended to be between the residential and large commercial sectors (small commercial tended to be more similar to the residential than large commercial sector). While 19% of respondents indicated that "correct" system sizing and ductwork defined quality installation, only about 5% said this defined quality installation for large commercial jobs ($X^2 = 2.178$ ($df = 2$), $p < .05$). Similarly, while about 14% said installation according to manufacturer specifications defined quality installation for the residential sector, only 4% said this was part of the definition for the large commercial sector ($X^2 = 6.842$ ($df = 2$), $p < .05$).

Table 7-2: Contractors' Definitions of "Quality Installation"

Response	Residential (n = 116)	Small Commercial (n = 114)	Large Commercial (n = 97)	Total (n = 327)
In compliance with city/state codes (e.g., California Title 24)	19%	21%	13%	18%
'Correct' system and duct sizing	19%	15%	5%	13%
Duct sealing	16%	12%	6%	12%
A clean looking or 'neat' system	11%	9%	6%	9%
Customer is satisfied	9%	8%	11%	9%
Peak/optimum performance	9%	10%	8%	9%
Installed to manufacturer specifications	14%	7%	4%	9%
'Complete' or 'proper' - doing the job the 'right way'	3%	12%	9%	8%
A 'good' job	6%	8%	9%	8%
Commissioning	4%	4%	5%	5%

Note. Multiple responses were accepted. Responses are only shown for those mentioned by at least 5% of respondents.

7.3. The Installation Process

This section of the report presents the results of a series of questions that asked contractors how they go about implementing installation services with their customers. It covers a range of issues including what type of equipment they use, the tasks they conduct, the perceived benefits of proper HVAC installation, company policies, and perceived barriers to implementing quality installations.

Contractor respondents who were presented the installation module were asked to rate their level of agreement/disagreement with six statements as they related to HVAC system installation. A 4-point scale was provided ("strongly agree," "disagree," "neutral," and "strongly agree"; a "don't know" option was also included). Table 7-3 presents the percent of respondents who indicated they "strongly agree" or "agree" with each of the six statements. Overall, the vast majority of contractors, regardless of sector, agreed in some form, with all of the statements. No statistically significant differences were detected across sectors at the $\alpha = .05$ level of significance.

Table 7-3: Perceived Benefits of Proper HVAC Installation

Statement	Residential (n = 114 to 115)	Small Commercial (n = 112 to 114)	Large Commercial (n = 95 to 96)	Total (n = 322 to 325)
Increase customer comfort	92%	90%	94%	92%
Increase energy savings and reduce electric bills	92%	89%	94%	92%
Improve a system's reliability	92%	89%	93%	91%
Prolong a system's operational lifespan	90%	89%	88%	89%
Improve indoor air quality	88%	87%	90%	88%
Prevent expensive repairs	88%	87%	91%	88%

Note. Multiple responses were accepted. Percentages shown indicate the percentage of respondents who stated they "agree" or "strongly agree" with each benefit.

Installation contractors were asked if their company had formal policies or guidelines that technicians are required to follow for installation jobs, and Table 7-4 shows the percentage of respondents who indicated they have such policies or guidelines. While overall, just over two-thirds (69%) of contractors indicated they have formal policies or guidelines, the percentage of those who have such guidelines for small commercial customers (59%) was notably less than those who have guidelines for residential (76%) or large commercial contractors (71%) ($X^2 = 8.009$ ($df = 2$), $p < .05$).

Table 7-4: Percent of Companies That Have Formal Policies or Guidelines That Technicians Are Required to Follow for Installations

Response	Residential (n = 114)	Small Commercial (n = 113)	Large Commercial (n = 97)	Total (n = 324)
Yes	76%	59%	71%	69%
No/ Don't know	24%	41%	29%	30%
Total	**100%**	**100%**	**100%**	**100%**

Table 7-5 shows the results of a question asking contractors what tasks their technician staff perform during a typical installation, sorted in decreasing order by total percent. The most commonly performed tasks were inspecting electrical components, making repairs to existing ductwork, installing a programmable thermostat, and installing a properly matched indoor coil and outdoor unit. Less common tasks include 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.

With regards to the tasks performed during a typical installation job, only four statistically significant differences were detected across sectors. First, relatively fewer large commercial contractors said they leave all manuals with the customer (85%) than either residential (95%) or small commercial (91%) contractors ($X^2 = 6.600$ ($df = 2$), $p < .05$). Second, fewer large commercial contractors reported inspecting the integrity of all accessible ductwork insulation (85%) as compared to residential (90%) or small commercial (95%) ($X^2 = 6.0009$ ($df = 2$), $p < .05$). Third, far fewer large commercial contractors reported showing their customers how to replace air filters (65%) than residential (95%) and small commercial (82%) contractors ($X^2 = 31.086$ ($df = 2$), $p < .001$). Finally, while less than one-half (46%) of residential contractors stated that they install new refrigerant lines (instead of reusing old ones), just over one-half of

small commercial contractors (54%) did the same, while almost two-thirds of large commercial contractors replace the lines (65%) ($X^2 = 6.280$ ($df = 2$), $p < .05$).

Table 7-5: Tasks Performed During a Typical Installation

Task	Residential (n = 116)	Small Commercial (n = 114)	Large Commercial (n = 97)	Total (n = 327)
Inspect all electrical components for proper operation	95%	92%	92%	93%
Make repairs to existing ductwork if necessary	94%	95%	87%	92%
Install programmable thermostat (if not already in use)	91%	96%	88%	92%
Install a properly matched indoor coil and outdoor unit (AC & heat pump only)	95%	93%	89%	92%
Inspect blower motors for proper operation	91%	93%	87%	91%
Inspect condensate drains (and traps) for proper operation	90%	92%	90%	91%
Leave all manuals with customer	95%	91%	85%	91%
Inspect integrity of all accessible ductwork insulation	90%	95%	85%	90%
Inspect the integrity of all accessible ductwork including: duct strapping, hangers, sections, joints, and seams	91%	92%	84%	89%
Test system controls' modes of operation and control sequences	89%	89%	88%	89%
Setup programmable thermostat with customer (if not already in use)	86%	91%	89%	89%
Measure refrigerant charge	91%	91%	85%	89%
Inspect condensate drains (and traps) for proper operation	86%	90%	85%	87%
Inspect accessible refrigerant lines, joints, and coils for oil leaks	85%	90%	82%	86%
If insulating ducts, seal all duct seams before insulating	83%	89%	84%	85%
Inspect air filter housing integrity and air seal	84%	89%	80%	85%
Confirm proper levels of refrigerant and airflow across the coil	87%	86%	80%	85%
Show customer how to replace air filter(s) in new system	95%	82%	65%	81%
Inspect cabinet, cabinet fasteners, and cabinet panels	81%	81%	76%	80%
Inspect cabinet, cabinet fasteners, and cabinet panels	79%	78%	78%	79%
Test to confirm that duct leakage does not exceed recommended levels	77%	64%	65%	69%
Inspect all accessible ductwork for areas of moisture accumulation or biological growth	64%	72%	71%	69%
Consider zoning, with separate temperature controls for different areas	59%	69%	73%	67%
Measure airflow across heat exchanger/coil	65%	60%	66%	63%
Calculate correct sizing for equipment using Manual J	64%	49%	62%	58%
Test ductwork to determine maximum system size	53%	56%	58%	56%
Install new refrigerant lines (not reuse existing lines)	46%	54%	63%	54%
Provide customer with documentation of installation procedures, including Manual J calculations, AHRI certificate, and records of any measurements or testing	50%	39%	47%	46%

As a follow up to the previous question, any respondents who indicated they checked the refrigerant charge as one of the tasks they typically conduct when performing an installation were also asked how they determined that they had the *correct* refrigerant charge. Overall, the contractors surveyed tend to use manufacturer's recommended settings in contrast to generic table settings. Roughly two-thirds of all contractors stated that they check subcooling for TXV (thermal expansion valve) and compare this with the manufacturer's recommended superheat (66%), and check superheat for fixed orifice and compare with manufacturer's recommended superheat (60%). Less than one-half of contractors indicated they check subcooling for TXV and compare with a generic table (40%), or check superheat for fixed orifice and compare with a generic table (36%). No statistically significant differences were detected across sectors at the $\alpha = .05$ level of significance.

Table 7-6: How Technicians Determine the Correct Refrigerant Charge in HVAC Units—Installation contractors

Response	Residential (n = 106)	Small Commercial (n = 104)	Large Commercial (n = 82)	Total (n = 292)
Check subcooling for TXV and compare with manufacturer's recommended subcooling [(a)]	71%	64%	63%	66%
Check temperature split across coil before using gauges	57%	64%	61%	61%
Check superheat for fixed orifice and compare with manufacturer's recommended superheat	63%	61%	56%	60%
Check both superheat and subcooling (regardless of metering device)	55%	57%	62%	58%
Check subcooling for TXV and compare with a generic table (e.g., T24)	42%	39%	40%	40%
Check superheat for fixed orifice and compare with a generic table (e.g., T24)	35%	38%	34%	36%

Note. Multiple responses were accepted.
(a) This was inadvertently termed "manufacturer's recommended superheat" in the survey. It is likely that respondents recognized this mistake and correctly assumed the intended meaning of the question.

Surveyed contractors were also asked if their company had formal policies for following up with customers after an installation job. Table 7-7 shows that roughly two-thirds (64%) of all responding contractors, regardless of sector, reported having such policies. No statistically significant differences were detected across sectors at the α=.05 level of significance.

Table 7-7: Percent of Companies That Have Formal Policies for Following-up With Customers after an Installation Job

Response	Residential (n = 114)	Small Commercial (n = 112)	Large Commercial (n = 95)	Total (n = 321)
Yes	63%	64%	64%	64%
No/Don't know	37%	26%	36%	36%
Total	**100%**	**100%**	**100%**	**100%**

Installation contractor respondents who reported having formal follow-up policies (residential n = 72; small commercial n = 72; large commercial n = 61) were also asked, in an open-ended format, what kind of procedures they use to follow-up with customers. Table 7-8 shows that the procedures mentioned by at least 10% of respondents (in aggregate) included: a phone call (29%), a maintenance agreement (22%), a maintenance follow-up (19%), a customer satisfaction check (16%), a customer meeting or education effort (14%), and general check-ups (13%).

Notable differences across sectors included: contractors tend to use phone calls less frequently with large commercial customers (11%) than with residential (41%) or small commercial customers (32%), contractors tend to use customer meetings less frequently with small commercial customers (8%) than

both residential (20%) and large commercial customers (15%), and contractors tend to use surveys more frequently with residential customers (13%) than with small commercial (5%) or large commercial customers (2%).[37]

Table 7-8: Customer Follow-Up Procedures after an Installation Job

Response	Residential (n = 56)	Small Commercial (n = 59)	Large Commercial (n = 46)	Total (n = 161)
Phone call	41%	32%	11%	29%
Maintenance agreement	16%	29%	20%	22%
Maintenance follow-up	18%	20%	17%	19%
Customer satisfaction check	18%	17%	11%	16%
Customer meeting/education	20%	8%	15%	14%
Check-ups	9%	12%	20%	13%
Inspection	9%	12%	7%	9%
Survey	13%	5%	2%	7%
Follow-up test	7%	8%	7%	7%
Support as needed	4%	2%	2%	2%
Register equipment	4%	2%	0%	2%
Warranty follow-up	4%	0%	4%	2%
Email	2%	0%	0%	1%
Card/Letter/Mailing	0%	2%	2%	1%
According to manufacturer specs	0%	2%	2%	1%
Energy savings check	2%	0%	0%	1%
Retro-commissioning	0%	0%	2%	1%

Note. Multiple responses were accepted.

Finally for this section, contractors presented the installation module were also asked what barriers, if any, existed as they relate to implementing high quality installation services for their customers. Table 7-9 shows that almost two-thirds (62%) of the contractors indicated that their customers simply did not want to pay for it. Interestingly, the two next most mentioned reasons were that technicians lack the knowledge of what is necessary (29%), and contractors/owners lack the knowledge of what is necessary (28%). Twenty-two percent of contractors indicated there are no barriers. Only one statistically significant difference was detected: contractors were less likely to state that there were no barriers for small commercial customers (13%) than for both residential (22%) and large commercial (31%) customers ($X^2 = 9.788$ ($df = 2$), $p < .01$).[38]

Bivariate correlations were calculated to assess whether contractor respondents that reported any particular barrier were likely to report other specific barriers.[39] This analysis revealed that this was not the case, as all of the barriers were positively correlated, with the exception of the barrier "customers don't want to pay for it," which was unrelated to "contractor/owner's knowledge of what is necessary," "access

[37] These conclusions are not derived from statistical tests, and instead are made based on a general observation of the data. The actual *n*s are rather small in each of the cells (most expected cell counts are less than 5), so results of statistical tests would be unreliable.

[38] "Time constraints," "Costs to contractor," and "Poor enforcement of permits/lowball contractors" were not tested due to insufficient cell counts.

[39] Open-ended responses were not included in this analysis.

to the right diagnostic tools," and "access to quality maintenance checklists." Especially highly and positively correlated were "access to quality maintenance checklists" and "access to the right diagnostic tools" ($r(325) = .53$, $p < .001$).

Table 7-9: Barriers to Implementing High Quality Installation Services

Response	Residential (n = 116)	Small Commercial (n = 114)	Large Commercial (n = 97)	Total (n = 327)
Customers don't want to pay for it	63%	66%	57%	62%
Technicians' knowledge of what is necessary	27%	34%	25%	29%
Contractor/owner's knowledge of what is necessary	25%	35%	25%	28%
There are no barriers	22%	13%	31%	22%
Available technical training in the market	16%	20%	20%	18%
Access to the right diagnostic tools	16%	16%	11%	14%
Access to quality maintenance checklists	15%	16%	12%	14%
* Time constraints	3%	2%	0%	2%
* Costs to contractor	2%	1%	1%	1%
* Poor enforcement of permits, "lowball" contractors	2%	2%	1%	2%

Note. Multiple responses were accepted. Asterisks (*) indicate coded open-ended responses.

7.4. Training and Certification - Installation Contractors

Installation contractor respondents rated their perceived level of effectiveness for ten different training methods in terms of how well they teach the technical skills needed to perform quality installations. Overwhelmingly, as shown in Table 7-10, the responding contractors, regardless of sector, felt that on-the-job training is most effective at teaching the skills needed to perform quality installations (95% rated on-the-job training as "effective" or "very effective"). All of the other training methods were rather similar with roughly one-half to three-quarters (57-78%) of the contractors rating them "effective" or "very effective." The exception to this are online HVAC courses, for which only 31% stated that they would be "effective" or "very effective" at teaching someone the skills needed to perform quality installations.

Table 7-10: Perceived Effectiveness of Training Methods for Teaching the Technical Skills Needed to Perform Quality Installation

Training	Very Effective	Effective	Somewhat Effective	Not at All Effective	No Opinion	Not Familiar with Training	Total
On-the-job training (n = 321)	75%	20%	3%	0%	1%	1%	100%
Manufacturer training (n = 318)	38%	39%	17%	2%	2%	1%	100%
Technical or trade school (n = 316)	36%	39%	19%	2%	1%	3%	100%
Certification training (n = 319)	36%	38%	18%	3%	2%	4%	100%
Union apprenticeship (n = 314)	28%	27%	14%	5%	11%	15%	100%
Private training institute (n = 315)	27%	36%	21%	3%	5%	9%	100%
Training offered by an electric utility (n = 316)	22%	45%	20%	1%	5%	7%	100%
Distributor training (n = 318)	21%	43%	29%	3%	2%	2%	100%
Community college (n = 314)	18%	39%	30%	7%	4%	3%	100%
Online HVAC course (n = 311)	7%	24%	44%	11%	4%	10%	100%

All survey respondents were asked to rate their company's level of interest in six different training methods. Table 7-11 presents these results among respondents at contractor firms that conduct installation jobs. Two trainings that received "very interested" or "interested" responses by three-quarters or more of the contractors were manufacturer training (77%) and utility training (75%). The only training that received a "very interested" or "interested" by less than 50% of contractors was a private training institute (42%).

Table 7-11: Interest in Training Opportunities—Installation Contractors

Training	Very Interested	Interested	Somewhat Interested	Not at All Interested	No Opinion	Not Familiar with Training	Total
Manufacturer training (n = 309)	43%	34%	11%	6%	5%	1%	100%
Utility training (n = 316)	42%	33%	12%	7%	4%	3%	100%
Distributor training (n = 305)	36%	33%	17%	8%	5%	1%	100%
IHACI training (n = 305)	32%	31%	13%	8%	7%	9%	100%
Online HVAC course (n = 305)	23%	28%	22%	18%	6%	4%	100%
Private training institute (n = 300)	19%	23%	22%	24%	8%	5%	100%

Finally, in the survey, all respondents of contractor firms that conduct installation jobs were also asked to rate their perceived level of effectiveness for six different HVAC industry certifications in terms of how well the certification process prepares technicians to perform quality installations. Table 7-12 presents these results.

Overall, NATE certification was ranked the highest and is the only certification that was rated "very effective" or "effective" by more than one-half (62%) of the installation contractors. About one-third of contractors rated HVAC Excellence (35%) and RSES certification (33%) "very effective" or "effective." Interestingly, between 32% and 42% of respondents were not familiar with certifications other than NATE.

Table 7-12: Perceived Effectiveness of the Certification Process for Preparing a Technician to Perform Quality Installation

Certification	Very Effective	Effective	Somewhat Effective	Not At All Effective	No Opinion	Not Familiar with Certification	Total
NATE (n = 301)	35%	27%	12%	7%	9%	12%	100%
HVAC Excellence (n = 281)	16%	19%	9%	6%	14%	36%	100%
RSES (n = 283)	16%	17%	13%	7%	15%	32%	100%
TABB (n = 273)	8%	18%	10%	8%	18%	38%	100%
UA STAR (n = 276)	7%	17%	10%	8%	16%	43%	100%
PAHRA/Industry Competency Exam (n = 273)	6%	16%	10%	7%	16%	44%	100%

8. SUMMARY AND RECOMMENDATIONS

This section summarizes 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.

8.1. Summary of Key Findings

This section provides a summary of key findings with respect to the overarching research questions presented in Chapter 1. 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.

8.2. 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.[40] 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.[41,42]

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.

[40] 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).

[41] 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

[42] 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

Appendix A: CRITERIA USED BY CONTRACTORS TO DEFINE THE RESIDENTIAL, SMALL COMMERCIAL, AND LARGE COMMERCIAL SECTORS

Response	Residential (n = 231; 317 total comments)	Small Commercial (n = 217; 281 total comments)	Large Commercial (n = 97; 125 total comments)
Building Use/Type			
Single Family	50%	-	-
4 Residences or Less	2%	1%	-
Specific Mention of Condos, Apts., and/or Townhomes	12%	2%	-
General Multi-family Comment	11%	-	-
Number of Building Floors/Stories	1%	2%	4%
A Place Where People Live	11%	-	-
Building/Business Type	-	33%	28%
Tenants Making Improvements	-	2%	-
Total Building Use/Type Comments	**86%**	**41%**	**32%**
Equipment Size/Capacity			
Less Than 5 tons	3%	7%	
Less Than 7.5 tons		1%	
Less Than 10 tons		10%	
Less Than 15 tons	<1%	2%	
Less Than 20 tons		4%	1%
Less Than 25 tons		2%	0%
Less Than 30 tons		1%	0%
Greater Than 5 tons		1%	8%
Greater Than 7.5 tons			2%
Greater Than 10 tons			6%
Greater Than 15 tons		<1%	2%
Greater Than 20 tons			3%
Greater Than 25 tons			2%
Greater Than 30 tons			2%
Greater Than 50 tons		1%	1%
Greater Than 100 tons			2%
General Equipment Size/Capacity Comments	<1%	3%	3%
Total Equipment Size/Capacity Comments	**3%**	**33%**	**31%**
Other Comments			

Response	Residential (n = 231; 317 total comments)	Small Commercial (n = 217; 281 total comments)	Large Commercial (n = 97; 125 total comments)
Equipment Characteristics Other Than Size/Capacity	2%	8%	16%
Building/Space Square Footage	2%	7%	7%
Cost of Equipment/Job	-	5%	4%
No Valid Response	5%	3%	4%
Other	2%	4%	6%

Note. Because multiple responses were accepted, the total sum of comments is greater than the number of respondents.

Appendix B: INCIDENCE STUDY TELEPHONE SURVEY

INTRODUCTION

INT1. Hello, this is <INTERVIEWER NAME> calling from the Blackstone Group on behalf of Southern California Edison and Pacific Gas and Electric Company. May I please speak with [FIRST_NAME1 LAST_NAME1] or FIRSTNAME2 LAST_Name2]?

1. YES (SKIP TO INT3)
2. NO, THAT PERSON IS NOT AVAILABLE (CONTINUE WITH INT2)

INT2. May I please speak with someone who is knowledgeable about your firm's credentials and licensing?

1. YES [CONTINUE WITH INT3 CORRECT PERSON]
2. NO, THAT PERSON IS NOT AVAILABLE (SCHEDULE CALL BACK)
3. NO (THANK AND TERMINATE)

Hello, this is <INTERVIEWER NAME> calling from the Blackstone Group on behalf of Southern California Edison and Pacific Gas and Electric Company.

INT3. We're calling to conduct a brief 5-minute survey to help electric utilities in California better understand the HVAC industry. This is not a sales call. We will not share this information with marketers or sales people so you can be confident that we will keep your information strictly confidential. May I continue?

1. YES (CONTINUE WITH IS1)
2. NO (THANK AND TERMINATE)

IS1. You are listed as a C-20 licensed contractor in the state of California. Is your company currently working in the HVAC industry?

1. YES
2. NO
98. DON'T KNOW [THANK AND TERMINATE]
99. REFUSED [THANK AND TERMINATE]

IS2. [NOTE TWO DIFFERENT WORDINGS BASED ON IS1] [IF IS1 = 1:] According to our records, we have your company address as <COMPANY ADDRESS>, is this correct? [IF IS1 = 2:] According to our records, your company address was <COMPANY ADDRESS>, is that correct?

1. YES [SKIP TO IS3]
2. NO
98. DON'T KNOW [SKIP TO IS3]
99. REFUSED [SKIP TO IS3]

(ASK IF IS2 = 2)
IS2b. What is/was the correct address?
[RECORD OPEN-END] [CONTINUE TO IS3]
98. DON'T KNOW [CONTINUE TO IS3]
99. REFUSED [CONTINUE TO IS3]

IS3. [NOTE TWO DIFFERENT WORDINGS BASED ON IS1] [IF IS1 = 1:] In order to ensure that we do not call multiple people from your company, please confirm what is your company name. [IF IS1 = 2:] In order to ensure that we do not call multiple people from your company, please confirm what was your company name.
[RECORD OPEN-END] [CONTINUE]
98. DON'T KNOW [CONTINUE]
99. REFUSED [CONTINUE]

INCIDENCE ESTIMATES

IS4. Do you personally hold a C-20 license in the State of California? Please note that this information is strictly confidential and will not be shared with the state or used to take any negative actions against you or your firm.
1. YES
2. NO
98. DON'T KNOW [THANK AND TERMINATE]
99. REFUSED [THANK AND TERMINATE]

IF IS1 = 2, THANK AND TERMINATE AFTER IS4

IS5. Does any other employee of your firm hold a C-20 license in the State of California?
1. YES [SKIP TO IS7 IF IS4 = 1; ASK IS6 IF IS4 = 2]
2. NO [TERMINATE IF IS4 = 2; CONTINUE TO IS7 IF IS4 = 1]
98. DON'T KNOW [TERMINATE IF IS4 = 2; CONTINUE TO IS7 IF IS4 = 1]
99. REFUSED [TERMINATE IF IS4 = 2; CONTINUE TO IS 7 IF IS4 = 1]

ASK ONLY IF IS4 = 2 and IS5 = 1
IS6. To ensure our records are complete and that we don't call anyone else from your company, please provide the name and email address of others in your company that hold a C-20 license (RECORD UPTO 3):
RECORD NAME #1 _____ RECORD EMAIL #1 _____
RECORD NAME #2 _____ RECORD EMAIL #2 _____
RECORD NAME #3 _____ RECORD EMAIL #3 _____
98. DON'T KNOW [CONTINUE]
99. REFUSED [CONTINUE]

IF IS4 = 2, THANK AND TERMINATE AFTER IS6

IS7. What percent of your company's work is done in the following HVAC market sectors? Please answer based on the number of jobs completed in each area and **not** on revenue. The three categories I am going to ask about are residential, small commercial, and large commercial. [READ PROMPTS BELOW; IF DON'T KNOW, PROMPT FOR BEST ESTIMATE]

[SUM OF (**IS7a, IS7b and IS7c) = 100%.**]

IS7a. Residential (RECORD PERCENT)____%
IS7b. Small Commercial (RECORD PERCENT) ____%
IS7c. Large Commercial (RECORD PERCENT)____%

998. DON'T KNOW (UNABLE TO PROVIDE BEST ESTIMATE) [CONTINUE TO IS10] (MAKE EXCLUSIVE)
999. REFUSED [THANK AND TERMINATE] (MAKE EXCLUSIVE)

ASK IF IS7b > 0%
IS7SC. What criteria does your company use to define the small commercial sector?
[RECORD OPEN-END]
98. DON'T KNOW [CONTINUE]
99. REFUSED [CONTINUE]

ASK IF IS7c > 0%
IS7LC. What criteria does your company use to define the large commercial market sector?
[RECORD OPEN-END]
98. DON'T KNOW [CONTINUE]
99. REFUSED [CONTINUE]

ASK IF IS7a > 0%
IS7R. What criteria does your company use to define the residential market sector? For example, how does your company classify single family homes or multifamily housing?
[RECORD OPEN-END]
98. DON'T KNOW [CONTINUE]
99. REFUSED [CONTINUE]

ASK IF IS7b > 0 or IS7c > 0 (EXCLUDING 998 AND 999)
IS8. What percent of your company's work is done on the following types of HVAC systems? Please answer based on the number of jobs completed and **not** on revenue. First I will read all of the categories and then I will ask you to report the percentage for each type of system. The total percent for all HVAC systems your company works with, should add to 100%. [READ ALL FOUR OPTIONS BELOW BEFORE ASKING FOR PERCENTAGES; IF DON'T KNOW, PROMPT FOR BEST ESTIMATE.]

[SUM OF (**IS8a, IS8b, IS8c, and IS8d) = 100%**.]

IS8c. Unitary systems (split or packaged) that are less than 20 tons in capacity ____ RECORD PERCENT
IS8b. Unitary systems (split or packaged) that are greater than or equal to 20 tons in capacity ____ RECORD PERCENT
IS8a. Built-up systems ____ RECORD PERCENT
IS8d. Does your company work on any other types of HVAC systems? [If yes, specify type _____ and RECORD PERCENT ____%.]

998. DON'T KNOW (UNABLE TO PROVIDE BEST ESTIMATE) [CONTINUE] (MAKE EXCLUSIVE)
999. REFUSED [CONTINUE] (MAKE EXCLUSIVE)

ASK IF IS8c>0
IS9. Are the unitary systems less than 20 tons that you install/maintain most often integrated with sophisticated computer controls such as building energy management systems (EMS) or building automation systems (BAS)?
1. YES
2. NO
98. DON'T KNOW
99. REFUSED

IS10. Approximately what percent of your company's business (based on the number of jobs completed and **not** revenue) comes from service calls, maintenance visits, and installation jobs? [READ ALL THREE DEFINITIONS BELOW; IF DON'T KNOW, PROMPT FOR BEST ESTIMATE]

- By **service calls**, we mean appointments that are made to fix a fault in HVAC systems that either shut the system down or inhibits the system's operation to the point that the customer detects a problem.
- By **maintenance visits**, we mean checkups to inspect, test, measure, and preserve an HVAC system.
- By **installation jobs**, we mean projects where the primary purpose is to install new equipment or replace existing equipment.

[SUM OF (**IS10a, IS10b and IS10c) = 100%.)**

IS10a. Service calls ___ %____ RECORD PERCENT
IS10b. Maintenance visits ___ %____ RECORD PERCENT
IS10c. Installation jobs ___ % ____ RECORD PERCENT
998. DON'T KNOW (UNABLE TO PROVIDE BEST ESTIMATE) [THANK AND TERMINATE] (MAKE EXCLUSIVE)
999. REFUSED [THANK AND TERMINATE] (MAKE EXCLUSIVE)

IF IS7 = 998, THANK AND TERMINATE AFTER IS10c.
IS11. Based on your responses, you likely qualify for an upcoming web-based survey that SCE and PG&E are conducting regarding installation, maintenance and service practices in the California HVAC industry. The survey will take approximately 30 minutes to complete and you will be sent a $75 gas card as a thank you for your participation. We will not share your email address with anyone else. Would you be interested in participating in this web-based survey?

1. Yes
2. No (THANK AND TERMINATE)
98. DON'T KNOW (THANK AND TERMINATE)
99. REFUSED (THANK AND TERMINATE)

(ASK IF IS11 = 1)
IS12. In order to send you the survey link, may we please have your email address? [RECORD EMAIL ADDRESS]

98. DON'T KNOW (THANK AND TERMINATE)
99. REFUSED (THANK AND TERMINATE)

Thank you so much for your willingness to participate. We will be sending you an email in the next two weeks with directions on how to access the survey!
(ASK IF IS11 = 2, 98 OR 99.)
I understand. Thank you so much for your willingness to answer my questions today! Your information will greatly assist California electric utilities in designing future programs.

IF TERMINATED AT ANY POINT: Those are all of my questions. Thank you, and have a great day!

Appendix C: ONLINE CONTRACTOR SURVEY

SURVEY INTRO

Thank you for agreeing to participate in this CA HVAC Contractor & Technician Behavior Study sponsored by Southern California Edison (SCE) and Pacific Gas and Electric Company (PG&E) and administered by Energy Market Innovations, Inc.

The purpose of this survey is to help electric utilities in California better understand the HVAC industry. Your input will help inform the future design of utility programs.

[IF PHONE RECRUITED SKIP SCREENING QUESTIONS]

SCREENING QUESTIONS

- SCREEN SO THAT ONLY TARGETED RESPONDENTS COMPLETE SURVEY.
- SCREENING WILL ALSO BE USED TO ASSIGN RESPONDENTS TO THE APPROPRIATE SECTOR FACILITATING SKIP LOGIC IN SURVEY.
- IF RESPONDENT PHONE RECRUITED, SCREENING QUESTIONS WILL BE SKIPPED.

The first step is to answer a few questions to determine if you qualify for the study!

Click "Next >>" to begin.

IS1. Is your company currently working in the HVAC industry? [REQUIRE RESPONSE]

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't Know [THANK & TERMINATE – DO NOT QUALIFY]

IS2. [NOTE TWO DIFFERENT WORDINGS BASED ON IS1] [IF IS1 = 1:] According to our records, we have your company address as <COMPANY ADDRESS>, is this correct? [IF IS1 = 2:] According to our records, your company address was <COMPANY ADDRESS>, is that correct?

- ❍ Yes (1) [SKIP TO IS3]
- ❍ No (2)
- ❍ Don't Know [SKIP TO IS3]

If IS2 = 2

IS2b. What is/was the correct address?
- ❍ [OPEN-END]
- ❍ Don't Know [CONTINUE]

IS3. [NOTE TWO DIFFERENT WORDINGS BASED ON IS1] [IF IS1 = 1:] In order to ensure that we do not survey multiple people from your company, please confirm what is your company name. [IF IS1 = 2:] In order to ensure that we do not call multiple people from your company, please confirm what was your company name.

- ❍ [OPEN-END]
- ❍ Don't Know [CONTINUE]

IS4. Do you personally hold a C-20 license in the State of California? Please note that this information is strictly confidential and will not be shared with the state or used to take any negative actions against you or your firm. [REQUIRE RESPONSE]

- ❍ Yes (1)
- ❍ No (2)

IF IS1 = 2, THANK AND TERMINATE AFTER IS4.

IS5. Does any other employee of your firm hold a C-20 license in the State of California?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't Know [THANK & TERMINATE – DO NOT QUALIFY IF IS4 = 2; CONTINUE TO IS7 IF IS4 = 1]
- ❍ Prefer not to answer [THANK & TERMINATE – DO NOT QUALIFY IF IS4 = 2; CONTINUE TO IS7 IF IS4 = 1]

ASK ONLY IF IS4 = 2 and IS5 = 1

IS6. To ensure our records are complete and that we don't call anyone else from your company, please provide the name and email address of others in your company that hold a C-20 license:

Name #1 _____ Email #1 _____

Name #2 _____ Email #2 _____

Name #3 _____ Email #3 _____

- ❍ Prefer not to answer [CONTINUE]

IF IS4 = 2, THANK AND TERMINATE – DO NOT QUALIFY

IS7. What percent of your company's work is done in the following HVAC market sectors? Please answer based on the number of jobs completed in each area and **not** on revenue. Your best estimate is

fine.

(Please make sure responses add to 100%.)

IS7a Residential ____%
IS7b Small Commercial ____%
IS7c Large Commercial ____%

IF (IS7a + IS7b + IS7c ≠ 100) THEN DO NOT ADVANCE TO NEXT QUESTION, AND DISPLAY THE FOLLOWING MESSAGE: Your responses must total to 100%.

COMPUTE NEW VARIABLE "SECTOR."
SECTOR = 3 IF LARGE COMMERCIAL > or = 10%.
IF LARGE COMMERCIAL < 10%, THEN:
SECTOR = 2 IF SMALL COMMERCIAL > or = 20%.
OTHERWISE SECTOR = 1 (RESIDENTIAL).

IS10. Approximately what percent of your company's business (based on the number of jobs completed and **not** revenue) comes from service calls, maintenance visits, and installation jobs? Your BEST ESTIMATE is fine. [REQUIRE RESPONSE]

- By **service calls**, we mean appointments that are made to fix a fault in HVAC systems that either shut the system down or inhibits the system's operation to the point that the customer detects a problem.
- By **maintenance visits**, we mean checkups to inspect, test, measure, and preserve an HVAC system.
- By **installation jobs**, we mean projects where the primary purpose is to install new equipment or replace existing equipment.

[Please make sure responses add to 100%.]

IS10a. Service calls ___ %

IS10b. Maintenance visits ___ %

IS10c. Installation jobs ___ %

IF (IS10a + IS10b + IS10c ≠ 100) THEN DO NOT ADVANCE TO NEXT QUESTION, AND DISPLAY THE FOLLOWING MESSAGE: Your responses must total to 100%.

IF SKIPPED IS7, THANK AND TERMINATE AFTER IS10c.

BEGIN SURVEY

Congratulations! You have qualified for this survey. The survey should take approximately thirty minutes to complete and we will email you a $75 gas card within 3 weeks of successfully completing the survey. All of your responses will be kept confidential.

If you have any questions about the study, please contact Donna Whitsett at (206) 621-1160 or by email at survey@emiconsulting.com.

FIRMOGRAPHICS

F1. What is your primary role in the company where you work?

- ❍ Owner (1)
- ❍ President/CEO (2)
- ❍ General Manager (3)
- ❍ Service Manager (4)
- ❍ Technician (5)
- ❍ Other (Specify) _____ (6)

F2. How long has your company been operating?

- ❍ Less than 5 years (1)
- ❍ 5 to 9 years (2)
- ❍ 10 to 19 years (3)
- ❍ 20 to 29 years (4)
- ❍ 30 years or more (5)
- ❍ Don't know (6)

F3. What is your company's annual revenue?

- ❍ Less than $100,000 (1)
- ❍ $100,000 to $249,999 (2)
- ❍ $250,000 and $499,999 (3)
- ❍ $500,000 and $999,999 (4)
- ❍ $1 million and $2,999,999 (5)
- ❍ $3 million and $7,999,999 (6)
- ❍ $8 million or more (7)
- ❍ Prefer not to answer (8)
- ❍ Don't know (9)

F4. The facility where you work is:

- ❑ Your company's only location (1)
- ❑ The headquarters of a company with multiple locations (2)
- ❑ A branch or franchise location of a company based in California (3)
- ❑ A branch or franchise location of a company based outside California (4)
- ❑ Other (Specify) _____ (5)
- ❑ Don't know (6)

F5. How many employees, including yourself, work at your company?

- ❍ 1-4 (1)
- ❍ 5-9 (2)
- ❍ 10-24 (3)
- ❍ 25-49 (4)
- ❍ 50-99 (5)
- ❍ 100 or more (6)
- ❍ Don't know (7)

F6. Are the employees at your company members of a union?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF F6 = 1

F6b. Which union(s) do the employees at your company belong to? (Check all that apply).

- ❍ United Association (UA) (1)
- ❍ Sheet Metal Workers International Association (SMWIA) (2)
- ❍ Other (Specify) _____ (3)
- ❍ Don't know (4)

F7. Does your company belong to any of the following associations? If so, please indicate each association your company belongs to by checking the corresponding box:

- ❑ No, my company does not belong to any associations (1)
- ❑ Air Conditioning Contractors of America (ACCA) (2)
- ❑ Institute of Heating and Air Conditioning Industries (IHACI) (3)
- ❑ Refrigeration Service Engineers Society (RSES) (4)
- ❑ Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) (5)
- ❑ Mechanical Service Contractors of America (MSCA) (6)
- ❑ Other (Specify) (7)
- ❑ Don't know

RESPONSE OPTIONS 2-6 RANDOMIZED

F7b. Does your company have any of the certifications listed below? If so, please indicate each certification your company has by checking the corresponding box.

(Check all that apply).

- ❑ Our company has none of these certifications (6)
- ❑ ACCA Quality Assured (1)
- ❑ MSCA STAR (2)
- ❑ NATE C3 (3)
- ❑ Associated Air Balance Council (AABC) (4)

- ❑ National Balancing Council (NBC) (5)
- ❑ Other (Specify) _____ (7)

RESPONSE OPTIONS 1-5 RANDOMIZED

F8. Which service territories does your company operate within?

(Check all that apply).

- ❑ Pacific Gas and Electric Company (1)
- ❑ San Diego Gas and Electric (2)
- ❑ Southern California Edison (3)
- ❑ Southern California Gas (4)
- ❑ Los Angeles Department of Water & Power (5)
- ❑ Sacramento Municipal Utility District (6)
- ❑ Other 1 (Specify) _____ (7)
- ❑ Other 2 (Specify) _____ (8)
- ❑ Don't know (8)

RESPONSE OPTIONS 1-6 RANDOMIZED

F9. Research indicates that technicians use an array of tools when they are performing diagnostic tests on HVAC systems. What tools do your company's technicians most **use** to perform the following diagnostic tests on HVAC systems?

Click-and-drag from the list on the left into each box on the right.

Digital Refrigeration Gauges(1)	1st Most Used
Analog Compound Gauges (2)	
Flow Hood (3)	
Anemometer (4)	
Flow Plates (5)	
Duct Leakage Tester (6)	
Humidity Probe (7)	2nd Most Used
Type K Thermocouple with Wet Sock (8)	
Electronic Wet Bulb Thermometer (9)	
Digital Thermometer (10)	
Type K Thermocouples (11)	
Pipe Clamp Thermometer (12)	3rd Most Used
Current Clamp (13)	
Multimeter (14)	
Software (15)	
Other (Specify) _____ (16)	

RESPONSE OPTIONS 1-15 RANDOMIZED

F10. If you had to choose, what tools do technicians **need** the most in order to successfully perform diagnostic tests on HVAC systems?

Click-and-drag the three tools from the list on the left, to the appropriate boxes on the right.

Digital Refrigeration Gauges (1)	1st Most Important
Analog Compound Gauges (2)	
Flow Hood (3)	
Anemometer (4)	
Flow Plates (5)	
Duct Leakage Tester (6)	
Humidity Probe (7)	2nd Most Important
Type K Thermocouple with Wet Sock (8)	
Electronic Wet Bulb Thermometer (9)	
Digital Thermometer (10)	
Type K Thermocouples (11)	
Pipe Clamp Thermometer (12)	3rd Most Important
Current Clamp (13)	
Multimeter (14)	
Software (15)	
Other (Specify) _____ (16)	

RESPONSE OPTIONS 1-15 RANDOMIZED

ASK SERV.Res Module IF SECTOR = 1 AND IS10a > or = 1%.

SERVICE– RESIDENTIAL (SERV.Res Module)

Next is a set of service-focused questions specific to your residential customers.

Serv5.Res
In your opinion, what factors influence residential customers' decision-making of whether to replace or repair an HVAC unit?

Please rank the following factors from most important (on top) to least important (on the bottom) by clicking-and-dragging them into the appropriate order.

- ❑ Financial cost (1)
- ❑ Our company's recommendation of whether to replace or repair (2)
- ❑ Speed with which unit can be made operational (3)
- ❑ Age of unit (4)
- ❑ SEER rating of unit (5)
- ❑ Other (Specify) _____ (6)

RESPONSE OPTIONS 1-5 RANDOMIZED

Serv7.Res
What would trigger your company to recommend replacement rather than repair for residential customers?

(Check all that apply).

- ❑ Repair cost is high relative to replacement cost (1)
- ❑ System is old (2)
- ❑ System is inefficient (3)
- ❑ System is under capacity (4)
- ❑ System is over capacity (5)
- ❑ Other (Specify) _____ (6)
- ❑ Don't know (7)

RESPONSE OPTIONS 1-5 RANDOMIZED

Serv6.Res
At what percentage of replacement cost does your company recommend replacement instead of repair for residential customers?

- ❍ When repair costs are equal to the cost of replacement (100%) (1)
- ❍ When repair costs are about 90% of the cost of replacement (2)
- ❍ When repair costs are about 80% of the cost of replacement (3)
- ❍ When repair costs are about 70% of the cost of replacement (4)
- ❍ When repair costs are about 60% of the cost of replacement (5)
- ❍ When repair costs are about 50% of the cost of replacement (6)
- ❍ When repair costs are about 40% of the cost of replacement (7)
- ❍ When repair costs are about 30% of the cost of replacement (8)
- ❍ When repair costs are about 20% of the cost of replacement (9)
- ❍ When repair costs are about 10% of the cost of replacement (10)
- ❍ Don't know (11)

Serv8.Res
How does your company price a service call for residential customers? By **service calls**, we mean appointments that are made to fix a fault in HVAC systems that either shut the system down or inhibits the system's operation to the point that the customer detects a problem.

(Check all that apply).

- ❑ The customer pays an hourly rate based on the time a technician spends working on site (1)
- ❑ The customer pays based on the number and type of repairs performed (2)
- ❑ The customer pays based on the type of HVAC equipment in his/her home (3)
- ❑ The customer pays based on the square footage of his/her home (4)
- ❑ Other (Specify) _____ (5)
- ❑ Don't know (6)

RESPONSE OPTIONS 1-4 RANDOMIZED

ASK MAINT.Res Module IF SECTOR = 1 AND IS10b > or = 1%.

MAINTENANCE– RESIDENTIAL (MAINT.Res Module)

Next is a set of maintenance-focused questions specific to your residential customers.
By maintenance, we mean checkups to inspect, test, measure, and preserve an HVAC system.

Maint1.RES
Approximately what percentage of your ***residential customers*** have at least one maintenance check-up per year for their HVAC systems?

- ❍ Less than 10 percent (1)
- ❍ 10 to 24 percent (2)
- ❍ 25 to 49 percent (3)
- ❍ 50 to 74 percent (4)
- ❍ 75 to 100 percent (5)
- ❍ Don't know (6)

Maint2.RES
How often does your company recommend that ***homeowners*** have maintenance check-ups for their home HVAC systems?

- ❍ We do not recommend that our customers schedule maintenance appointments (1)
- ❍ Every other year (2)
- ❍ Once a year (3)
- ❍ Twice a year (4)
- ❍ Three times a year (5)
- ❍ Four times a year (6)
- ❍ Other (Specify) _____ (7)

Maint3.RES
Please indicate your level of agreement or disagreement with the following statements.

Regular, proper maintenance of a residential customer's HVAC system can:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (3)	Strongly Agree (4)	Don't know (5)
Improve indoor air quality (1)	❍	❍	❍	❍	❍	❍
Increase customer comfort (2)	❍	❍	❍	❍	❍	❍
Increase energy savings and reduce electric bills (3)	❍	❍	❍	❍	❍	❍
Prolong a system's	❍	❍	❍	❍	❍	❍

operational lifespan (4)						
Prevent expensive repairs (5)	❍	❍	❍	❍	❍	❍
Improve a system's reliability (6)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-6 RANDOMIZED

Maint4.RES
Does your company have a formal policy or set of guidelines that technicians are required to follow for residential maintenance procedures?

- ❍ Yes – Please explain or describe: _____ (1)
- ❍ No (2)
- ❍ Don't know (3)

Maint6.RES
Which of the following tasks do your company's technicians perform during a typical residential maintenance visit?

Please indicate each task that your technicians perform by checking the corresponding box.

(Check all that apply).

- ❑ Inspect filters for particulate accumulation and clean/replace as needed (1)
- ❑ Inspect air filter housing integrity and air seal (2)
- ❑ Inspect grilles, registers and diffusers for dirt accumulation (3)
- ❑ Inspect all accessible ductwork for areas of moisture accumulation or biological growth (4)
- ❑ Inspect integrity of all accessible ductwork insulation (5)
- ❑ Inspect the integrity of all accessible ductwork including: duct strapping, hangers, sections, joints, and seams (6)
- ❑ Test system controls' modes of operation and control sequences (7)
- ❑ Visually inspect heat exchanger for signs of corrosion, fouling, structural problems (e.g. cracks, perforations, bulges) (8)
- ❑ Measure airflow across heat exchanger/coil (9)
- ❑ Inspect condensing coil and clean/adjust as needed (10)
- ❑ Inspect evaporator coil and clean/adjust as needed (11)
- ❑ Measure refrigerant charge (13)
- ❑ Inspect accessible refrigerant lines, joints, and coils for oil leaks (14)
- ❑ Inspect all electrical components for proper operation (15)
- ❑ Inspect blower motors for proper operation (16)
- ❑ Inspect cabinet, cabinet fasteners, and cabinet panels (17)
- ❑ Inspect condensate drains (and traps) for proper operation (18)
- ❑ Inspect economizers (19)
- ❑ Other 1 (Specify) _____ (20)
- ❑ Other 2 (Specify) _____ (21)

- ❑ Other 3 (Specify) _____ (22)
- ❑ Other 4 (Specify) _____ (23)
- ❑ Other 5 (Specify) _____ (24)
- ❑ Other 6 (Specify) _____ (25)
- ❑ Our company's technicians do not perform any of these tasks (26)

RESPONSE OPTIONS 1-19 RANDOMIZED

SHOW ONLY IF Maint6.RES = 13

Maint6b.RES
You indicated that your company's technicians check an HVAC unit's refrigerant charge during a typical residential maintenance visit. How do your technicians determine that you have the correct refrigerant charge in air conditioners? (Check all that apply)

- ❑ Check superheat for fixed orifice and compare with manufacturer's recommended superheat (1)
- ❑ Check superheat for fixed orifice and compare with a generic table (e.g. T24) (2)
- ❑ Check subcooling for TXV and compare with manufacturer's recommended superheat (3)
- ❑ Check subcooling for TXV and compare with a generic table (e.g. T24) (4)
- ❑ Check both superheat and subcooling (regardless of metering device) (5)
- ❑ Check temperature split across coil before using gauges (6)
- ❑ Other (Specify)
- ❑ Don't know

RESPONSE OPTIONS 1-6 RANDOMIZED

Maint5.RES
Are you aware of "ACCA Standard 4: Maintenance of Residential HVAC Systems", developed by Air Conditioning Contractors of America (ACCA)?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF Maint5.RES = 1

Maint5b.RES
How would you characterize your company's use or implementation of the specifications or guidelines of ACCA Standard 4?

- ❍ We are aware of the standard but do not adhere to it on a job (1)
- ❍ We adhere to some of the standard's specifications on a job, but not all of the specifications (2)
- ❍ We adhere to the majority of the standard's specifications on a job, but not all of the specifications (3)
- ❍ We adhere to all of the standard's specifications on job (4)

Maint7.RES
During a typical residential maintenance visit, how long does a technician from your company spend working on each unit?

- ❍ Less than 15 minutes (1)
- ❍ Between 15 and 29 minutes (2)
- ❍ Between 30 and 44 minutes (3)
- ❍ Between 45 minutes and 59 minutes (4)
- ❍ Between 1 hour and 1 hour and 59 minutes (5)
- ❍ Between 2 hours and 2 hours and 59 minutes (6)
- ❍ Between 3 hours and 3 hours and 59 minutes (7)
- ❍ 4 hours or more (8)
- ❍ Don't know (9)

Maint8 .RES
For jobs with residential customers, how does your company define "quality maintenance"?

OPEN-ENDED RESPONSE _____

Maint9.RES
How effective do you think the following training methods are at teaching someone the technical skills needed to ***perform*** quality maintenance on residential HVAC systems?

	Not at all effective (1)	Somewhat effective (2)	Effective (3)	Very effective (4)	No opinion (5)	I'm not familiar with the training method (6)
Technical or trade school (1)	❍	❍	❍	❍	❍	❍
Community college (2)	❍	❍	❍	❍	❍	❍
Union apprenticeship (3)	❍	❍	❍	❍	❍	❍
Private training institute (4)	❍	❍	❍	❍	❍	❍
Online HVAC course (5)	❍	❍	❍	❍	❍	❍
Training offered by an electric utility (6)	❍	❍	❍	❍	❍	❍
Distributor training (7)	❍	❍	❍	❍	❍	❍
Manufacturer training (8)	❍	❍	❍	❍	❍	❍
Certification training (9)	❍	❍	❍	❍	❍	❍
On-the-job training (10)	❍	❍	❍	❍	❍	❍
Other (Specify) _____	❍	❍	❍	❍	❍	❍

(11)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-10 RANDOMIZED

Maint12.RES
Does your company actively try selling or marketing HVAC maintenance services to your residential customers?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF Maint12.RES = 2

Maint13.RES
For what reasons does your company not actively try and sell maintenance services to your residential customers?

(Check all that apply).

- ❑ There is no value in doing maintenance (1)
- ❑ Customers do not understand the value of maintenance (2)
- ❑ Customers understand the value of maintenance, but are not interested in having maintenance performed on a regular basis (3)
- ❑ Customers are not willing to make long-term commitments (4)
- ❑ Customers do not want to pay extra money for regular maintenance (5)
- ❑ We don't make enough money on maintenance contracts (6)
- ❑ Our technicians need more technical training to be able to perform regular maintenance (7)
- ❑ Our technicians need more "soft skills" training, such as communication skills, to be able to sell maintenance contracts to customers (8)
- ❑ Other (Specify) _____ (9)

[RANDOMIZE OPTIONS 1 THROUGH 8]

Maint14.RES
In your opinion, what are your ***residential*** customers' priorities when it comes to their HVAC systems?

Please rank the following benefits from most important (on top) to least important (on the bottom) by clicking-and-dragging them into the appropriate order.

Reliability (1)
Cost efficiency (2)
Longevity of unit (3)
Occupant comfort (4)
Minimizing repair costs (5)
Peace of mind (6)

Energy efficiency (7)
Other (Specify)

RESPONSE OPTIONS 1-7 RANDOMIZED

Maint15.RES
What do you see as the primary barriers to your company *selling* HVAC maintenance services to your residential customers?

(Check all that apply).

- ❑ There are no barriers, all our customers have maintenance performed on their HVAC systems regularly (1)
- ❑ Customers do not know that maintenance can reduce their electric bills (2)
- ❑ Customers do not know that maintenance can improve the performance and longevity of their cooling system (3)
- ❑ Customers know about the benefits of maintenance, but do not want to pay extra money for it (4)
- ❑ Customers know about the benefits of maintenance, but do not want to pay extra money for it unless someone can show them evidence of how much money they can save (5)
- ❑ Technicians need more technical training to be able to perform maintenance (6)
- ❑ Technicians need more "soft skills" training, such as communication skills, to be able to sell maintenance to customers (7)
- ❑ Equipment warranties make certain customers less willing to have maintenance performed on their HVAC units (8)
- ❑ Other barrier 1 (Specify)_____ (9)
- ❑ Other barrier 2 (Specify) _____ (10)
- ❑ Other barrier 3 (Specify) _____ (11)

[RANDOMIZE 2 THROUGH 8]

→ If Maint12.RES = 2 Or Maint12.RES = 3, SKIP TO Inst1.RES

SHOW ONLY IF Maint12.RES = 1

Maint16.RES
What are your company's sales and marketing strategies for finding new residential customers to purchase maintenance services?

(Check all that apply).

- ❑ Our company does not have a marketing strategy for finding new customers to purchase maintenance services (1)
- ❑ Our main strategy is to transition existing/former customers that have received other services into purchasing maintenance work (2)
- ❑ Recommendations from current customers (3)
- ❑ Recommendations from other contractor firms (4)
- ❑ The phone book (5)
- ❑ Online postings including social media (6)
- ❑ Online advertising (7)
- ❑ Direct mailing (8)
- ❑ Advertising in newspapers (9)

- ❑ Advertising in magazines (10)
- ❑ Advertising on the radio (11)
- ❑ Advertising on television (12)
- ❑ Visibility through utility HVAC installation and maintenance programs (13)
- ❑ Other (Specify) _____ (14)

RESPONSE OPTIONS 2-13 RANDOMIZED

SHOW ONLY IF Maint12.RES = 1

Maint17.RES
What is your company's practice for bidding various maintenance approaches to residential customers?

(Check all that apply)

- ❑ We only have one level of maintenance (1)
- ❑ We have multiple tiers of maintenance (e.g. basic and premium) and each has a different price point (3)
- ❑ We bid different prices for different market segments (4)
- ❑ We guarantee the lowest cost maintenance contracts (5)
- ❑ We offer performance contracts (6)
- ❑ Other (Specify) _____ (7)

SHOW ONLY IF Maint12.RES = 1

Maint18.RES
Do the individuals in your company that sell maintenance agreements to residential customers have a formal set of questions that they ask customers to determine how to bid a maintenance agreement?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF Maint12.RES = 1

Maint19.RES
Do the technicians at your company sell HVAC maintenance services to your residential customers?

- ❍ Yes, our technicians sell maintenance services directly to customers (1)
- ❍ Our technicians recommend that customers purchase maintenance services, but then refer the customer to a sales person who completes the sale (2)
- ❍ No, our technicians play no role in the maintenance service sales process (3)
- ❍ Other (Specify) _____ (4)
- ❍ Don't know (5)

SHOW ONLY IF Maint19.RES = 1

Maint20.RES
When selling maintenance services, how does your company communicate to residential customers the

benefits of proper air conditioner maintenance versus the cost?

(Check all that apply).

- ❑ Our technicians provide a basic explanation of benefits a customers can get from proper maintenance (1)
- ❑ Our technicians are explicit with how maintenance addresses each benefit such as how maintenance impacts energy savings and electric bills and how maintenance impacts indoor air quality (2)
- ❑ Our technicians show the customer data gathered with diagnostic tools to demonstrate how much money they can save through maintenance (3)
- ❑ Our technicians write up a service report that addresses benefits and costs (4)
- ❑ Other (Specify) _____ (5)

SHOW IF Maint19.RES =1

Maint21.RES
Does your company provide its technician staff with sales training that encourages residential customers to purchase maintenance services?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW IF Maint19.RES =1 AND Maint21.RES =1

Maint22.RES
If your company's training covers any of the following selling points, please check the corresponding boxes.

(Check all that apply).

- ❑ The impact of maintenance on indoor air quality (1)
- ❑ The impact of maintenance on energy savings and electric bills (2)
- ❑ The impact of maintenance on customer comfort (3)
- ❑ The impact of maintenance on system longevity (4)
- ❑ The impact of maintenance on system reliability (5)
- ❑ Other (Specify) _____ (6)
- ❑ Don't know (7)

SHOW ONLY IF Maint12.RES = 1

Maint23.RES
Do the maintenance services your company sells to residential customers stipulate a certain number of maintenance visits at regularly scheduled intervals (i.e. a contract), or are they single maintenance visits?

- ❍ Contracts (1)
- ❍ Single visits (2)
- ❍ Don't know (3)

SHOW ONLY IF Maint12.RES=1

Maint24.RES
What percentage of your existing maintenance contracts with residential customers fail to renew each year (for any reason)?

- ❍ Less than 5 percent (1)
- ❍ 5 to 9 percent (2)
- ❍ 10 to 19 percent (3)
- ❍ 20 to 29 percent (4)
- ❍ 30 to 39 percent (5)
- ❍ 40 to 49 percent (6)
- ❍ 50 percent or more (7)
- ❍ Prefer not to answer (8)
- ❍ Don't know (9)

SHOW ONLY IF Maint12.RES=1

Maint25.RES
What is the structure of your company's residential maintenance contracts in terms of:

	Enter response (1)
The number of maintenance visits per year (1)	_____
Length of contract (in months) (2)	_____

SHOW ONLY IF Maint12.RES=1

Maint26.RES
How does your company price a maintenance contract with residential customers?

(Check all that apply).

- ❑ The customer pays an hourly rate based on the time a technician spends working on site during each visit (1)
- ❑ The customer pays based on a rate specific to customer type (e.g., residential, small commercial, large commercial) (2)
- ❑ The customer pays based on a rate specific to system type (cooling capacity, design of HVAC unit, etc.) (3)
- ❑ The customer pays based on a rate specific to size of the unit (4)
- ❑ The customer pays based on the square footage of his home or facility (5)
- ❑ Other (Specify) _____ (6)

ASK INST.RES Module IF SECTOR = 1 AND IS10c > or = 1%.

INSTALLATION – RESIDENTIAL (INST.RES MODULE)

Next is a set of installation-focused questions specific to your residential customers. By installation jobs, we mean projects where the primary purpose is to install new equipment or replace existing equipment.

Inst0.RES
For jobs with residential customers, how does your company define "quality installation"?

OPEN-ENDED RESPONSE _____

Inst1.Res
Please indicate your level of agreement or disagreement with the following statements.

Proper installation of a residential customer's HVAC system can:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (3)	Strongly Agree (4)	Don't know (5)
Improve indoor air quality (1)	❍	❍	❍	❍	❍	❍
Increase customer comfort (2)	❍	❍	❍	❍	❍	❍
Increase energy savings and reduce electric bills (3)	❍	❍	❍	❍	❍	❍
Prolong a system's operational lifespan (4)	❍	❍	❍	❍	❍	❍
Prevent expensive repairs (5)	❍	❍	❍	❍	❍	❍
Improve a system's reliability (6)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-6 RANDOMIZED

Inst2.RES
Does your company have a formal policy or set of guidelines that technicians are required to follow for residential installation procedures?

❍ Yes (1)
❍ No (2)

❍ Don't know (3)

Inst5.RES
Which of the following tasks do your company's technicians perform during a typical residential installation?

Please indicate each task that your technicians perform by checking the corresponding box.

(Check all that apply).

EQUIPMENT

- ❑ Calculate correct sizing for equipment using Manual J (1)
- ❑ Install a properly matched indoor coil and outdoor unit (AC & heat pump only) (2)
- ❑ Test ductwork to determine maximum system size (3)
- ❑ Install new refrigerant lines (not reuse existing lines) (4)
- ❑ Install programmable thermostat (if not already in use) (5)
- ❑ Setup programmable thermostat with customer (if not already in use) (6)
- ❑ Consider zoning, with separate temperature controls for different areas (7)

DUCT WORK

- ❑ Inspect the integrity of all accessible ductwork including: duct strapping, hangers, sections, joints, and seams (8)
- ❑ Inspect integrity of all accessible ductwork insulation (9)
- ❑ Make repairs to existing ductwork if necessary (10)
- ❑ If insulating ducts, seal all duct seams before insulating (11)
- ❑ Test to confirm that duct leakage does not exceed recommended levels (12)
- ❑ Inspect air filter housing integrity and air seal (13)
- ❑ Inspect all accessible ductwork for areas of moisture accumulation or biological growth (14)

VERIFICATION & MAINTENANCE

- ❑ Show customer how to replace air filter(s) in new system (15)
- ❑ Leave all manuals with customer (16)
- ❑ Provide customer with documentation of installation procedures, including Manual J calculations, AHRI certificate, and records of any measurements or testing (17)
- ❑ Confirm proper levels of refrigerant and airflow across the coil (18)
- ❑ Inspect cabinet, cabinet fasteners, and cabinet panels (19)
- ❑ Inspect condensate drains (and traps) for proper operation (20)
- ❑ Test system controls' modes of operation and control sequences (21)
- ❑ Measure airflow across heat exchanger/coil (22)
- ❑ Measure refrigerant charge (23)
- ❑ Inspect accessible refrigerant lines, joints, and coils for oil leaks (24)
- ❑ Inspect all electrical components for proper operation (25)
- ❑ Inspect blower motors for proper operation (26)
- ❑ Inspect cabinet, cabinet fasteners, and cabinet panels (27)
- ❑ Inspect condensate drains (and traps) for proper operation (28)

OTHER

- ❑ Other 1 (Specify) _____ (29)
- ❑ Other 2 (Specify) _____ (30)
- ❑ Other 3 (Specify) _____ (31)
- ❑ Other 4 (Specify) _____ (32)
- ❑ Other 5 (Specify) _____ (33)
- ❑ Other 6 (Specify) _____ (34)
- ❑ Our company's technicians do not perform any of the tasks above (35)

RESPONSE OPTIONS RANDOMIZED IN EACH SECTION

SHOW ONLY IF Inst5.RES = 23

Inst6.RES
You indicated that your company's technicians check an HVAC unit's refrigerant charge during a typical residential installation. How do your technicians determine that you have the correct refrigerant charge in air conditioners? (Check all that apply)

- ❑ Check superheat for fixed orifice and compare with manufacturer's recommended superheat (1)
- ❑ Check superheat for fixed orifice and compare with a generic table (e.g. T24) (2)
- ❑ Check subcooling for TXV and compare with manufacturer's recommended superheat (3)
- ❑ Check subcooling for TXV and compare with a generic table (e.g. T24) (4)
- ❑ Check both superheat and subcooling (regardless of metering device) (5)
- ❑ Check temperature split across coil before using gauges (6)
- ❑ Other (Specify)
- ❑ Don't know

RESPONSE OPTIONS 1-6 RANDOMIZED

Inst3.Res
Are you aware of "ACCA Standard 5: HVAC Quality Installation Specification", developed by Air Conditioning Contractors of America (ACCA)?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF Inst3.RES = 1

Inst4.RES
How would you characterize your company's use or implementation of the specifications or guidelines of ACCA Standard 5 for residential installations?

- ❍ We are aware of the standard but do not adhere to it on a job (1)
- ❍ We adhere to some of the standard's specifications on a job, but not all of the specifications (2)
- ❍ We adhere to the majority of the standard's specifications on a job, but not all of the specifications (3)
- ❍ We adhere to all of the standard's specifications on a job (4)

Inst7.RES
How effective do you think the following training methods are at teaching someone the technical skills needed to perform quality installation of residential HVAC systems?

	Not at all effective (1)	Somewhat effective (2)	Effective (3)	Very effective (4)	No opinion (5)	I'm not familiar with the training method (6)
Technical or trade school (1)	❍	❍	❍	❍	❍	❍
Community college (2)	❍	❍	❍	❍	❍	❍
Union apprenticeship (3)	❍	❍	❍	❍	❍	❍
Private training institute (4)	❍	❍	❍	❍	❍	❍
Online HVAC course (5)	❍	❍	❍	❍	❍	❍
Training offered by an electric utility (6)	❍	❍	❍	❍	❍	❍
Distributor training (7)	❍	❍	❍	❍	❍	❍
Manufacturer training (8)	❍	❍	❍	❍	❍	❍
Certification training (9)	❍	❍	❍	❍	❍	❍
On-the-job training (10)	❍	❍	❍	❍	❍	❍
Other (Specify) _____ (11)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-10 RANDOMIZED

Inst8.RES
Does your company have a formal policy or process for following up with residential customers after an installation?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

INST8.RES=1

Inst9.RES
After an installation, what kind of follow up procedures with residential customers does your company perform?

OPEN-ENDED RESPONSE _____

Inst10.RES
What are the primary barriers to contractors *implementing* high quality installation services for residential customers?

(Check all that apply).

- ❑ There are no barriers (1)
- ❑ Contractor/owner's knowledge of what is necessary (2)
- ❑ Technicians' knowledge of what is necessary (3)
- ❑ Available technical training in the market (4)
- ❑ Access to the right diagnostic tools (5)
- ❑ Access to quality maintenance checklists (6)
- ❑ Customers don't want to pay for it (7)
- ❑ Other (Specify) _____(8)
- ❑ [RANDOMIZE 2 THROUGH 7]

ASK SERV.SC Module IF SECTOR = 2 AND IS10a > or = 1%.

SERVICE CALLS – SMALL COMMERCIAL (SERV.SC MODULE)

Next is a set of service-focused questions specific to your small commercial customers.

Serv5.SC
In your opinion, what factors influence small commercial customers' decision-making of whether to replace or repair an HVAC unit?

Please rank the following factors from most important (on top) to least important (on the bottom) by clicking-and-dragging them into the appropriate order.

- ❑ Financial cost (1)
- ❑ Our company's recommendation of whether to replace or repair (2)
- ❑ Speed with which unit can be made operational (3)
- ❑ Age of unit (4)
- ❑ SEER rating of unit (5)
- ❑ Other (Specify) _____ (6)

RESPONSE OPTIONS 1-5 RANDOMIZED

Serv7.SC
What would trigger your company to recommend replacement rather than repair for small commercial customers?

(Check all that apply).

- ❑ Repair cost is high relative to replacement cost (1)
- ❑ System is old (2)
- ❑ System is inefficient (3)
- ❑ System is under capacity (4)
- ❑ System is over capacity (5)
- ❑ Other (Specify) _____ (6)
- ❑ Don't know (7)

RESPONSE OPTIONS 1-5 RANDOMIZED

Serv6.SC
At what percentage of replacement cost does your company recommend replacement instead of repair for small commercial customers?

- ❍ When repair costs are equal to the cost of replacement (100%) (1)
- ❍ When repair costs are about 90% of the cost of replacement (2)
- ❍ When repair costs are about 80% of the cost of replacement (3)
- ❍ When repair costs are about 70% of the cost of replacement (4)
- ❍ When repair costs are about 60% of the cost of replacement (5)
- ❍ When repair costs are about 50% of the cost of replacement (6)
- ❍ When repair costs are about 40% of the cost of replacement (7)
- ❍ When repair costs are about 30% of the cost of replacement (8)
- ❍ When repair costs are about 20% of the cost of replacement (9)
- ❍ When repair costs are about 10% of the cost of replacement (10)
- ❍ Don't know (11)

Serv8.SC
How does your company price a service call for small commercial customers? By **service calls**, we mean appointments that are made to fix a fault in HVAC systems that either shut the system down or inhibits the system's operation to the point that the customer detects a problem.

(Check all that apply).

- ❑ The customer pays an hourly rate based on the time a technician spends working on site (1)
- ❑ The customer pays based on the number and type of repairs performed (2)
- ❑ The customer pays based on the type of the HVAC equipment in his/her facility (3)
- ❑ The customer pays based on the square footage of his facility (4)
- ❑ Other (Specify) _____ (5)
- ❑ Don't know (6)

RESPONSE OPTIONS 1-4 RANDOMIZED

ASK MAINT.SC Module IF SECTOR = 2 AND IS10b > or = 1%.

MAINTENANCE - SMALL COMMERCIAL (MAINT.SC MODULE)

Next is a set of maintenance-focused questions specific to your small commercial customers. By maintenance, we mean checkups to inspect, test, measure, and preserve an HVAC system.

Maint1.SC
Approximately what percentage of your ***small commercial customers*** have at least one maintenance check-up per year for their HVAC systems?

- ❍ Less than 10 percent (1)
- ❍ 10 to 24 percent (2)
- ❍ 25 to 49 percent (3)
- ❍ 50 to 74 percent (4)
- ❍ 75 to 100 percent (5)
- ❍ Don't know (6)

Maint2.SC
How often does your company recommend that ***small commercial customers*** have maintenance check-ups for their facility HVAC systems?

- ❍ We do not recommend that our customers schedule maintenance appointments (1)
- ❍ Every other year (2)
- ❍ Once a year (3)
- ❍ Twice a year (4)
- ❍ Three times a year (5)
- ❍ Four times a year (6)
- ❍ Other (Specify) _____ (7)

Maint3.SC
Please indicate your level of agreement or disagreement with the following statements.

Regular, proper maintenance of a small commercial customer's HVAC system can:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (3)	Strongly Agree (4)	Don't know (5)
Improve indoor air quality (1)	❍	❍	❍	❍	❍	❍
Increase customer comfort (2)	❍	❍	❍	❍	❍	❍
Increase energy savings and reduce electric bills (3)	❍	❍	❍	❍	❍	❍
Prolong a system's	❍	❍	❍	❍	❍	❍

operational lifespan (4)						
Prevent expensive repairs (5)	❍	❍	❍	❍	❍	❍
Improve a system's reliability (6)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-6 RANDOMIZED

Maint4.SC
Does your company have a formal policy or set of guidelines that technicians are required to follow for small commercial maintenance procedures?

- ❍ Yes (1) – Please explain or describe: _____
- ❍ No (2)
- ❍ Don't know

Maint6.SC
Which of the following tasks do your company's technicians perform during a typical small commercial maintenance visit?

Please indicate each task that your technicians perform by checking the corresponding box.

(Check all that apply).

- ❑ Inspect filters for particulate accumulation and clean/replace as needed (1)
- ❑ Inspect air filter housing integrity and air seal (2)
- ❑ Inspect grilles, registers and diffusers for dirt accumulation (3)
- ❑ Inspect all accessible ductwork for areas of moisture accumulation or biological growth (4)
- ❑ Inspect integrity of all accessible ductwork insulation (5)
- ❑ Inspect the integrity of all accessible ductwork including: duct strapping, hangers, sections, joints, and seams (6)
- ❑ Test system controls' modes of operation and control sequences (7)
- ❑ Visually inspect heat exchanger for signs of corrosion, fouling, structural problems (e.g. cracks, perforations, bulges) (8)
- ❑ Measure airflow across heat exchanger/coil (9)
- ❑ Inspect condensing coil and clean/adjust as needed (10)
- ❑ Inspect evaporator coil and clean/adjust as needed (11)
- ❑ Measure refrigerant charge (13)
- ❑ Inspect accessible refrigerant lines, joints, and coils for oil leaks (14)
- ❑ Inspect all electrical components for proper operation (15)
- ❑ Inspect blower motors for proper operation (16)
- ❑ Inspect cabinet, cabinet fasteners, and cabinet panels (17)
- ❑ Inspect condensate drains (and traps) for proper operation (18)
- ❑ Inspect economizers (19)Other 1 (Specify) _____ (20)
- ❑ Other 2 (Specify) _____ (21)
- ❑ Other 3 (Specify) _____ (22)

- ❑ Other 4 (Specify) _____ (23)
- ❑ Other 5 (Specify) _____ (24)
- ❑ Other 6 (Specify) _____ (25)
- ❑ Our company's technicians do not perform any of these tasks (20)

RESPONSE OPTIONS 1-19 RANDOMIZED

SHOW ONLY IF Maint6.SC = 13

Maint6b.SC
You indicated that your company's technicians check an HVAC unit's refrigerant charge during a typical small commercial maintenance visit. How do your technicians determine that you have the correct refrigerant charge in air conditioners? (Check all that apply)

- ❑ Check superheat for fixed orifice and compare with manufacturer's recommended superheat (1)
- ❑ Check superheat for fixed orifice and compare with a generic table (e.g. T24) (2)
- ❑ Check subcooling for TXV and compare with manufacturer's recommended superheat (3)
- ❑ Check subcooling for TXV and compare with a generic table (e.g. T24) (4)
- ❑ Check both superheat and subcooling (regardless of metering device) (5)
- ❑ Check temperature split across coil before using gauges (6)
- ❑ Other (Specify) (7)
- ❑ Don't know (8)

RESPONSE OPTIONS 1-6 RANDOMIZED

Maint5.SC
Are you aware of "ACCA/ASHRAE Standard 180: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems", developed by Air Conditioning Contractors of America (ACCA) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know

[Ask if Maint5.SC = 1.]

Maint5b.SC
How would you characterize your company's use or implementation of the specifications or guidelines of ACCA/ASHRAE Standard 180?

- ❍ We are aware of the standard, but do not know adhere to it on a job (1)
- ❍ We adhere to some of the standard's specifications on a job, but not all of the specifications (2)
- ❍ We adhere to the majority of the standard's specifications on a job, but not all of the specifications (3)
- ❍ We adhere to all of the standard's specifications on a job (4)

Maint7.SC
During a typical small commercial maintenance visit, how long does a technician from your company spend working on each unit?

- ❍ Less than 15 minutes (1)
- ❍ Between 15 and 29 minutes (2)
- ❍ Between 30 and 44 minutes (3)
- ❍ Between 45 minutes and 59 minutes (4)
- ❍ Between 1 hour and 1 hour and 59 minutes (5)
- ❍ Between 2 hours and 2 hours and 59 minutes (6)
- ❍ Between 3 hours and 3 hours and 59 minutes (7)
- ❍ 4 hours or more (8)
- ❍ Don't know

Maint8.SC
For jobs with small commercial customers, how does your company define "quality maintenance"?

OPEN-ENDED RESPONSE _____

Maint9.SC
How effective do you think the following training methods are at teaching someone the technical skills needed to ***perform*** quality maintenance on small commercial HVAC systems?

	Not at all effective (1)	Somewhat effective (2)	Effective (3)	Very effective (4)	No opinion (5)	I'm not familiar with the training method (6)
Technical or trade school (1)	❍	❍	❍	❍	❍	❍
Community college (2)	❍	❍	❍	❍	❍	❍
Union apprenticeship (3)	❍	❍	❍	❍	❍	❍
Private training institute (4)	❍	❍	❍	❍	❍	❍
Online HVAC course (5)	❍	❍	❍	❍	❍	❍
Training offered by an electric utility (6)	❍	❍	❍	❍	❍	❍
Distributor training (7)	❍	❍	❍	❍	❍	❍
Manufacturer training (8)	❍	❍	❍	❍	❍	❍
Certification training (9)	❍	❍	❍	❍	❍	❍
On-the-job training (10)	❍	❍	❍	❍	❍	❍
Other (Specify) _____	❍	❍	❍	❍	❍	❍

(11)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-10 RANDOMIZED

Maint12.SC
Does your company actively try selling or marketing HVAC maintenance services to your small commercial customers?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF Maint12.SC = 2

Maint13.SC
For what reasons does your company not actively try and sell maintenance services to your small commercial customers?

(Check all that apply).

- ❑ There is no value in doing maintenance (1)
- ❑ Customers do not understand the value of maintenance (2)
- ❑ Customers understand the value of maintenance, but are not interested in having maintenance performed on a regular basis (3)
- ❑ Customers are not willing to make long-term commitments (4)
- ❑ Customers do not want to pay extra money for regular maintenance (5)
- ❑ We don't make enough money on maintenance contracts (6)
- ❑ Our technicians need more technical training to be able to perform regular maintenance (7)
- ❑ Our technicians need more "soft skills" training, such as communication skills, to be able to sell maintenance contracts to customers (8)
- ❑ Other (Specify) _____ (9)
- ❑ [RANDOMIZE 1 THROUGH 8]

Maint14.SC
In your opinion, what are your ***small commercial*** customers' priorities when it comes to their HVAC systems?

Please rank the following benefits from most important (on top) to least important (on the bottom) by clicking-and-dragging them into the appropriate order.

Reliability (1)
Cost efficiency (2)
Longevity of unit (3)
Occupant comfort (4)
Minimizing repair costs (5)
Peace of mind (6)
Energy efficiency (7)
Other (Specify)

RESPONSE OPTIONS 1-7 RANDOMIZED

Maint15.SC
What do you see as the primary barriers to your company *selling* HVAC maintenance services to your small commercial customers?

(Check all that apply).

- ❑ There are no barriers, all our customers have maintenance performed on their HVAC systems regularly (1)
- ❑ Customers do not know that maintenance can reduce their electric bills (2)
- ❑ Customers do not know that maintenance can improve the performance and longevity of their cooling system (3)
- ❑ Customers know about the benefits of maintenance, but do not want to pay extra money for it (4)
- ❑ Customers know about the benefits of maintenance, but do not want to pay extra money for it unless someone can show them evidence of how much money they can save (5)
- ❑ Technicians need more technical training to be able to perform maintenance (6)
- ❑ Technicians need more "soft skills" training, such as communication skills, to be able to sell maintenance to customers (7)
- ❑ Equipment warranties make certain customers less willing to have maintenance performed on their HVAC units (8)
- ❑ Other barrier 1 (Specify)_____ (9)
- ❑ Other barrier 2 (Specify) _____ (10)
- ❑ Other barrier 3 (Specify) _____ (11)

RESPONSE OPTIONS 2-8 RANDOMIZED

→ If Maint12.SC = 2 Or Maint12.SC = 3, SKIP TO Inst1.SC

SHOW ONLY IF Maint12.SC = 1

Maint16 .SC
What are your company's sales and marketing strategies for finding new small commercial customers to purchase maintenance services?

(Check all that apply).

- ❑ Our company does not have a marketing strategy for finding new customers to purchase maintenance services (1)
- ❑ Our main strategy is to transition existing/former customers that have received other services into purchasing maintenance work (2)
- ❑ Recommendations from current customers (3)
- ❑ Recommendations from other contractor firms (4)
- ❑ The phone book (5)
- ❑ Online postings including social media (6)
- ❑ Online advertising (7)
- ❑ Direct mailing (8)
- ❑ Advertising in newspapers (9)
- ❑ Advertising in magazines (10)
- ❑ Advertising on the radio (11)

- ❑ Advertising on television (12)
- ❑ Visibility through utility HVAC installation and maintenance programs (13)
- ❑ Other (Specify) _____ (14)

RESPONSE OPTIONS 2-13 RANDOMIZED

SHOW ONLY IF Maint12.SC = 1

Maint17.SC
What is your company's practice for bidding various maintenance approaches to small commercial customers?

(Check all that apply)

- ❑ We only have one level of maintenance (1)
- ❑ We have multiple tiers of maintenance (e.g. basic and premium) and each has a different price point (3)
- ❑ We bid different prices for different market segments (4)
- ❑ We guarantee the lowest cost maintenance contracts (5)
- ❑ We offer performance contracts (6)
- ❑ Other (Specify) _____ (7)

SHOW ONLY IF Maint12.SC = 1

Maint18.SC
Do the individuals in your company that sell maintenance agreements to small commercial customers have a formal set of questions that they ask customers to determine how to bid a maintenance agreement?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF Maint12.SC = 1

Maint19.SC
Do the technicians at your company sell HVAC maintenance services to your small commercial customers?

- ❍ Yes, our technicians sell maintenance services directly to customers (1)
- ❍ Our technicians recommend that customers purchase maintenance services, but then refer the customer to a sales person who completes the sale (2)
- ❍ No, our technicians play no role in the maintenance service sales process (3)
- ❍ Other (Specify) _____ (4)
- ❍ Don't know (5)

SHOW ONLY IF Maint19.SC = 1

Maint20.SC
When selling maintenance services, how does your company communicate to small commercial

customers the benefits of proper air conditioner maintenance versus the cost?

(Check all that apply).

- ❑ Our technicians provide a basic explanation of benefits a customers can get from proper maintenance (1)
- ❑ Our technicians are explicit with how maintenance addresses each benefit such as how maintenance impacts energy savings and electric bills and how maintenance impacts indoor air quality (2)
- ❑ Our technicians show the customer data gathered with diagnostic tools to demonstrate how much money they can save through maintenance (3)
- ❑ Our technicians write up a service report that addresses benefits and costs (4)
- ❑ Other (Specify) _____ (5)

SHOW IF Maint19.SC =1

Maint21.SC
Does your company provide its technician staff with sales training that encourages small commercial customers to purchase maintenance services?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW IF Maint19.SC =1 AND Maint21.SC =1

Maint22.SC
If your company's training covers any of the following selling points, please check the corresponding boxes.

(Check all that apply).

- ❑ The impact of maintenance on indoor air quality (1)
- ❑ The impact of maintenance on energy savings and electric bills (2)
- ❑ The impact of maintenance on customer comfort (3)
- ❑ The impact of maintenance on system longevity (4)
- ❑ The impact of maintenance on system reliability (5)
- ❑ Other (Specify) _____ (6)
- ❑ Don’t know (7)

SHOW ONLY IF Maint12.SC = 1

Maint23.SC
Do the maintenance services your company sells to small commercial customers stipulate a certain number of maintenance visits at regularly scheduled intervals (i.e. a contract), or are they single maintenance visits?

- ❍ Contracts (1)
- ❍ Single visits (2)
- ❍ Don't know (3)

SHOW ONLY IF Maint12.SC=1

Maint24.SC
What percentage of your existing maintenance contracts with small commercial customers fail to renew each year (for any reason)?

- ❍ Less than 5 percent (1)
- ❍ 5 to 9 percent (2)
- ❍ 10 to 19 percent (3)
- ❍ 20 to 29 percent (4)
- ❍ 30 to 39 percent (5)
- ❍ 40 to 49 percent (6)
- ❍ 50 percent or more (7)
- ❍ Prefer not to answer (8)
- ❍ Don't know (9)

SHOW ONLY IF Maint12.SC=1

Maint25.SC
What is the structure of your company's small commercial maintenance contracts in terms of:

	Enter response
The number of maintenance visits per year (1)	_____
Length of contract (in months) (2)	_____

SHOW ONLY IF Maint12.SC=1

Maint26.SC
How does your company price a maintenance contract with small commercial customers?

(Check all that apply).

- ❑ The customer pays an hourly rate based on the time a technician spends working on site during each visit (1)
- ❑ The customer pays based on a rate specific to customer type (e.g., residential, small commercial, large commercial) (2)
- ❑ The customer pays based on a rate specific to system type (cooling capacity, design of HVAC unit, etc.) (3)
- ❑ The customer pays based on a rate specific to size of the unit (4)
- ❑ The customer pays based on the square footage of his home or facility (5)
- ❑ Other (Specify) _____ (6)

ASK INST.SC Module IF SECTOR = 2 AND IS10c > or = 1%.

INSTALLATION – SMALL COMMERCIAL (INST.SC MODULE)

Next is a set of installation-focused questions specific to your small commercial customers. By installation jobs, we mean projects where the primary purpose is to install new equipment or replace existing equipment.

Inst0.SC
For jobs with small commercial customers, how does your company define "quality installation"?

OPEN-ENDED RESPONSE _____

Inst1.SC
Please indicate your level of agreement or disagreement with the following statements.

Proper installation of a small commercial customer's HVAC system can:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (3)	Strongly Agree (4)	Don't know (5)
Improve indoor air quality (1)	❍	❍	❍	❍	❍	❍
Increase customer comfort (2)	❍	❍	❍	❍	❍	❍
Increase energy savings and reduce electric bills (3)	❍	❍	❍	❍	❍	❍
Prolong a system's operational lifespan (4)	❍	❍	❍	❍	❍	❍
Prevent expensive repairs (5)	❍	❍	❍	❍	❍	❍
Improve a system's reliability (6)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-6 RANDOMIZED

Inst2.SC
Does your company have a formal policy or set of guidelines that technicians are required to follow for small commercial installation procedures?

❍ Yes (1)
❍ No (2)

❍ Don't know (3)

Inst5.SC
Which of the following tasks do your company's technicians perform during a typical small commercial installation?

Please indicate each task that your technicians perform by checking the corresponding box.

(Check all that apply).

EQUIPMENT

- ❑ Calculate correct sizing for equipment using Manual J (1)
- ❑ Install a properly matched indoor coil and outdoor unit (AC & heat pump only) (2)
- ❑ Test ductwork to determine maximum system size (3)
- ❑ Install new refrigerant lines (not reuse existing lines) (4)
- ❑ Install programmable thermostat (if not already in use) (5)
- ❑ Setup programmable thermostat with customer (if not already in use) (6)
- ❑ Consider zoning, with separate temperature controls for different areas (7)

DUCT WORK

- ❑ Inspect the integrity of all accessible ductwork including: duct strapping, hangers, sections, joints, and seams (8)
- ❑ Inspect integrity of all accessible ductwork insulation (9)
- ❑ Make repairs to existing ductwork if necessary (10)
- ❑ If insulating ducts, seal all duct seams before insulating (11)
- ❑ Test to confirm that duct leakage does not exceed recommended levels (12)
- ❑ Inspect air filter housing integrity and air seal (13)
- ❑ Inspect all accessible ductwork for areas of moisture accumulation or biological growth (14)

VERIFICATION & MAINTENANCE

- ❑ Show customer how to replace air filter(s) in new system (15)
- ❑ Leave all manuals with customer (16)
- ❑ Provide customer with documentation of installation procedures, including Manual J calculations, AHRI certificate, and records of any measurements or testing (17)
- ❑ Confirm proper levels of refrigerant and airflow across the coil (18)
- ❑ Inspect cabinet, cabinet fasteners, and cabinet panels (19)
- ❑ Inspect condensate drains (and traps) for proper operation (20)
- ❑ Test system controls' modes of operation and control sequences (21)
- ❑ Measure airflow across heat exchanger/coil (22)
- ❑ Measure refrigerant charge (23)
- ❑ Inspect accessible refrigerant lines, joints, and coils for oil leaks (24)
- ❑ Inspect all electrical components for proper operation (25)
- ❑ Inspect blower motors for proper operation (26)
- ❑ Inspect cabinet, cabinet fasteners, and cabinet panels (27)
- ❑ Inspect condensate drains (and traps) for proper operation (28)
- ❑ Inspect Economizers (29)

OTHER

- ❑ Other 1 (Specify) _____ (30)
- ❑ Other 2 (Specify) _____ (31)
- ❑ Other 3 (Specify) _____ (32)
- ❑ Other 4 (Specify) _____ (33)
- ❑ Other 5 (Specify) _____ (34)
- ❑ Other 6 (Specify) _____ (35)
- ❑ Our company's technicians do not perform any of the tasks above(36)

RESPONSE OPTIONS RANDOMIZED IN EACH SECTION

SHOW ONLY IF Inst5.SC = 23

Inst6.SC
You indicated that your company's technicians check an HVAC unit's refrigerant charge during a typical small commercial installation. How do your technicians determine that you have the correct refrigerant charge in air conditioners? (Check all that apply)

- ❑ Check superheat for fixed orifice and compare with manufacturer's recommended superheat (1)
- ❑ Check superheat for fixed orifice and compare with a generic table (e.g. T24) (2)
- ❑ Check subcooling for TXV and compare with manufacturer's recommended superheat (3)
- ❑ Check subcooling for TXV and compare with a generic table (e.g. T24) (4)
- ❑ Check both superheat and subcooling (regardless of metering device) (5)
- ❑ Check temperature split across coil before using gauges (6)
- ❑ Other (Specify)
- ❑ Don't know

RESPONSE OPTIONS 1-6 RANDOMIZED

Inst3.SC
Are you aware of "ACCA Standard 5: HVAC Quality Installation Specification", developed by Air Conditioning Contractors of America (ACCA)?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF Inst3.SC = 1

Inst4.SC
How would you characterize your company's use or implementation of the specifications or guidelines of ACCA Standard 5 for small commercial installations?

- ❍ We are aware of the standard but do not adhere to it on a job (1)
- ❍ We adhere to some of the standard's specifications on a job, but not all of the specifications (2)
- ❍ We adhere to the majority of the standard's specifications on a job, but not all of the specifications (3)
- ❍ We adhere to all of the standard's specifications on a job (4)

Inst7.SC
How effective do you think the following training methods are at teaching someone the technical skills needed to perform quality installation of small commercial HVAC systems?

	Not at all effective (1)	Somewhat effective (2)	Effective (3)	Very effective (4)	No opinion (5)	I'm not familiar with the training method (6)
Technical or trade school (1)	❍	❍	❍	❍	❍	❍
Community college (2)	❍	❍	❍	❍	❍	❍
Union apprenticeship (3)	❍	❍	❍	❍	❍	❍
Private training institute (4)	❍	❍	❍	❍	❍	❍
Online HVAC course (5)	❍	❍	❍	❍	❍	❍
Training offered by an electric utility (6)	❍	❍	❍	❍	❍	❍
Distributor training (7)	❍	❍	❍	❍	❍	❍
Manufacturer training (8)	❍	❍	❍	❍	❍	❍
Certification training (9)	❍	❍	❍	❍	❍	❍
On-the-job training (10)	❍	❍	❍	❍	❍	❍
Other (Specify) _____ (11)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-10 RANDOMIZED

Inst8.SC
Does your company have a formal policy or process for following up with small commercial customers after an installation?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

ASK IF INST8.SC=1

Inst9.SC
After an installation, what kind of follow up procedures with small commercial customers does your company perform?

OPEN-ENDED RESPONSE _____

Inst10.SC
What are the primary barriers to contractors *implementing* high quality installation services for small commercial customers?

(Check all that apply).

- ❑ There are no barriers (1)
- ❑ Contractor/owner's knowledge of what is necessary (2)
- ❑ Technicians' knowledge of what is necessary (3)
- ❑ Available technical training in the market (4)
- ❑ Access to the right diagnostic tools (5)
- ❑ Access to quality maintenance checklists (6)
- ❑ Customers don't want to pay for it (7)
- ❑ Other (Specify) _____(8)

[RANDOMIZE 2 THROUGH 7]

ASK SERV.LC Module IF SECTOR = 3 AND IS10a > or = 1%.

SERVICE CALLS – LARGE COMMERICAL (SERV.LC MODULE)

Next is a set of service-focused questions specific to your large commercial customers.

Serv5.LC
In your opinion, what factors influence large commercial customers' decision-making of whether to replace or repair an HVAC unit?

Please rank the following factors from most important (on top) to least important (on the bottom) by clicking-and-dragging them into the appropriate order.

- ❑ Financial cost (1)
- ❑ Our company's recommendation of whether to replace or repair (2)
- ❑ Speed with which unit can be made operational (3)
- ❑ Age of unit (4)
- ❑ SEER rating of unit (5)
- ❑ Other (Specify) _____ (6)

RESPONSE OPTIONS 1-5 RANDOMIZED

Serv7.LC
What would trigger your company to recommend replacement rather than repair for large commercial

customers?

(Check all that apply).

- ❑ Repair cost is high relative to replacement cost (1)
- ❑ System is old (2)
- ❑ System is inefficient (3)
- ❑ System is under capacity (4)
- ❑ System is over capacity (5)
- ❑ Other (Specify) _____ (6)
- ❑ Don't know (7)

RESPONSE OPTIONS 1-5 RANDOMIZED

Serv6.LC
At what percentage of replacement cost does your company recommend replacement instead of repair for large commercial customers?

- ❍ When repair costs are equal to the cost of replacement (100%) (1)
- ❍ When repair costs are about 90% of the cost of replacement (2)
- ❍ When repair costs are about 80% of the cost of replacement (3)
- ❍ When repair costs are about 70% of the cost of replacement (4)
- ❍ When repair costs are about 60% of the cost of replacement (5)
- ❍ When repair costs are about 50% of the cost of replacement (6)
- ❍ When repair costs are about 40% of the cost of replacement (7)
- ❍ When repair costs are about 30% of the cost of replacement (8)
- ❍ When repair costs are about 20% of the cost of replacement (9)
- ❍ When repair costs are about 10% of the cost of replacement (10)
- ❍ Don't know (11)

Serv8.LC
How does your company price a service call for large commercial customers? By **service calls**, we mean appointments that are made to fix a fault in HVAC systems that either shut the system down or inhibits the system's operation to the point that the customer detects a problem.

(Check all that apply).

- ❑ The customer pays an hourly rate based on the time a technician spends working on site (1)
- ❑ The customer pays based on the number and type of repairs performed (2)
- ❑ The customer pays based on the type of the HVAC equipment in his/her facility (3)
- ❑ The customer pays based on the square footage of his/her facility (4)
- ❑ Other (Specify) _____ (5)
- ❑ Don't know (6)

RESPONSE OPTIONS 1-4 RANDOMIZED

ASK MAINT.LC Module IF SECTOR = 3 AND IS10b > or = 1%.

MAINTENANCE –LARGE COMMERICAL (MAINT.LC MODULE)

Next is a set of maintenance-focused questions specific to your large commercial customers. By maintenance, we mean checkups to inspect, test, measure, and preserve an HVAC system.

Maint1.LC
Approximately what percentage of your ***large commercial customers*** have at least one maintenance check-up per year for their HVAC systems?

- ❍ Less than 10 percent (1)
- ❍ 10 to 24 percent (2)
- ❍ 25 to 49 percent (3)
- ❍ 50 to 74 percent (4)
- ❍ 75 to 100 percent (5)
- ❍ Don't know (6)

Maint2.LC
How often does your company recommend that ***large commercial customers*** have maintenance check-ups for their facility HVAC systems?

- ❍ We do not recommend that our customers schedule maintenance appointments (1)
- ❍ Every other year (2)
- ❍ Once a year (3)
- ❍ Twice a year (4)
- ❍ Three times a year (5)
- ❍ Four times a year (6)
- ❍ Other (Specify) _____ (7)

Maint3.LC
Please indicate your level of agreement or disagreement with the following statements.

Regular, proper maintenance of a large commercial customer's HVAC system can:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (3)	Strongly Agree (4)	Don't know (5)
Improve indoor air quality (1)	❍	❍	❍	❍	❍	❍
Increase customer comfort (2)	❍	❍	❍	❍	❍	❍
Increase energy savings and reduce electric bills (3)	❍	❍	❍	❍	❍	❍
Prolong a system's	❍	❍	❍	❍	❍	❍

operational lifespan (4)						
Prevent expensive repairs (5)	❍	❍	❍	❍	❍	❍
Improve a system's reliability (6)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-6 RANDOMIZED

Maint4.LC
Does your company have a formal policy or set of guidelines that technicians are required to follow for large commercial maintenance procedures?

- ❍ Yes – Please explain or describe: _____ (1)
- ❍ No (2)
- ❍ Don't know (3)

Maint6.LC
Which of the following tasks do your company's technicians perform during a typical large commercial maintenance visit?

Please indicate each task that your technicians perform by checking the corresponding box.

(Check all that apply).

- ❑ Inspect filters for particulate accumulation and clean/replace as needed (1)
- ❑ Inspect air filter housing integrity and air seal (2)
- ❑ Inspect grilles, registers and diffusers for dirt accumulation (3)
- ❑ Inspect all accessible ductwork for areas of moisture accumulation or biological growth (4)
- ❑ Inspect integrity of all accessible ductwork insulation (5)
- ❑ Inspect the integrity of all accessible ductwork including: duct strapping, hangers, sections, joints, and seams (6)
- ❑ Test system controls' modes of operation and control sequences (7)
- ❑ Visually inspect heat exchanger for signs of corrosion, fouling, structural problems (e.g. cracks, perforations, bulges) (8)
- ❑ Measure airflow across heat exchanger/coil (9)
- ❑ Inspect condensing coil and clean/adjust as needed (10)
- ❑ Inspect evaporator coil and clean/adjust as needed (11)
- ❑ Measure refrigerant charge (13)
- ❑ Inspect accessible refrigerant lines, joints, and coils for oil leaks (14)
- ❑ Inspect all electrical components for proper operation (15)
- ❑ Inspect blower motors for proper operation (16)
- ❑ Inspect cabinet, cabinet fasteners, and cabinet panels (17)
- ❑ Inspect condensate drains (and traps) for proper operation (18)
- ❑ Inspect economizers (19)
- ❑ Other 1 (Specify) _____ (20)
- ❑ Other 2 (Specify) _____ (21)
- ❑ Other 3 (Specify) _____ (22)

- ❑ Other 4 (Specify) _____ (23)
- ❑ Other 5 (Specify) _____ (24)
- ❑ Other 6 (Specify) _____ (25)
- ❑ Our company's technicians do not perform any of these tasks (26)

RESPONSE OPTIONS 1-19 RANDOMIZED

SHOW ONLY IF Maint6.LC = 13

Maint6b.LC
You indicated that your company's technicians check an HVAC unit's refrigerant charge during a typical large commercial maintenance visit. How do your technicians determine that you have the correct refrigerant charge in air conditioners? (Check all that apply)

- ❑ Check superheat for fixed orifice and compare with manufacturer's recommended superheat (1)
- ❑ Check superheat for fixed orifice and compare with a generic table (e.g. T24) (2)
- ❑ Check subcooling for TXV and compare with manufacturer's recommended superheat (3)
- ❑ Check subcooling for TXV and compare with a generic table (e.g. T24) (4)
- ❑ Check both superheat and subcooling (regardless of metering device) (5)
- ❑ Check temperature split across coil before using gauges (6)
- ❑ Other (Specify) (7)
- ❑ Don't know (8)

RESPONSE OPTIONS 1-6 RANDOMIZED

Maint5.LC
Are you aware of "ACCA/ASHRAE Standard 180: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems", developed by Air Conditioning Contractors of America (ACCA) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

Maint5b.LC
How would you characterize your company's use or implementation of the specifications or guidelines of ACCA/ASHRAE Standard 180?

- ❍ We are aware of the standard, but do not know adhere to it on a job (1)
- ❍ We adhere to some of the standard's specifications on a job, but not all of the specifications (2)
- ❍ We adhere to the majority of the standard's specifications on a job, but not all of the specifications (3)
- ❍ We adhere to all of the standard's specifications on a job (4)

Maint7.LC
During a typical large commercial maintenance visit, how long does a technician from your company spend working on each unit?

- ❍ Less than 15 minutes (1)
- ❍ Between 15 and 29 minutes (2)
- ❍ Between 30 and 44 minutes (3)

- ❍ Between 45 minutes and 59 minutes (4)
- ❍ Between 1 hour and 1 hour and 59 minutes (5)
- ❍ Between 2 hours and 2 hours and 59 minutes (6)
- ❍ Between 3 hours and 3 hours and 59 minutes (7)
- ❍ 4 hours or more (8)

Maint8 .LC
For jobs with large commercial customers, how does your company define "quality maintenance"?

OPEN-ENDED RESPONSE _____

Maint9.LC
How effective do you think the following training methods are at teaching someone the technical skills needed to ***perform*** quality maintenance on large commercial HVAC systems?

	Not at all effective (1)	Somewhat effective (2)	Effective (3)	Very effective (4)	No opinion (5)	I'm not familiar with the training method (6)
Technical or trade school (1)	❍	❍	❍	❍	❍	❍
Community college (2)	❍	❍	❍	❍	❍	❍
Union apprenticeship (3)	❍	❍	❍	❍	❍	❍
Private training institute (4)	❍	❍	❍	❍	❍	❍
Online HVAC course (5)	❍	❍	❍	❍	❍	❍
Training offered by an electric utility (6)	❍	❍	❍	❍	❍	❍
Distributor training (7)	❍	❍	❍	❍	❍	❍
Manufacturer training (8)	❍	❍	❍	❍	❍	❍
Certification training (9)	❍	❍	❍	❍	❍	❍
On-the-job training (10)	❍	❍	❍	❍	❍	❍
Other (Specify) _____ (11)	❍	❍	❍	❍	❍	❍
	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-10 RANDOMIZED

Maint12.LC
Does your company actively try selling or marketing HVAC maintenance services to your large commercial customers?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF Maint12.LC = 2

Maint13.LC
For what reasons does your company not actively try and sell maintenance services to your large commercial customers?

(Check all that apply).

- ❑ There is no value to maintenance (1)
- ❑ Customers do not understand the value of maintenance (2)
- ❑ Customers understand the value of maintenance, but are not interested in having maintenance performed on a regular basis (3)
- ❑ Customers are not willing to make long-term commitments (4)
- ❑ Customers do not want to pay extra money for regular maintenance and we will not compromise our standards (5)
- ❑ We don't make enough money on maintenance contracts (6)
- ❑ Our technicians need more technical training to be able to perform regular maintenance (7)
- ❑ Our technicians need more "soft skills" training, such as communication skills, to be able to sell maintenance contracts to customers (8)
- ❑ Other (Specify) _____ (9)

[RANDOMIZE 1 THROUGH 8]

Maint14.LC
In your opinion, what are your ***large commercial*** customers' priorities when it comes to their HVAC systems?

Please rank the following benefits from most important (on top) to least important (on the bottom) by clicking-and-dragging them into the appropriate order.

Reliability (1)
Cost efficiency (2)
Longevity of unit (3)
Occupant comfort (4)
Minimizing repair costs (5)
Peace of mind (6)
Energy efficiency (7)
Other (Specify)

RESPONSE OPTIONS 1-7 RANDOMIZED

Maint15.LC

What do you see as the primary barriers to your company *selling* HVAC maintenance services to your large commercial customers?

(Check all that apply).

- ❑ There are no barriers, all our customers have maintenance performed on their HVAC systems regularly (1)
- ❑ Customers do not know that maintenance can reduce their electric bills (2)
- ❑ Customers do not know that maintenance can improve the performance and longevity of their cooling system (3)
- ❑ Customers know about the benefits of maintenance, but do not want to pay extra money for it (4)
- ❑ Customers know about the benefits of maintenance, but do not want to pay extra money for it unless someone can show them evidence of how much money they can save (5)
- ❑ Technicians need more technical training to be able to perform maintenance (6)
- ❑ Technicians need more "soft skills" training, such as communication skills, to be able to sell maintenance to customers (7)
- ❑ Equipment warranties make certain customers less willing to have maintenance performed on their HVAC units. (8)
- ❑ Other barrier 1 (Specify)_____ (9)
- ❑ Other barrier 2 (Specify) _____ (10)
- ❑ Other barrier 3 (Specify) _____ (11)

[RANDOMIZE 2 THROUGH 8]

→ If Maint12.LC = 2 Or Maint12.LC = 3, SKIP TO Inst1.LC

SHOW ONLY IF Maint12.LC = 1

Maint16.LC
What are your company's sales and marketing strategies for finding new large commercial customers to purchase maintenance services?

(Check all that apply).

- ❑ Our company does not have a marketing strategy for finding new customers to purchase maintenance services (1)
- ❑ Our main strategy is to transition existing/former customers that have received other services into purchasing maintenance work (2)
- ❑ Recommendations from current customers (3)
- ❑ Recommendations from other contractor firms (4)
- ❑ The phone book (5)
- ❑ Online postings including social media (6)
- ❑ Online advertising (7)
- ❑ Direct mailing (8)
- ❑ Advertising in newspapers (9)
- ❑ Advertising in magazines (10)
- ❑ Advertising on the radio (11)
- ❑ Advertising on television (12)
- ❑ Visibility through utility HVAC installation and maintenance programs (13)
- ❑ Other (Specify) _____ (14)

RESPONSE OPTIONS 2-13 RANDOMIZED

SHOW ONLY IF Maint12.LC = 1

Maint17.LC
What is your company's practice for bidding various maintenance approaches to large commercial customers?

(Check all that apply)

- ❑ We only have one level of maintenance (1)
- ❑ We have multiple tiers of maintenance (e.g. basic and premium) and each has a different price point (3)
- ❑ We bid different prices for different market segments (4)
- ❑ We guarantee the lowest cost maintenance contracts (5)
- ❑ We offer performance contracts (6)
- ❑ Other (Specify) _____ (7)

SHOW ONLY IF Maint12.LC = 1

Maint18.LC
Do the individuals in your company that sell maintenance agreements to large commercial customers have a formal set of questions that they ask customers to determine how to bid a maintenance agreement?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF Maint12.LC = 1

Maint19.LC
Do the technicians at your company sell HVAC maintenance services to your large commercial customers?

- ❍ Yes, our technicians sell maintenance services directly to customers (1)
- ❍ Our technicians recommend that customers purchase maintenance services, but then refer the customer to a sales person who completes the sale (2)
- ❍ No, our technicians play no role in the maintenance service sales process (3)
- ❍ Other (Specify) _____ (4)
- ❍ Don't know (5)

SHOW ONLY IF Maint19.LC = 1

Maint20.LC
When selling maintenance services, how does your company communicate to large commercial customers the benefits of proper air conditioner maintenance versus the cost?

(Check all that apply).

- ❑ Our technicians provide a basic explanation of benefits a customers can get from proper maintenance (1)
- ❑ Our technicians are explicit with how maintenance addresses each benefit such as how maintenance impacts energy savings and electric bills and how maintenance impacts indoor air quality (2)
- ❑ Our technicians show the customer data gathered with diagnostic tools to demonstrate how much money they can save through maintenance (3)
- ❑ Our technicians write up a service report that addresses benefits and costs (4)
- ❑ Other (Specify) _____ (5)

SHOW IF Maint19.LC =1

Maint21.LC
Does your company provide its technician staff with sales training that encourages large commercial customers to purchase maintenance services?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW IF Maint19.LC =1 AND Maint21.LC =1

Maint22.LC
If your company's training covers any of the following selling points, please check the corresponding boxes.

(Check all that apply).

- ❑ The impact of maintenance on indoor air quality (1)
- ❑ The impact of maintenance on energy savings and electric bills (2)
- ❑ The impact of maintenance on customer comfort (3)
- ❑ The impact of maintenance on system longevity (4)
- ❑ The impact of maintenance on system reliability (5)
- ❑ Other (Specify) _____ (6)
- ❑ Don't know (7)

SHOW ONLY IF Maint12.LC = 1

Maint23.LC
Do the maintenance services your company sells to large commercial customers stipulate a certain number of maintenance visits at regularly scheduled intervals (i.e. a contract), or are they single maintenance visits?

- ❍ Contracts (1)
- ❍ Single visits (2)
- ❍ Don't know (3)

SHOW ONLY IF Maint12.LC=1

Maint24.LC

What percentage of your existing maintenance contracts with large commercial customers fail to renew each year (for any reason)?

- ❍ Less than 5 percent (1)
- ❍ 5 to 9 percent (2)
- ❍ 10 to 19 percent (3)
- ❍ 20 to 29 percent (4)
- ❍ 30 to 39 percent (5)
- ❍ 40 to 49 percent (6)
- ❍ 50 percent or more (7)
- ❍ Prefer not to answer (8)
- ❍ Don't know (9)

SHOW ONLY IF Maint12.LC=1

Maint25.LC
What is the structure of your company's large commercial maintenance contracts in terms of:

	Enter response
The number of maintenance visits per year (1)	_____
Length of contract (in months) (2)	_____

SHOW ONLY IF Maint12.LC=1

Maint26.LC
How does your company price a maintenance contract with large commercial customers?

(Check all that apply).

- ❑ The customer pays an hourly rate based on the time a technician spends working on site during each visit (1)
- ❑ The customer pays based on a rate specific to customer type (e.g., residential, small commercial, large commercial) (2)
- ❑ The customer pays based on a rate specific to system type (cooling capacity, design of HVAC unit, etc.) (3)
- ❑ The customer pays based on a rate specific to size of the unit (4)
- ❑ The customer pays based on the square footage of his home or facility (5)
- ❑ Other (Specify) _____ (6)

ASK INST.LC Module IF SECTOR = 3 AND IS10c > or = 1%.

INSTALLATION –LARGE COMMERCIAL (INST.LC MODULE)

Next is a set of installation-focused questions specific to your large commercial customers. By installation jobs, we mean projects where the primary purpose is to install new equipment or replace existing equipment.

Inst0.LC
For jobs with large commercial customers, how does your company define "quality installation"?

OPEN-ENDED RESPONSE _____

Inst1.LC
Please indicate your level of agreement or disagreement with the following statements.

Proper installation of a large commercial customer's HVAC system can:

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (3)	Strongly Agree (4)	Don't know (5)
Improve indoor air quality (1)	❍	❍	❍	❍	❍	❍
Increase customer comfort (2)	❍	❍	❍	❍	❍	❍
Increase energy savings and reduce electric bills (3)	❍	❍	❍	❍	❍	❍
Prolong a system's operational lifespan (4)	❍	❍	❍	❍	❍	❍
Prevent expensive repairs (5)	❍	❍	❍	❍	❍	❍
Improve a system's reliability (6)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-6 RANDOMIZED

Inst2.LC
Does your company have a formal policy or set of guidelines that technicians are required to follow for large commercial installation procedures?

❍ Yes (1)
❍ No (2)
❍ Don't know (3)

Inst5.LC
Which of the following tasks do your company's technicians perform during a typical large commercial installation?

Please indicate each task that your technicians perform by checking the corresponding box.

(Check all that apply).

EQUIPMENT

- ❑ Calculate correct sizing for equipment using Manual J (1)
- ❑ Install a properly matched indoor coil and outdoor unit (AC & heat pump only) (2)
- ❑ Test ductwork to determine maximum system size (3)
- ❑ Install new refrigerant lines (not reuse existing lines) (4)
- ❑ Install programmable thermostat (if not already in use) (5)
- ❑ Setup programmable thermostat with customer (if not already in use) (6)
- ❑ Consider zoning, with separate temperature controls for different areas (7)

DUCT WORK

- ❑ Inspect the integrity of all accessible ductwork including: duct strapping, hangers, sections, joints, and seams (8)
- ❑ Inspect integrity of all accessible ductwork insulation (9)
- ❑ Make repairs to existing ductwork if necessary (10)
- ❑ If insulating ducts, seal all duct seams before insulating (11)
- ❑ Test to confirm that duct leakage does not exceed recommended levels (12)
- ❑ Inspect air filter housing integrity and air seal (13)
- ❑ Inspect all accessible ductwork for areas of moisture accumulation or biological growth (14)

VERIFICATION & MAINTENANCE

- ❑ Show customer how to replace air filter(s) in new system (15)
- ❑ Leave all manuals with customer (16)
- ❑ Provide customer with documentation of installation procedures, including Manual J calculations, AHRI certificate, and records of any measurements or testing (17)
- ❑ Confirm proper levels of refrigerant and airflow across the coil (18)
- ❑ Inspect cabinet, cabinet fasteners, and cabinet panels (19)
- ❑ Inspect condensate drains (and traps) for proper operation (20)
- ❑ Test system controls' modes of operation and control sequences (21)
- ❑ Measure airflow across heat exchanger/coil (22)
- ❑ Measure refrigerant charge (23)
- ❑ Inspect accessible refrigerant lines, joints, and coils for oil leaks (24)
- ❑ Inspect all electrical components for proper operation (25)
- ❑ Inspect blower motors for proper operation (26)
- ❑ Inspect cabinet, cabinet fasteners, and cabinet panels (27)
- ❑ Inspect condensate drains (and traps) for proper operation (28)
- ❑ Inspect Economizers (29)

OTHER

- ❑ Other 1 (Specify) _____ (30)
- ❑ Other 2 (Specify) _____ (31)
- ❑ Other 3 (Specify) _____ (32)

- ❑ Other 4 (Specify) _____ (33)
- ❑ Other 5 (Specify) _____ (34)
- ❑ Other 6 (Specify) _____ (35)
- ❑ Our company's technicians do not perform any of the tasks above(36)

RESPONSE OPTIONS RANDOMIZED IN EACH SECTION

SHOW ONLY IF Inst5.LC = 23

Inst6.LC
You indicated that your company's technicians check an HVAC unit's refrigerant charge during a typical large commercial installation. How do your technicians determine that you have the correct refrigerant charge in air conditioners? (Check all that apply)

- ❑ Check superheat for fixed orifice and compare with manufacturer's recommended superheat (1)
- ❑ Check superheat for fixed orifice and compare with a generic table (e.g. T24) (2)
- ❑ Check subcooling for TXV and compare with manufacturer's recommended superheat (3)
- ❑ Check subcooling for TXV and compare with a generic table (e.g. T24) (4)
- ❑ Check both superheat and subcooling (regardless of metering device) (5)
- ❑ Check temperature split across coil before using gauges (6)
- ❑ Other (Specify)
- ❑ Don't know

RESPONSE OPTIONS 1-6 RANDOMIZED

Inst3.LC
Are you aware of "ACCA/ASHRAE Standard 180: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems", developed by Air Conditioning Contractors of America (ACCA) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF Inst3.SC = 1

Inst4.LC
How would you characterize your company's use or implementation of the specifications or guidelines of ACCA/ASHRAE Standard 180 for large commercial installations?

- ❍ We are aware of the standard but do not adhere to it on a job (1)
- ❍ We adhere to some of the standard's specifications on a job, but not all of the specifications (2)
- ❍ We adhere to the majority of the standard's specifications on a job, but not all of the specifications (3)
- ❍ We adhere to all of the standard's specifications on a job (4)

Inst7.LC
How effective do you think the following training methods are at teaching someone the technical skills needed to perform quality installation of large commercial HVAC systems?

	Not at all effective (1)	Somewhat effective (2)	Effective (3)	Very effective (4)	No opinion (5)	I'm not familiar with the training method (6)
Technical or trade school (1)	❍	❍	❍	❍	❍	❍
Community college (2)	❍	❍	❍	❍	❍	❍
Union apprenticeship (3)	❍	❍	❍	❍	❍	❍
Private training institute (4)	❍	❍	❍	❍	❍	❍
Online HVAC course (5)	❍	❍	❍	❍	❍	❍
Utility training (6)	❍	❍	❍	❍	❍	❍
Distributor training (7)	❍	❍	❍	❍	❍	❍
Manufacturer training (8)	❍	❍	❍	❍	❍	❍
Certification training (9)	❍	❍	❍	❍	❍	❍
On-the-job training (10)	❍	❍	❍	❍	❍	❍
Other (Specify) _____ (11)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-10 RANDOMIZED

Inst8.LC
Does your company have a formal policy or process for following up with large commercial customers after an installation?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

ASK IF INST8.LC=1

Inst9.LC
After an installation, what kind of follow up procedures with large commercial customers does your company perform?

OPEN-ENDED RESPONSE _____

Inst10.LC
What are the primary barriers to contractors *implementing* high quality installation services for large commercial customers?

(Check all that apply).

- ❑ There are no barriers (1)
- ❑ Contractor/owner's knowledge of what is necessary (2)
- ❑ Technicians' knowledge of what is necessary (3)
- ❑ Available technical training in the market (4)
- ❑ Access to the right diagnostic tools (5)
- ❑ Access to quality maintenance checklists (6)
- ❑ Customers don't want to pay for it (7)
- ❑ Other (Specify) _____(8)

[RANDOMIZE 2 THROUGH 7]

ASK Maint.PP Module IF IS10b > or = 1%.

PROGRAM PARTICIPATION – Maintenance (Maint.PP Module)

Next is a set of questions regarding HVAC <u>maintenance programs offered by California utilities</u>.

PP1
Some electric utilities in California offer Quality Maintenance programs designed to promote HVAC maintenance practices that improve the efficiency of existing residential and commercial HVAC systems. In addition to promoting common practices such as refrigerant charge and airflow (RCA) and residential duct testing and sealing (DTS), both the residential and commercial programs support additional measures that encourage taking a comprehensive approach to system maintenance. Participation in the program allows your customers to access utility rebates for Quality Maintenance services. Has your company ever participated in a HVAC quality maintenance program from a California utility?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF PP1 = 2

PP1b
You indicated that your company has never participated in an electric utility's HVAC quality maintenance program. Please indicate why your company has not participated.

(Check all that apply).

- ❑ Never thought about it (1)
- ❑ I was not aware that electric utilities have HVAC quality maintenance programs (2)
- ❑ Utilities' HVAC quality maintenance programs would not benefit our business (3)

- ❑ Our customers would not care if we participated (4)
- ❑ Too much of a hassle (5)
- ❑ Other (Specify) _____ (6)
- ❑ Prefer not to answer (7)
- ❑ Don't know (8)

RESPONSE OPTIONS 2-5 RANDOMIZED

SHOW ONLY IF PP1 = 1

PP1c
Is your company currently participating in a HVAC quality maintenance program from a California utility?

- ❍ Yes (1)
- ❍ No (2)

SHOW ONLY IF PP1 = 1

PP1e
In your opinion, what are the main advantages to your company of participating in a utility's HVAC maintenance program?

(Check all that apply).

- ❑ It drives customers directly to us (1)
- ❑ It allows us to approach new customers (2)
- ❑ Customers get incentives, which makes them happier with us (3)
- ❑ Our company's technician staff have benefited from the program's training opportunities (4)
- ❑ Our customers get incentives to do maintenance correctly, which makes them more apt to hire us (5)
- ❑ There have been no significant advantages (6)
- ❑ Other (Specify) _____ (7)

RESPONSE OPTIONS 1-5 RANDOMIZED

ASK Inst.PP Module IF IS10c > or = 1%.

PROGRAM PARTICIPATION – Installation (Inst.PP Module)

Next is a set of questions regarding HVAC <u>installation programs offered by California utilities</u>.

P-Inst1
Some electric utilities in California offer Quality Installation programs designed to promote proper HVAC installation practices. Quality installation criteria include correct sizing and correct charge (for non-factory charged units). New residential system installations are also required to satisfy duct leakage requirements. Participation in the program allows your customers to access rebates for installations of new HVAC systems. Has your company ever participated in a HVAC quality installation program from a

California electric utility?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW ONLY IF P-Inst1 = 2

P-Inst1b
You indicated that your company has never participated in an electric utility's HVAC quality installation program. Please indicate why your company has not participated.

(Check all that apply).

- ❑ Never thought about it (1)
- ❑ I was not aware that electric utilities have HVAC quality installation programs (2)
- ❑ Utilities' HVAC quality installation programs would not benefit our business (3)
- ❑ Our customers would not care if we participated (4)
- ❑ Too much of a hassle (5)
- ❑ Other (Specify) _____ (6)
- ❑ Refuse to answer (7)
- ❑ Don't know (8)

RESPONSE OPTIONS 2-5 RANDOMIZED

SHOW ONLY IF P-Inst1 = 1

P-Inst1c
Is your company currently participating in a HVAC quality installation program from a California electric utility?

- ❍ Yes (1)
- ❍ No (2)

SHOW ONLY IF P-Inst1 = 1

P-Inst1e
In your opinion, what are the main advantages to your company of participating in a utility's HVAC installation program?

(Check all that apply).

- ❑ It drives customers directly to us (1)
- ❑ It allows us to approach new customers (2)
- ❑ Customers get incentives, which makes them happier with us (3)
- ❑ Our company's technician staff have benefited from the program's training opportunities (4)
- ❑ Our customers get incentives to do installations correctly, which makes them more apt to hire us (5)
- ❑ There have been no significant advantages (6)
- ❑ Other (Specify) _____ (7)

RESPONSE OPTIONS 1-5 RANDOMIZED

WHOLE HOUSE

WH.1
Has your company ever participated in a utility-sponsored "Whole House" program that goes beyond HVAC and includes building envelope, lighting, or appliances?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

SHOW IF WH.1 = 2

WH.2
Would your company be interested in participating in a utility-sponsored "Whole House" program that goes beyond HVAC and includes building envelope, lighting, or appliances?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know (3)

STAFFING AND TRAINING

ST1
Please indicate how many employees your company has on staff with the following roles:

	0 (1)	1 to 4 (2)	5 to 9 (3)	10 or greater (4)
Service/Maintenance Technician (1)	❍	❍	❍	❍
Installer (2)	❍	❍	❍	❍
Design Engineer (3)	❍	❍	❍	❍
Sales/Estimator(4)	❍	❍	❍	❍

RESPONSE OPTIONS 1-4 RANDOMIZED

ASK ST3.m IF JOB_TYPE = 1.

ST3.m
What percentage of technicians at your company that perform maintenance work currently has the following certifications?

	0-24% (1)	25-49% (2)	50-74% (3)	75-100% (4)	Don't know (5)

NATE (1)	❍	❍	❍	❍	❍
HVAC Excellence (2)	❍	❍	❍	❍	❍
PAHRA/Industry Competency Exam (3)	❍	❍	❍	❍	❍
TABB (4)	❍	❍	❍	❍	❍
RSES (5)	❍	❍	❍	❍	❍
UA STAR (6)	❍	❍	❍	❍	❍
Other (Specify) _____ (7)	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-6 RANDOMIZED

ASK ST3.i IF JOB_TYPE = 2.

ST3.i
What percentage of technicians at your company that perform installation work currently has the following certifications?

	0-24% (1)	25-49% (2)	50-74% (3)	75-100% (4)	Don't know (5)
NATE (1)	❍	❍	❍	❍	❍
HVAC Excellence (2)	❍	❍	❍	❍	❍
PAHRA/Industry Competency Exam (3)	❍	❍	❍	❍	❍
TABB (4)	❍	❍	❍	❍	❍
RSES (5)	❍	❍	❍	❍	❍
UA STAR (6)	❍	❍	❍	❍	❍
Other (Specify) _____ (7)	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-6 RANDOMIZED

ASK ST4.m IF JOB_TYPE = 1.

ST4.m
Please indicate how effective you think the following certifications are in preparing a technician to perform quality maintenance on HVAC systems.

	Not at all effective (1)	Somewhat effective (2)	Effective (3)	Very effective (4)	No opinion (5)	I'm not familiar with the certification

						(6)
NATE (1)	❍	❍	❍	❍	❍	❍
HVAC Excellence (2)	❍	❍	❍	❍	❍	❍
PAHRA/Industry Competency Exam (3)	❍	❍	❍	❍	❍	❍
TABB (4)	❍	❍	❍	❍	❍	❍
RSES (5)	❍	❍	❍	❍	❍	❍
UA STAR (6)	❍	❍	❍	❍	❍	❍
Other (Specify) _____ (7)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-6 RANDOMIZED

ASK ST4.i IF JOB_TYPE = 2.

ST4.i
Please indicate how effective you think the following certifications are in preparing a technician to perform quality installation on HVAC systems.

	Not at all effective (1)	Somewhat effective (2)	Effective (3)	Very effective (4)	No opinion (5)	I'm not familiar with the certification (6)
NATE (1)	❍	❍	❍	❍	❍	❍
HVAC Excellence (2)	❍	❍	❍	❍	❍	❍
PAHRA/Industry Competency Exam (3)	❍	❍	❍	❍	❍	❍
TABB (4)	❍	❍	❍	❍	❍	❍
RSES (5)	❍	❍	❍	❍	❍	❍
UA STAR (6)	❍	❍	❍	❍	❍	❍
Other (Specify) _____ (7)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-6 RANDOMIZED

ST5
What is the approximate turnover in your company's technician staff each year?

- ❍ Less than 5 percent (1)
- ❍ 5 to 9 percent (2)
- ❍ 10 to 19 percent (3)
- ❍ 20 to 29 percent (4)

- ❍ 30 to 39 percent
- ❍ 40 to 49 percent
- ❍ 50 percent or more (5)
- ❍ Prefer not to answer (6)
- ❍ Don't know (7)

ST6
How important are the following attributes when your company is thinking about hiring a technician?

	Not at all important (1)	Somewhat important (2)	Important (3)	Very important (4)	No opinion (5)
Formal HVAC education (1)	❍	❍	❍	❍	❍
Work experience (2)	❍	❍	❍	❍	❍
Certifications (3)	❍	❍	❍	❍	❍
Work ethic (4)	❍	❍	❍	❍	❍
Communication skills (5)	❍	❍	❍	❍	❍
Union membership (6)	❍	❍	❍	❍	❍
Presentation (e.g. neat, dressed appropriately) (7)	❍	❍	❍	❍	❍
Other (Specify) _____ (8)	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-7 RANDOMIZED

ST7
Please indicate how interested your company is in being involved in the following training opportunities:

	Not at all Interested (1)	Somewhat Interested (2)	Interested (3)	Very Interested (4)	No opinion (5)	I'm not familiar with the training opportunity (6)
Private training institute (1)	❍	❍	❍	❍	❍	❍
Online HVAC course (2)	❍	❍	❍	❍	❍	❍
Utility training (3)	❍	❍	❍	❍	❍	❍
Distributor training (4)	❍	❍	❍	❍	❍	❍
Manufacturer training (5)	❍	❍	❍	❍	❍	❍

IHACI training (7)	❍	❍	❍	❍	❍	❍
Other (Specify) _____ (8)	❍	❍	❍	❍	❍	❍

RESPONSE OPTIONS 1-11 RANDOMIZED

CONTACT INFO

CI1
In order to verify our records, please provide the following information:

a. Company Name _____
b. Company Address _____
c. Company City _____
d. Company State _____
e. Company Zip _____
f. Company Phone _____

Note: We do not share this information with marketers or sales people and be confident that we will keep your information strictly confidential.

INCENTIVE

As a thank you for your participation, we will be emailing you a $75 gas card. Below, please enter your contact info so we can get you your gas card:

NAME1
Name _____

EMAIL1
Email address _____

[BOTH NAME1 and EMAIL WILL BE REQUIRED FIELDS]

Note that without this information we will be unable to send you your gas card. Please be confident that we do not share this information with marketers or sales people and will keep your information strictly confidential.

SURVEY END

Thank you for completing the survey! Your input is valuable to the development of the California HVAC industry.

You should be receiving your gas card within the next 3 weeks.

IF TERMINATED DURING SCREENING:

Sorry, you do not qualify for the remainder of the survey. Thank you very much for your time.

Appendix D: CHARACTERISTICS OF RESPONDENTS ASSIGNED TO THE RESIDENTIAL, SMALL COMMERCIAL, AND LARGE COMMERCIAL ONLINE SURVEY MODULES

As described in Section 2.2, the online survey respondents were presented different modules based on the sector in which they reported conducting their work (residential, small commercial, or large commercial). Because of the length of the survey, even if a contractor reported doing work in more than one sector, they were only asked to complete one survey module. While the firmographic results are provided in aggregate in the body of this report (i.e. there is no differentiation across sectors), this appendix provides results comparing the online respondents across the survey modules they were assigned.

It is worth noting that caution should be taken in interpreting these results as being definitively indicative of contractors operating in any particular sector. In reality, most contractors actually reported working in more then one sector. Thus, a contractor that completed the residential module may also be a contractor that operates in the small commercial sector.

Table D-1 shows the mean percentage of jobs contractors reported doing in each of the sectors by the module they completed. In general, the vast majority of the work done by the contractors that completed the residential module was in the residential sector (93.1%); little work was done by these contractors in the small commercial (6.6%) or large commercial (0.3%) sectors. Similar to the contractors that completed the residential module, those that completed the small commercial module also reported doing very little work in the large commercial sector (0.4%); they reported doing an average of 60.3% of their work in the residential sector and 39.2% in the small commercial sector. Those that competed the large commercial module reported doing a greater diversity of work (22.8% residential; 36.3% small commercial), although most of it was in the large commercial sector (40.9%).

Table D-1: Mean Percentage of Jobs in Each Sector by Survey Module Assignment

	Percentage of Jobs Worked in Each Sector		
Survey Module Assignment	**Residential Mean (*SD*)**	**Small Commercial Mean (*SD*)**	**Large Commercial Mean (*SD*)**
Residential (n = 126)	93.1% (5.2)	6.6% (4.9)	0.3% (1.0)
Small Commercial (n = 119)	60.3% (22.4)	39.2% (22.3)	0.4% (1.4)
Large Commercial (n = 97)	22.8% (23.5)	36.3% (21.9)	40.9% (27.4)

Table D-2 shows the number of years in business by survey module assignment. A statistically significant difference was detected across sectors ($X^2 = 30.68$ ($df = 8$), $p < .001$), with the general finding being that few large commercial respondents reported being in business less than five years (4% as compared to 17% for residential and 18% for small commercial), and a relatively greater proportion being in business

30 years or more (38% as compared to 21% for residential and 15% for small commercial). No notable difference was apparent between residential and small commercial respondents.

Table D-2: Years in Business by Survey Module Assignment

Years in Operation	Survey Module Assignment			Total (n = 343)
	Residential (n = 126)	Small Commercial (n = 119)	Large Commercial (n = 98)	
Less than 5 years	17%	18%	4%	14%
5 to 9 years	17%	28%	12%	19%
10 to 19 years	21%	22%	23%	22%
20 to 29 years	25%	18%	22%	22%
30 years or more	21%	15%	38%	24%

Table D-3 shows the company's annual revenue by survey module assignment. There is a notable difference between the large commercial contractors as compared to the small commercial and residential contractors ($X^2 = 57.50$ ($df = 12$), $p < .001$). Overall, residential and small commercial respondents tended to report lower levels of annual revenue (83% and 80% reported less than $1 million/year, respectively) than the large commercial contractors (only 53% reported less than $1 million/year).

Table D-3: Company's Annual Revenue by Survey Module Assignment

Annual Revenue	Survey Module Assignment			Total (n = 342)
	Residential (n = 120)	Small Commercial (n = 114)	Large Commercial (n = 93)	
Less than $100,000	25%	25%	8%	20%
$100,000 to $249,999	29%	26%	9%	22%
$250,000 and $499,999	17%	20%	18%	18%
$500,000 and $999,999	12%	9%	18%	13%
$1 million and $2,999,999	10%	11%	20%	13%
$3 million and $7,999,999	2%	3%	8%	4%
$8 million or more	2%	0%	12%	4%
Prefer not to answer	5%	3%	4%	4%
Don't know	0%	1%	1%	1%

Table D-4 shows the number of employees by survey module assignment. A statistically significant difference was detected across sectors ($X^2 = 47.85$ ($df = 6$), $p < .001$), with the general result being that respondents assigned to the large commercial module tended to be larger companies, with only 40% reporting 1 to 4 employees in contrast to 78% of those assigned to the residential module and 76% of those assigned to the small commercial module. This result is likely tied to the previous result showing generally higher annual revenues for the large commercial contractors – they are simply larger firms.

Table D-4: Number of Employees by Survey Module Assignment

Number of Employees	Survey Module Assignment			Total (n = 343)
	Residential (n = 126)	Small Commercial (n = 119)	Large Commercial (n = 98)	
1-4	78%	76%	40%	66%
5-9	10%	13%	27%	16%
10-24	7%	8%	16%	10%
25 or more	5%	3%	17%	8%

Table D-5 shows the proportion of employees holding a union membership by survey module assignment. None of the contractors assigned to the residential module reported that any of their employees were union members, and very few (only 4%) of the contractors assigned to the small commercial module indicated so. In contrast, just over one-quarter (26%) of contractors assigned to the large commercial module indicated they had union members on their payroll. These results were statistically significantly different ($X^2 = 50.91$ ($df = 2$), $p < .001$).

Table D-5: Union Membership by Survey Module Assignment

Union	Survey Module Assignment			Total (n = 343)
	Residential (n = 124)	Small Commercial (n = 114)	Large Commercial (n = 98)	
Yes	0%	4%	26%	8%

Table D-6 shows the respondents' facility type by survey module assignment. A statistically significant difference was detected across sectors ($X^2 = 23.80$ ($df = 6$), $p < .001$), with the general result being that fewer contractors assigned to the large commercial module indicated that the site they worked at was their company's only facility (80%) in contrast to those assigned to the residential (93%) and small commercial (88%) moduels. Notably, a relatively greater proportion of contractors assigned to the large commercial module indicated that the site they worked from was the headquarters of a company with multiple locations (15%) as compared to those assigned to the residential (1%) and small commercial (4%) modules.

Table D-6: Facility Type by Survey Module Assignment

Facility Type	Survey Module Assignment			Total (n = 343)
	Residential (n = 126)	Small Commercial (n = 119)	Large Commercial (n = 98)	
Your company's only location	93%	88%	80%	87%
The headquarters of a company with multiple locations	1%	4%	15%	6%
A branch or franchise location of a company based in California	2%	1%	4%	2%
A branch or franchise location of a company based outside California	2%	1%	1%	1%

Finally, Table D-7 shows the respondents' service territory by survey module assignment. Here too a statistically significant difference was detected across sectors ($X^2 = 25.44$ ($df = 12$), $p = .013$). Overall, a relatively greater percentage of contractors assigned to the residential and large commercial (46% and 50%, respectively) modules reported operating in the PG&E service territory compared to those assigned to the small commercial module (33%). More large commercial contractors (26%) indicated they worked in the SDG&E service territory than those assigned to either the residential (17%) or small commercial (10%) modules. A greater percentage of those assigned to the large and small commercial modules (62% and 61%, respectively) reported operating in the SCE service territory compared to those assigned to the residential module (49%). Also, a relatively greater percentage of those assigned to the large commercial module reported operating in the LADWP service territory (44%) compared to those assigned to the residential (18%) or small commercial (31%) modules.

Table D-7: Service Territory by Survey Module Asignment

	Survey Module Assignment			
Service Territory	**Residential (n = 126)**	**Small Commercial (n = 119)**	**Large Commercial (n = 98)**	**Total (n = 343)**
Pacific Gas and Electric Company	46%	33%	50%	43%
San Diego Gas and Electric	17%	10%	26%	17%
Southern California Edison	49%	61%	62%	57%
Southern California Gas	44%	45%	47%	45%
Los Angeles Department of Water & Power	18%	31%	44%	30%
Sacramento Municipal Utility District	10%	10%	14%	11%
Other	16%	11%	5%	11%

Appendix E: TECHNICAL OBSERVATION CHECKLIST

Technician Name _____
Time Started _____
Time Ended _____
Date _____

Task		Done?	How, Notes
SPACE			
S1	Check registers throughout the house to make sure they are all open		
S2	Inspect grilles, registers and diffusers for dirt or moisture accumulation or biological growth		
S3	Test modes of operation and control sequences		
S4	Check thermostat programming		
S5	Inspect air filter housing integrity and air seal		
S6	Inspect for particulate accumulation on filters		
S7			
S8			
ATTIC			
A1	Inspect all electrical components for proper operation		
A2	Measure and record full-load amps on motors.		
A3	Inspect all accessible ductwork for areas of moisture accumulation or biological growth		
A4	Inspect the all accessible ductwork and connections for leaks		
A5	Inspect the accessible ductwork for possible airflow restrictions		
A6	Measure and record static pressure across evaporator coil		
A7	Measure and record temperature difference across evaporator coil.		
A8	Inspect evaporator coil fins and clean evaporator coil		
A9	Visually inspect furnace heat exchanger and flue for corrosion, fouling, structural problems (eg cracks, perforations, bulges).		
A10	Inspect refrigerant line and duct insulation		
A11	Inspect metering device…ascertain type.		
A12			
A13			
OUTSIDE			
O1	Inspect refrigerant line insulation.		
O2	Inspect all electrical components for proper operation		
O3	Measure and record full-load amps on motors.		
O4	Inspect coil fins and clean condensing coil		
O5	Check refrigerant charge…did he do it correctly?		
O6	Inspect and test contactors, relays, and capacitors		
O7			
O8			

Diagnosis		Dx?	How?
D1	Closed off registers		
D2	Airflow restriction		
D3	Refrigerant restriction		
D4			

Did they send their A team or B team?

A ☐
B ☐

Notes

	Device							Have?	Type, Make, Notes	Calib?
D1	Duct Pressurization Tester									
D2	Current Clamp									
D3	Multi-meter	Amps	Volts	MF	RMS					
D4	Refrig Pressure Manifold	Digital	Analog							
D5	Static Pressure Manometer	Digital	Analog							
D6	Airflow Measurement	Hood	Grid	Anamom	Pitot					
D7	Pipe Temperature	RTD	TC	Digital	Analog	Strapon	Clampon			
D8	Air Temperature	RTD	TC	Digital	Analog					
D9	Refrigeration System and Airflow Analyzer									
D10	Humidity	Digital	Analog							
D11	Refrigerant Vacuum Pump	Clean Oil								
D12	Vacuum Gauge	Digital	Analog							
D13	Recovery Pump									
D14	Schrader Core Repair Tool									
D15	Scale	Digital	Analog							
D16	Combustion Analyzer	Digital	Analog							
D17	Furnace Heat Exchanger Inspection									
D18	Software									
D19										
D20										

Appendix F: Definitions of Correct Implementation of Technical Tasks

The master technician, ACCA Standard 4, and other industry sources provide guidance on proper technical tasks for residential HVAC maintenance. Definitions for each task are provided below.

Thermostat

The thermostat must be checked as follows: a) for digital thermostats compare displayed temperature with measured temperature using calibrated digital thermometer placed next to thermostat display, b) for heating technician must increase thermostat setting until heating system turns on and delivers heat, c) for cooling technician must decrease thermostat setting until cooling system turns and delivers cool air, d) for fan only operation technician must turn on fan and verify fan operates and delivers air to space, e) for programmable thermostats technician must check program with homeowner to ensure homeowner understands program and understands how to modify program, f) results must be entered into customer paperwork and technician software (if available).

Electrical

Electrical system operation must be checked as follows: a) visually evaluate quality of contactors to determine if pitting exists and measure voltage across contactor to ensure no voltage drop, b) turn on unit to ensure time delay relay "off" or "on" operate within manufacturer specifications, c) measure capacitor capacitance in microfarads using digital multi-meter and the measured value must be within +/-5% of the value shown on the capacitor, d) results must be entered into customer paperwork and technician software (if available).

Duct Leaks

Duct connections and leaks must be checked as follows: a) temporarily seal all supply and return registers and pressurize duct system to 25 Pascal with respect to ambient conditions to measure duct leakage in terms of cubic feet per minute (cfm) and percentage leakage by dividing duct leakage cfm by the cooling capacity in tons times 400 cfm/ton, b) results must be entered into customer paperwork and technician software (if available).

Condenser Coil

Clean condenser coil must be performed as follows: a) turn off power to unit, visually inspect condenser coil, and remove debris (leaves, grass, etc.), b) apply water pre-rinse on the entire coil, followed by non-toxic chemical application sprayed inside and outside of coil, followed by 5-minute dwell time, followed by water post-rinse spray from the inside to outside so water removes chemicals and debris in opposite direction of normal airflow c) results must be entered into customer paperwork and technician software (if available).

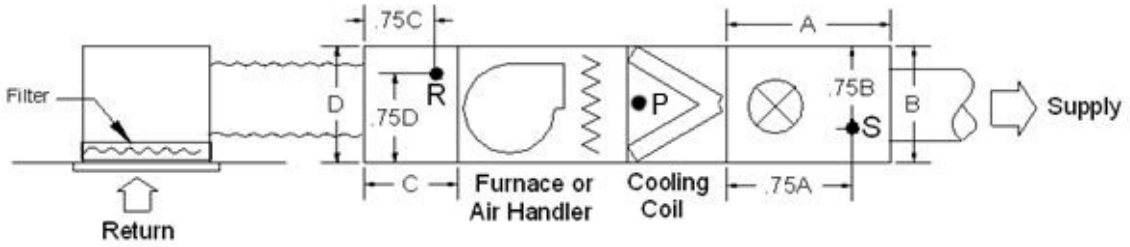
Air Filter

Air filter must be checked as follows: a) visually inspect the air filter housing for dirt and debris, b) install new MERV 7 air filter consistent with the homeowner and manufacturer specifications, c) results must be entered into customer paperwork and technician software (if available).

External Static

External static pressure must be checked as follows: a) locate or drill two 5/16 inch diameter holes at points R (return) and P (shown in Figure F-1) and install differential pitot tubes in the holes to measure return and supply plenum pressure, b) measured external static pressure must be entered into the customer paperwork and technician software (if available).

Figure F-1: Temperature and Pressure Test Points



Temperature Split must be evaluated as follows: a) locate or drill two 5/16" diameter holes at points R (return) and S (supply) as shown in Figure F-1, b) 15 minutes or more after the system is started, use accurate digital thermometer probes to measure and record dry bulb and wet bulb air temperatures at points R and S with probes centered in the air stream, c) look up the required temperature split in tables provided by manufacturer or California Energy Commission,[43] d) subtract measured supply air dry bulb (S) from return air dry bulb temperature (R) to calculate actual temperature split, e) actual temperature split should be within +/-3F of recommended temperature split values in the table, f) if actual temperature split is 3F greater than target value, then the system has low airflow, g) if the actual temperature split is 3F less than target value, then one or more defects are causing a reduction in cooling capacity (low refrigerant charge, restriction, non-condensables, etc.), h) measured and target temperature split must be entered into the customer paperwork and technician software (if available).

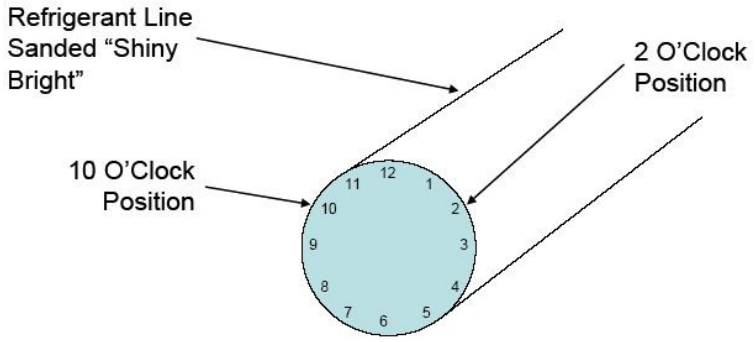
Refrigerant Charge

Refrigerant charge must be evaluated as follows per manufacturer specifications or specifications provided by the California Energy Commission: a) use calibrated digital dry bulb and wet bulb air and clamp-on temperature sensors and digital refrigerant pressure gauges with hoses equipped with EPA low-loss fittings, b) refrigerant hoses must be purged of air and contaminated refrigerant before attaching to valves on system, c) suction and liquid lines must be sanded before attaching temperature sensors which

[43] CEC 2008. "Residential Field Verification and Diagnostic Procedures." Appendix RA3 to the California 2008 Title 24 Residential Energy Standards. California Energy Commission.

must be attached between 10:00 and 2:00 o'clock positions on the pipe (shown in Figure F-2) near suction and liquid line service valves, d) pipe clamp sensors must be attached with good thermal contact and no air-gaps for accurate reading, and all cabinet panels that affect airflow must be in place before making measurements, e) sensors must be attached to system until finished, f) look up the required subcooling (RSC from manufacturer data or use 10F if no data is available), g) look up the required superheat in tables provided by manufacturer or California Energy Commission[44] based on measured condenser entering air and return air wet bulb temperatures, h) after the air conditioning system has been operating for at least 15 minutes, i) measure actual superheat based on difference between measured suction line temperature and evaporator saturation temperature (EST based on suction line pressure), j) measure actual subcooling based on difference between condenser saturation temperature (CST based on liquid line pressure) and the measured liquid line temperature, k) if the actual superheat minus the required superheat is greater than +5F or less than -5F and the actual subcooling minus required subcooling is greater than +3F or less than -3F (for TXV equipped units) then the refrigerant system, or is unlikely to be within manufacturer specifications, l) if the difference between the condenser entering air temperature and the condenser saturation temperature (CST) is greater than 30F then non-condensables might be present in the system, m) if the evaporator saturation temperature (EST) is less than 28F then a refrigerant restriction might be present in the refrigerant system, and n) if any of these refrigerant system faults exist the refrigerant system is unlikely to be within manufacturer specifications, o) results must be entered into customer paperwork and technician software (if available).

Figure F-2: Suction and Liquid Line Temperature Probe Attachment Location



Motor Amps

Motor and compressor amperage must be checked as follows: a) attach true RMS current probe to black power wire on blower motor, condenser fan motor, or compressor and reinstall all panels per normal operation, b) measure and record motor or compressor amperage, c) compare measured values to manufacturer specifications, d) results must be entered into customer paperwork and technician software (if available).

[44] CEC 2008. Residential Field Verification and Diagnostic Procedures. Appendix RA3 to the California 2008 Title 24 Residential Energy Standards. California Energy Commission.

Biological

Registers and/or ducts must be checked for dirt, moisture, or biological growth as follows: a) visually inspect registers and ducts for dirt, moisture, or biological growth, b) results must be entered into customer paperwork and technician software (if available).[45]

Evaporator Coil

Inspect and/or clean evaporator coil as follows: a) turn off power to unit, remove evaporator coil access panel, and visually inspect evaporator coil, b) if dirty, then perform chemical coil cleaning according to manufacturer recommendations, c) apply non-toxic chemical cleaner to cover entire evaporator coil surface, d) allow water condensed from air to rinse non-toxic cleaner from coil, d) results must be entered into customer paperwork and technician software (if available).

Furnace

Inspect furnace burner, heat exchanger, and flue as follows: a) remove access panels, and visually inspect furnace flame, heat exchanger, and flue while furnace is operating, b) flame should be blue with a touch of yellow (if not blue then turn off furnace and clean burner to correct flame), c) when blower motor turns on flame should be stable (if not, then heat exchanger might have crack), d) visually check flue collar for rust, moisture, or carbon black deposits (if rust, moisture, or carbon black are present, then check flue for blockage or replacement), e) remove cover from gas pressure tap and install pitot tube from digital differential pressure meter, measure gas valve pressure, and compare to manufacturer specifications (adjust valve setting if not within +/-10% of manufacturer specifications–clockwise decreases and counterclockwise increases gas pressure), g) results must be entered into customer paperwork and technician software (if available).

Refrigerant Line and Duct Insulation

Inspect refrigerant line and duct insulation as follows: a) visually inspect refrigerant line and duct insulation for missing or damaged insulation, b) inform homeowner of missing or damaged insulation, c) results must be entered into customer paperwork and technician software (if available).

Low Airflow

Airflow must be checked as follows: a) evaluate proper fan speed per manufacturer specifications, b) measure external static pressure or blower amps to determine motor wire tap for high speed operation and set blower motor to high speed, c) results must be entered into customer paperwork and technician software (if available).

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[45] USEPA indicates there is little or no evidence about duct cleaning improving HVAC system efficiency (http://www.epa.gov/iaq/pdfs/airducts.pdf).

Registers

Closed supply air registers must be checked as follows: a) check all supply air registers to ensure they are fully open, b) if any registers are partially or fully closed, then explain to the homeowner the importance of keeping all supply registers open to improve efficiency and save energy, c) with homeowner approval open partially or fully closed registers, d) results must be entered into customer paperwork and technician software (if available).

Appendix G: Recommendations from Observed Technicians

Most of the observed technicians did not identify the imposed faults. Despite this, most of the technicians recommended repairs. Table G-1 provides a summary of the cost and description of recommendations by some of the observed technicians. The average cost was $566 with a range from $129 to $1,236.

Table G-1: Observed Technicians' Recommended Repairs

Technician	Cost	Recommendation
1	$650	New supply ducts
2		New supply ducts and UV light
3	$150	New capacitor for condenser and fan
4	$129	Add up to 3 pounds of refrigerant
5		N/A
6		N/A
7	$1,236	Hard-start and run capacitors, UV bulb, Schrader core replacement
8	$1,194	UV lamp, blower fan, contactor, air filter for two systems
9	$445	New condenser fan motor
10		N/A
11		Add 1 pound of refrigerant
12	$156	Replace contactor
13		Improve airflow and add refrigerant charge

Note. An estimate of costs is included when it was provided on the invoice.