Swimming Against the Tide—Gauging HVAC Quality Installation and Quality Maintenance Program Efforts to Establish a Foothold in the Market

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ABSTRACT

The California investor-owned utilities have designed programs to increase the quality of HVAC installation (QI) and maintenance (QM) and the market share of high-efficiency systems. With a particular focus on residential and small commercial customers, this study established baselines for maintenance and installation practices and market shares of recently installed efficient systems. Overall, nearly three-fifths of HVAC units sold to residential and small commercial customers in 2011 and 2012 were high-efficiency systems.

A minority of contractors reported awareness of ACCA/ASHRAE standards for QI and QM, and very few said they adhere to all of the associated specifications. A small fraction of contractors reported participating in the utility programs. Customer awareness of QI and QM and the utility programs is also low. The QI field assessments found a mixed record of compliance with building codes among installations in the overall HVAC replacement market. The QM field assessments determined that the performance metrics among non-program systems validated QM program assumptions of sub-optimal performance. Contractors reported that the primary barrier to both QI and QM was customer reluctance to pay for it. The study also found that up to one-quarter of HVAC technicians in California may be unlicensed contractors. Coupled with customer reluctance to pay, the presence of so many unlicensed technicians who do not pull building permits for HVAC installations and perform low-cost, sub-standard work likely places strong cost pressures on licensed contractors, and may significantly limit the ability of the QI and QM programs to gain traction in the marketplace.

Background and Objectives

HVAC is a major definable market in California, accounting for sizable portions of peak demand and energy use as well as savings potential. The California Public Utilities Commission (CPUC) and investor-owned utilities (IOUs) have designed programs to increase the quality of HVAC installation (QI), the quality of HVAC maintenance (QM), and the market share of high-efficiency systems. With a particular focus on residential and small commercial customers, this study sought to establish a baseline for a range of current maintenance and installation practices and the market shares of highly efficient systems that have been recently installed. These data will assist the CPUC in future retrospective assessments of the market effects attributable to these programs. The key objectives of this study included the following:

- To use a prospective focus to provide a baseline for CPUC HVAC programs that will facilitate the CPUC's future assessments of the market effects that may be attributed to HVAC programs.
- To estimate the proportion of contractors adhering to QI and QM practices.
- To estimate the current levels of secondary indicators in order to facilitate future estimates of the influence of the IOU programs and other factors on the use of IOU-promoted methods outside the IOU programs.
- To summarize estimates of market share, sales, penetration, and saturation of energy-efficient HVAC equipment for residential and small commercial customers in order to provide a baseline for future retrospective studies.

Methodology

This multi-faceted study made use of data collected from contractors, customers, program managers, and others involved in the California HVAC market. It relied substantially on other concurrently running evaluations for information inputs and data collection, necessitating substantial coordination with those data collection efforts. The studies summarized in Table 1 contributed to key findings presented in this paper.

Table 1. HVAC Studies Used to Examine Market Effects

Study / Survey	Surveyed Group	Conducted by
California HVAC Contractor & Technician Behavior Study, Final Report, September 2012	Web survey of 245 residential and small commercial contractors	Energy Market Innovations for Southern California Edison and Pacific Gas & Electric
Surveys of residential customers and small commercial customers	Telephone surveys 297 residential customers and 300 small commercial customers	NMR for the CPUC
HVAC Distributor Interviews	Telephone interviews with 8 independent HVAC distributors	NMR for the CPUC
IOU Interviews	Telephone interviews with 7 HVAC program staff members	NMR for the CPUC
Commercial Saturation and Commercial Market Share Tracking Study. September 2014	Telephone surveys of 7,880 commercial customers; on-sites for 197 commercial customers that had recently installed new HVAC systems;123 contractors who install commercial HVAC systems surveyed	Itron
California Lighting and Appliance Saturation Study (CLASS 2012)	1,987 home on-sites	DNVGL
Residential and Small Commercial HVAC Impact Evaluation	Telephone interviews with 20 independent HVAC distributors	DNVGL
Residential and Small Commercial HVAC Impact Evaluation	50 participant and 50 non-participant residential installation on-sites; 50 residential and 30 commercial maintenance on-sites	DNVGL

Baseline Overview

The study objective was to provide a baseline for the Market Transformation Indicators (MTIs) established for CPUC HVAC programs. Table 2 shows the four HVAC subprograms and the four MTIs associated with them.

Table 2. CPUC HVAC Subprograms and Market Transformation Indicators

Subprogram	Subprogram Name	MTI	MTI Description
HVAC-1	Upstream HVAC Equipment Subprogram	MTI-1	Market share of climate-appropriate HVAC equipment.
HVAC-2	Residential ENERGY STAR Quality Installation Subprogram	MTI-2	Percentage change in the use of Quality Installation guidelines among all California Residential HVAC installation contractors.
HVAC-3	Commercial Quality Installation Subprogram	MTI-3	Percentage change in the use of Quality Installation guidelines among all California Commercial HVAC installation contractors.
HVAC-4	Quality Maintenance Development Subprogram	MTI-4	Percent change in the employment of Quality Maintenance practices among all California HVAC contractors and technicians.

In addition to the four MTIs listed in Table 2, this study identified several secondary indicators that may also be tracked to assess the HVAC subprograms' progress in promoting QI and QM (Table 3).

Table 3. Suggested Secondary Indicators Assessing HVAC Subprograms' Progress

Quality Installation	Quality Maintenance
Percent Change in…	
Contractor awareness of QI and ACCA standards	Contractor awareness of QM and ACCA/ASHRAE standards
Customer awareness of the concept of QI	Customer awareness of the concept of QM
Contractors currently participating in QI programs	Contractors currently participating in QM programs
Customer awareness of rebate and QI programs	Customer awareness of QM programs
Technicians with training in QI	Technicians with training in QM
Proportion of contractors who obtain building permits for HVAC installations	Proportion of customers who have regular maintenance of their HVAC systems

Overall, the study found significant market shares of energy-efficient HVAC equipment sold in 2011 and 2012 in California. However, the study also found low baseline values for adherence to Quality Installation (QI) and Quality Maintenance (QM) practices.

Market Shares of Energy-Efficient Equipment

Table 4 shows the estimated sales and market share in California by HVAC unit type and Table 5 shows the estimated distribution of HVAC market share by efficiency level and unit type.[1] Efficiency levels in Table 5 are shown as performance tiers which were defined using the 2010-2012 Southern California Edison Qualifying Minimum Equipment Efficiencies and Incentive Levels for Commercial Air Conditioners. The number of tiers and tier standards—defined based on minimum unit SEER, EER, or IEER ratings—vary by HVAC unit type and capacity.

Market shares of energy-efficient HVAC equipment in the residential and small commercial markets in 2011 and 2012 in California were significant.

- Overall, nearly one-half (46%) of the HVAC units sold were single-phase air-cooled (Table 4) and four out of every ten of these (40%) met Tier 1 or better efficiency standards (Table 5).
- The next largest market share (23%) was for air-cooled three-phase packaged and split equipment (Table 4); more than one-half of these units (56%) met Tier 1 or better efficiency standards (Table 5).[2] Just over eight out of ten (81%) of the remaining unit types met Tier 1 or better efficiency standards (Table 5).

The California Energy Efficiency Strategic Plan calls for 15% of HVAC equipment shipments optimized for California's climate by 2015 and 70% by 2020. The market transformation indicator of progress toward this goal is annual sales of climate-appropriate air conditioning (AC).

- Using Tier 1 or better as a proxy for climate-appropriate AC,[3] this study estimates that 57% of HVAC units sold to residential and small commercial customers in 2011 and 2012 met the criterion.

[1] The sales and market share estimates were based on the interviews with 20 distributors conducted for the Residential and Small Commercial HVAC Impact Evaluation (Table 1).

[2] Single-phase air-cooled equipment was predominantly residential, and three-phase equipment was almost exclusively commercial.

[3] A proxy was needed because HVAC equipment design and/or performance criteria that would qualify a unit as climate-appropriate, and the climate regions where they should be applied, had not yet been defined.

- Thus, based on a Tier 1 standard, the current estimate of sales exceeds the goal set by the California Energy Efficiency Strategic Plan for 2015 and approaches the more ambitious goal for 2020. Only 13.5% of HVAC units sold in 2011 and 2012 would meet a higher climate-appropriate standard as approximated by Tier 2 or better.

Table 4. Estimated Sales and Market Share in California by HVAC Unit Type

HVAC Unit Type	Estimated Sales	Estimated Market Share
Air Cooled Three-Phase Packaged & Split Equipment	42,743	23%
Water Source HP; Water/Evap. Cooled AC (3-phase & single-phase)	17,971	10%
Single-phase Air Cooled	84,531	46%
Ductless Mini-Split	31,543	17%
Ductless Multi-Split	8,894	5%
Total	185,683	100%

Percentages may not add to 100% because of rounding.

Table 5. Estimated Distribution of HVAC Market Share by Efficiency Level and Unit Type

HVAC Unit Type	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
Air Cooled Three-Phase Packaged & Split Equipment	44%	39%	10%	4%	2%
Water Source HP; Water/Evap. Cooled AC (3-phase & single-phase)	23%	51%	26%	na	na
Single-phase Air Cooled	60%	40%	na	na	na
Ductless Mini-Split	22%	60%	18%	0%	na
Ductless Multi-Split	1%	21%	78%	na	na
Overall	43%	44%	12%	1%	1%

Responding distributors represent over 35% of HVAC market share in California except for ductless multi-splits, where 2 distributors represent approximately 17% of HVAC market share. Some distributors reported equipment sales of units in tiers that were higher than available. These were included in the highest tier for the unit type. Percentages may not add to 100% because of rounding.

Quality Installation Findings

Quality Installation (QI) Baseline

The baseline for QI in California is relatively low. As Table 6 shows, only a minority of contractors (42% residential; 36% small commercial) were aware of ACCA Standard 5,[4] and a small minority said they adhere to all of its specifications (14% of all residential contractors; 8% of all small commercial contractors).

Table 6. Installation Contractor Adherence to QI Standards and Guidelines

QI Standards and Guidelines	Residential Installation Contractors	Small Commercial Installation Contractors
Sample Size	*116*	*114*
Aware of ACCA Standard 5	42%	36%
Adhere to all of ACCA Standard 5 specifications	14%	8%
Adhere to some of ACCA Standard 5 specifications	27%	23%
Aware of ACCA Standard 5 but do not adhere to specifications	0%	4%

[4] All three IOUs utilize the American National Standards Institute (ANSI)/ Air Conditioning Contractors of America (ACCA) Standard 5 for residential and commercial quality installation.

QI Standards and Guidelines	Residential Installation Contractors	Small Commercial Installation Contractors
Have formal installation policies and guidelines that technicians are required to follow	75%	59%

Thirty-five percent of residential contractors and 19% of small commercial contractors said they were currently participating or had ever participated in an IOU QI program.[5] However, only 10% of residential contractors and 8% of small commercial contractors said they were currently participating in such a program (Table 7).[6]

Table 7. Contractor Participation in a Quality Installation Program

Participation	Residential Installation Contractors	Small Commercial Installation Contractors
Sample Size	*116*	*114*
Currently participating in an IOU QI program	10%	8%
Currently participating or have participated in the past in an IOU QI program	35%	19%
Have never participated in an IOU QI program	64%	75%

Respondents to the survey of installation contractors were read out a list of certifications and were asked if they had any of them. More than one-half (53% residential; 59% small commercial) of the installation contractors said they were not certified by any organization. Only two-fifths (40%) of residential installation contractors and just over one-fourth (27%) of small commercial installation contractors hold NATE certifications, which are promoted by the IOU programs (Table 8). However, very small fractions of residential and small commercial contractors (1% to 3%) are estimated to have gone through IOU training and/or qualification.

Table 8. Installation Contractor Certifications

Certification	Residential Installation Contractors	Small Commercial Installation Contractors
Sample Size (multiple response)	*116*	*114*
Our company has none of these certifications	53%	59%
NATE Consumer Contractor Connection (C3)	40%	27%
Other certifications/organization memberships	20%	13%
No answer	3%	7%

Awareness of Quality Installation

Customer awareness of quality installation is fairly low. Less than one-fifth of residential respondents (16%) and small commercial respondents (17%) had heard of the term *quality installation*. Even after it was described to them, only about one-quarter of all customers (25% residential; 28% small commercial) said they had heard of QI (Table 9). When asked about the specific QI and rebate programs offered by their IOU, hardly any customers (7 out of 597 surveyed) could name any QI programs or guidelines unaided.

[5] This figure was likely overstated as a result of respondents including any IOU program they had participated in, even though they were specifically asked about the Quality Installation program.

[6] This self-reported participation rate is likely overstated by contractors responding to the survey, since only a very small percentage of installation contractors—ranging from 1% to 3%, depending on the IOU—have been trained and/or qualified by the IOUs. Program training, generally to ACCA Standard 5 and/or ENERGY STAR® QI, is a prerequisite for participation.

Table 9. Unaided and Aided Awareness of Quality Installation by Customers

Heard of Quality Installation	Residential Customers	Small Commercial Customers
Sample Size	*297*	*300*
Unaided	16%	17%
Aided	25%	28%

Barriers to Quality Installation

As Table 10 shows, contractors reported that the greatest barrier to QI is customers not wanting to pay for it (63% residential; 66% small commercial). This may at least partly be the result of the low customer awareness of QI.

Table 10. Contractor Self-Reported Barriers to Providing High Quality Installation Services

Barriers	Residential Installation Contractors	Small Commercial Installation Contractors
Sample Size (multiple response)	*116*	*114*
Customers don't want to pay for it	63%	66%
Technicians' knowledge of what is necessary	27%	34%
Contractor's/owner's knowledge of what is necessary	25%	35%
Available technical training in the market	16%	20%
Access to the right diagnostic tools	16%	16%
Access to quality maintenance checklists	15%	16%
There are no barriers	22%	13%

Quality Installation Field Assessments

The quality installation field assessments found a mixed record of compliance with Title 24 among installations in the overall HVAC replacement market. However, system performance metrics in the overall market were generally not as poor as assumed by the QI program.

- **Duct Leakage.** The field assessments found that many systems have duct leakage greater than the Title 24 specification of <15% and the program efficient case assumption of 12%, but the average of 17% shows they were not as leaky as the baseline 24% duct leakage assumed by the QI program.
- **System Airflow.** The Title 24 minimum and efficient case assumption specifies system airflow at 400 CFM/ton. System airflows of 300 CFM/ton measured during the program non-participant site visits were even lower than the 350 CFM/ton baseline assumed by the QI program.
- **System Oversizing.** While there was both undersizing and oversizing relative to Manual J, systems not participating in the program were oversized by an average of 13%, which is lower than the baseline assumption of 20%. Table 11 summarizes these findings.

Table 11. QI Field Observations and Assumptions for the Program Baseline and Efficient Case*

Statistic	Field Observations (mean)	QI Program Baseline Assumptions	QI Efficient Case Assumptions
Total System Duct Leakage	17%	24%	12%
System Airflow (CFM per ton)	300	350	400
System Oversizing	13%	20%	0%

* Based on on-sites at a sample of 50 non-participant residential installations (Table 1).

The field assessments used Title 24 and manufacturer diagnostics to verify that proper refrigerant charge was present in all the systems tested. However, recent studies have found that the Title 24 and other diagnostics used to verify refrigerant charge are flawed; thus, the results of this field assessment were considered to be indeterminate.

Quality Maintenance Findings

Quality Maintenance (QM) Baseline

As in the case of QI, the baseline for QM in California is also relatively low. A minority of contractors (45% residential; 34% small commercial) were aware of ACCA Standard 4 or ANSI/ASHRAE/ACCA Standard 180,[7] and a small minority said they adhere to all of the appropriate specifications (10% of all residential contractors; 7% of all small commercial contractors).

Table 12. Maintenance Contractor Adherence to QM Standards and Guidelines

QM Standards and Guidelines	Residential Installation Contractors	Small Commercial Installation Contractors
Sample Size	*116*	*114*
Aware of ACCA/ASHRAE Standards	45%	34%
Adhere to all of ACCA/ASHRAE standard specifications	10%	7%
Adhere to some of ACCA Standard 5 specifications	32%	25%
Aware of ACCA Standard 5 but do not adhere to specifications	2%	0%
Have formal installation policies and guidelines	63%	58%

Thirty percent of residential contractors and 22% of small commercial contractors said they were currently participating or had ever participated in an IOU QM program.[8] However, only 16% of residential contractors and 6% of small commercial contractors said they were currently participating in such a program.[9]

[7] All three IOUs utilize the American National Standards Institute ANSI/ACCA Standard 4 for residential QM and ANSI/ASHRAE[7]/ACCA Standard 180-2008 for commercial QM.

[8] Again, this figure was likely overstated due to the respondents including any IOU program they had participated in, even though they were specifically asked about the Quality Maintenance program.

[9] As in the case of QI, this self-reported participation rate is likely to be overstated by contractors responding to the survey, since only a small percentage of maintenance contractors—ranging from 1% to 10%, depending on the IOU—have been trained and/or qualified by the IOUs. Program training, generally to the ANSI/ACCA Standard 4 (residential) or ANSI/ASHRAE/ACCA Standard 180-2008 (commercial), is a prerequisite for participation. Note also that the IOU programs vary in their definitions of what constitutes qualified and trained contractors. In the PG&E program, contractors are qualified after receiving training. In the SCE and SDGE programs, the number of contractors trained is the number of contractors who received sales/operations training, and the number of contractors qualified is the number enrolled.

Table 13. Contractor Participation in a Quality Maintenance Program

Participation	Residential Maintenance Contractors	Small Commercial Maintenance Contractors
Sample Size	*109*	*110*
Currently participating in an IOU QM program	16%	6%
Currently participating or have participated in the past in an IOU QM program	30%	22%
Have never participated in an IOU QM program	66%	76%

Respondents to the survey of maintenance contractors were read out a list of certifications and were asked if they had any of them. More than one-half (55% residential; 56% small commercial) of maintenance contractors said their technicians were not certified by any organization. About two-fifths (39%) of residential maintenance contractors and three out of ten (30%) small commercial maintenance contractors said they hold NATE certifications, which are promoted by the IOU programs.

Table 14. Maintenance Contractor Certifications

Certification	Residential Maintenance Contractors	Small Commercial Maintenance Contractors
Sample Size (multiple response)	*109*	*110*
Our company has none of these certifications	55%	56%
NATE Consumer Contractor Connection (C3)	39%	30%
Other certifications/organization memberships	21%	13%
No answer	2%	7%

Awareness of Quality Maintenance

Customer awareness of quality maintenance also is fairly low. Just over one-fifth of residential respondents (22%) and small commercial respondents (21%) had heard of the term *quality maintenance*. Even after it was described to them, less than one-half of all customers (40% residential; 36% small commercial) said they had heard of QM. When asked about the specific QM and rebate programs offered by their IOU, hardly any customers (5 out of 597 surveyed) could name any QM programs or guidelines unaided.

Table 15. Unaided and Aided Awareness of Quality Maintenance by Customers

Aware of Quality Maintenance	Residential Customers	Small Commercial Customers
Sample Size	*297*	*300*
Unaided	22%	21%
Aided	40%	36%

Barriers to Quality Maintenance

As in the case for QI, contractors reported that the greatest barrier to quality maintenance is customers not wanting to pay for it (56% residential; 67% small commercial). This again may at least partly be the result of the low customer awareness of QM.

Table 16. Contractor Self-Reported Barriers to Selling HVAC Maintenance Services

Barriers	Maintenance Contractors	
	Residential	Small Commercial
Sample Size (multiple response)	*109*	*110*
Customers know benefits of maintenance, but do not want to pay extra for it without evidence of how much money they can save	58%	52%
Customers know benefits of maintenance, but do not want to pay extra money for it	52%	64%
Technicians need more soft skills training, such as communications, to sell maintenance	39%	39%
Customers do not know maintenance can improve performance and longevity of HVAC	37%	37%
Customers do not know that maintenance can reduce their electric bills	36%	38%
Equipment warranties make customers less willing to have maintenance of HVAC units	27%	18%
Technicians need more technical training to be able to perform maintenance	14%	17%
Customers cannot afford/do not want to pay for it	4%	3%
No barriers, all customers have maintenance performed on HVAC systems regularly	6%	11%

Frequency of Maintenance and Service

The incidence of regularly scheduled maintenance of HVAC systems is fairly low among residential customers and moderate among small commercial customers. Reflecting customers' propensity to call HVAC contractors only when their systems need repairs, once service calls for repairs are excluded, 24% of residential customers and 58% of small commercial customers said they have maintenance done on their HVAC systems at least once a year. One-third (33%) of residential customers and one-quarter (25%) of small commercial customers said they never have maintenance done, except for repairs.[10]

Table 17. Customer-Reported Frequency of Cooling Equipment Maintenance

Frequency	Residential Customers	Small Commercial Customers
Sample Size	*297*	*300*
Once a year or more frequently	24%	58%
Once every two years or less frequently	33	13
Never	33	25
Don't know/Refused	2	4
Installed Central AC within last 2 years [Ψ]	8	n/a

[Ψ] These survey respondents were not asked questions regarding maintenance frequency because they had recently installed a central AC. Their responses are included so as to provide percentages based on the total sample of customers.

The contractor surveys had a slightly different approach to estimating maintenance frequency. Sixty-four percent of residential maintenance contractors and 79% of small commercial maintenance contractors said they market maintenance contracts. Excluding the contractors who do not market contracts, 27% of residential contractors and 41% of small commercial contractors said that almost all of their maintenance customers renew their contracts each year.

Quality Maintenance Field Assessments

In general, the quality maintenance field assessments determined that the performance metrics among

[10] These statistics are based on customer responses. It may be that customers are receiving some regular maintenance services when their systems are being repaired, but are not aware of this.

non-program systems were consistent with and validated the QM program assumptions of sub-optimal performance.

- **Duct Leakage.** The field assessments found that residential system total duct leakage relative to nominal flow (23% for heating and 20% for cooling) is fairly close to the QM program baseline assumption of 24%. Leakage to the outside relative to the measured airflow (27% for heating and 32% for cooling) is slightly higher than the baseline.
- **System Airflow.** The residential (331 CFM per ton for cooling) and commercial (359 CFM per ton for cooling) system airflows were not significantly different from the QM program baseline of 350 CFM per ton. These values are all well below the QM program requirements.

Table 18. QM Field Observations and Assumptions for Program Baseline and Efficient Case*

Statistic	Field Observations (mean)	QM Program Baseline Assumptions	QM Efficient Case Assumptions
Total System Duct Leakage (using nominal heating airflow)	23%	24%	12%
Total System Duct Leakage (using nominal cooling airflow)	20%	24%	12%
Residential System Airflow in Cooling Mode (CFM per ton)	331	350	400
Commercial System Airflow (CFM per ton)	359	350	400

* Based on on-sites at a sample of 50 non-participant existing residential homes and 30 non-participant small commercial establishments (Table 1).

As noted for QI field assessments, verifications of refrigerant charge were considered indeterminate.

Field Observations of Technicians

Field observations of technicians conducting maintenance calls on a system with intentionally implemented faults yielded particularly important quality maintenance insights, and also served as a reminder that self-reports by contractors are not always accurate. Overall, the typical "maintenance" services provided were 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 basic maintenance tasks, but few performed the tasks correctly. Performance level was not related to the technician's certifications, training, years on the job, or participation in utility programs. Some of the most important tasks for energy-efficient operation were frequently not even attempted. There was, in fact, a disconnect between contractors' stated practices and technicians' practices in the field.
- Post-observation interviews indicated that observed 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.

Market Squeeze on Programs

In interviews for this study, IOU program staff referenced a "race to the bottom" in the market for HVAC service and installation. They thought that because customers are generally not experienced in identifying points of contrast between the work products of different HVAC maintenance contractors, the market tends to favor contractors who do the job the fastest and for the least amount of money, without regard for quality of work. The IOU QI and QM programs attempt to address this issue and seek to transform the market for HVAC installation and maintenance in such a way as to force poor-quality contractors to

adopt QM/QI practices in order to compete, and to reduce price pressure on contractors who want to do the best job possible. That said, the QI and QM programs may be caught between the pincers of a demand-side and supply-side squeeze. On the demand side, as noted previously, contractors reported that the primary barrier to both QI and QM was customer reluctance to pay for it. On the supply side, this study uncovered estimates of large numbers of unlicensed HVAC contractors operating in the state. According to the California Contractors State License Board (CLSB), there are between 15,000 and 19,000 HVAC contractors operating in California. However, the CLSB estimates that as many as one-quarter of these may be unlicensed contractors. The presence of so many unlicensed contractors who do not pull the necessary building permits for HVAC installations or who perform low-cost, sub-standard installation and maintenance jobs places additional cost pressure on licensed contractors, weakening adherence to QI and QM and constraining the ability of the programs to gain traction in the marketplace.

Conclusions and Recommendations

Program Design and Operation

The findings from this study led to the following recommendations pertaining to the design and operation of the HVAC subprograms.

- Focus on educating customers about the value of QI and QM. *Quality* is a generic term; many contractors will claim that they provide "quality" services. Customers need to be educated about the specifics (in lay terms) of QI and QM and the resulting energy savings. Customer education may also encourage the scheduling of regular maintenance visits, and also target those who are changing out HVAC systems such as through major renovations as well as those who are building or buying new homes.
- Collaborate with industry leaders to train contractors so that they have their NATE certifications in place. Industry leaders may also help promote IOU program qualification requiring more stringent ACCA/ASHRAE/ENERGY STAR standards to contractors, and educate customers about the value of QI and QM program-qualified contractors.
- Step up efforts to have contractors participate in the IOU training programs. Agreeing on a common definition across IOUs of qualification requirements is a first step. Without this, it will be difficult to sell the value of "program-qualified contractors" to contractors and consumers.
- Seek to increase the market share of more efficient systems by educating customers about the energy savings and other benefits associated with more efficient HVAC systems and the rebates available. As with the first recommendation above, effective strategies and messages should be explored with customer focus groups or surveys prior to launch.
- Specific recommendations from the field assessments include the following:
  - Continue to promote the use of software to perform system sizing calculations to reduce oversizing.
  - Research approaches to measuring refrigerant charge and develop diagnostics that are more reliable for maintenance.
  - Perform duct sealing as the primary residential maintenance measure.
  - Research approaches to repairing or replacing commercial economizers, reducing rooftop unit leakage (unit and economizers), and optimizing fan efficiency.

Research and Tracking

The following recommendations pertain to research and tracking of program indicators:

- Periodically assess the market transformation indicators and secondary indicators suggested by this study through contractor and customer interviews and on-site assessments of HVAC installations and maintenance.
- Develop more secondary indicators that can be measured through field assessments. Examples are increasing the number of systems properly sized within one-half ton of design load, increasing fan airflow (CFM per ton) and efficiency (Watts per CFM), reducing duct leakage to the outside in existing ducts, and reducing the number of new ducts in conditioned space. These indicators could be assessed through on-site assessments every four years.
- The on-site observations of maintenance work on a system with intentionally implemented faults provided invaluable information about the state of maintenance services available to most customers and should be repeated regularly.
- Further focus group research may be required to assess the extent to which customers (and contractors) are able to differentiate *Quality Installation* and *Quality Maintenance* from the generic term *quality,* to which all contractors would lay claim. This research could explore alternative terms and messaging to identify those to which customers are most responsive.
- Continue to study differences in the performance of installed or maintained HVAC units between HVAC contractors who participate in IOU programs and/or are NATE certified, and HVAC contractors who do not participate in IOU programs and/or are not NATE certified. These differences should get smaller to the extent that the HVAC market is being transformed, but are likely to remain significant for at least the next several years.
- Gauge the magnitude of the problem of competition from unlicensed contractors posing a major barrier to effective implementation of QI and QM. It may be worthwhile to work with the California State Licensing Board on this issue and solicit detailed feedback from contractors.

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