Implementation Guide

HVAC Quality Installation and Quality Maintenance

Prepared by: Kara Jonas

September 2018

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

Table of Contents

Introduction

The purpose of this Implementation Guide is to provide utilities and implementation contractors with the resources and information needed to integrate HVAC quality installation (QI) and quality maintenance (QM) practices into their existing efficiency program offerings. Quality installation focuses on following specific installation standards defined by manufacturer's specifications so that heating and cooling equipment is installed as intended. Quality maintenance focuses on commissioning previously installed existing equipment to improve operating performance. This guide showcases a scalable implementation model that has had great success in the Midwest.

Space conditioning accounts for nearly half of all the energy consumed in residential buildings and has long been the target of residential energy efficiency programs.[1] In order to reduce this substantial load, many energy efficiency programs offer end-users incentives for replacing old, inefficient heating and cooling equipment with high-efficiency equipment. These types of programs typically focus on the AFUE and SEER ratings for natural gas furnaces and central air conditioners, requiring minimum efficiency ratings for homeowners to be eligible to receive a rebate.

With rising HVAC efficiency baselines—and therefore savings becoming more difficult to capture—utilities must look to other sources to claim cost-effective savings. There is substantial evidence that the potential energy savings resulting from higher efficiency equipment is not being fully realized in the field for a variety of reasons, including the skill of the installation contractor and the lack of in-field visibility on installed performance. In fact, studies have shown that up to 30% of energy (BTUs) can be lost through the improper design, selection and installation of HVAC equipment. Fortunately, through QI and QM training, coupled with verification through performance testing, additional energy savings can be achieved.

A properly matched system, meaning equipment is chosen with thought as to how the system will work as a single, holistic unit for heating and cooling, and properly sized installation that has been measured, adjusted and verified through the commissioning process should be capable of operating near the nameplate rated capacity and efficiency performance. However, if an installation is not properly sized, matched with existing ductwork or fully commissioned it will under-perform in both capacity and efficiency.

About HVAC SAVE

MEEA has vast experience in this space through the implementation of the HVAC System Adjustment and Verified Efficiency (SAVE) program. HVAC SAVE is a utility-funded program that provides contractors with the tools and resources needed provide superior installation and maintenance services to customers for furnaces, air conditioners and heat pumps. The HVAC SAVE program began in 2010 and has been supported and implemented using a variety of program designs and incentive structures by multiple utilities across the Midwest. To date, there have been over 130,000 verified quality installations and over 2,500 contractors trained through

[1] U.S. Energy Information Administration. 2009 Residential Energy Consumption Survey.

this program. Quality installation programs augment the traditional installation process and the traditional clean and check service tiers to offer incremental efficiency opportunities.

The HVAC SAVE program was developed using the Air Conditioning Contractors of America's (ACCA) standards, which are recognized and approved by the American National Standards Institute (ANSI). These well-established standards have been accepted by utilities, government agencies and manufacturers nationwide and are available for download at www.acca.org.

While the energy efficiency industry uses these specifications as HVAC program guidance, a program's designs may vary depending on the entity's specific goals. With utilities needing to adhere to certain cost-effectiveness criteria depending on their specific regulatory body, it may not be feasible for some programs to integrate every component that is presented in ACCA specifications. Additionally, some utilities may be particularly sensitive to contractor's needs in the field, and following all of the specifications outlined through ACCA may be seen as burdensome to smaller businesses. Further, program administrators may wish to modify an existing program, such as adding HVAC QI practices to a home performance program. It is recommended that any QI and/or QM program leverage ACCA standards as guidelines, but administrators should analyze and carefully consider which specifications they can integrate into their portfolios.

The specific ACCA standards that are also required by the HVAC SAVE program are:

- Measuring airflow to ensure it is within acceptable CFM ranges
- Ensuring room airflows meet the design and application requirements
- Ensuring proper refrigerant charges

Certain standards outlined by ACCA are not required by the HVAC SAVE program, though some contractors who participate may still perform some or all of the standards independently. HVAC SAVE does not require contractors to:

- Calculate building ventilation requirements
- Perform heat loss and heat gain load calculations
- Submit a manual J calculation
- Verify that all heating and cooling equipment are properly matched systems
- Measure and verify waterflow
- Confirm all electrical requirements are met, as related to the installed equipment
- Ensure the equipment combustion is "on-rate" for gas-fired or oil-fired equipment and is at the equipment nameplate value
- Ensure proper sizing, design, material selection and assembly of the combustion gas venting system

Duct sealing is also not required, though some contractors do perform distribution improvements that can be captured through the program.

Found in this guidebook are resources and information regarding the benefits of incorporating QI and QM standards into an existing program, guidance on energy savings and getting measures into a Midwest Technical Resource Manual (TRM), training curriculum recommendations, recommended incentive models and how to achieve contractor buy-in and lessons learned.

Why Quality Installation and Quality Maintenance?

Rising Equipment Standards

The U.S. Department of Energy issued a Federal Register notice of proposed rulemaking to raise the minimum annual fuel utilization efficiency (AFUE) of installed furnaces from its current level of 80% to 92% starting in January 2021 for equipment producing more than 55,000 Btu/h.[2] It's important to note that although this is a substantial increase, the furnace efficiency standard has only raised 2% in the last 31 years. Although there is a chance that the rule may not be finalized or may be modified, utilities must anticipate all possible scenarios. A change in AFUE requirements will impact their energy efficiency portfolios as well as the overall cost effectiveness of individual measures. The potential new standard will impact furnace baseline assumptions, ultimately lessening the savings potential available to utilities from traditional programs that incent moving customers from a less efficient, non-condensing furnace to a higher efficiency unit.

Also on the horizon are rising central air conditioner standards set forth by the U.S. Department of Energy, with the AC standard set to rise to from 13 to 14 SEER in the northern region in 2023. This change is not expected to be modified before the effective date. Also in 2023, a new efficiency test method will take effect that increases the assumed external static pressure conditions (in order to be more representative of actual field performance). This change in baseline assumptions will ultimately reduce the level of potential electrical savings available to utilities through traditional equipment incentives.

One option that utilities will have to claim additional savings for a furnace and/or AC changeout is to capture the significant incremental savings that are achieved through a QI/QM program and mitigate the losses that occur as a result of improper HVAC system installation.

Non-Energy Benefits

QI and QM practices bring with them several non-energy benefits, including workforce development. Contractors who are trained on proper installation techniques can differentiate themselves from other contractors by performing higher quality work and can use that as a selling point with new potential customers. Having a verification component that calculates equipment operating performance allows them to quantitatively support the claim that their installations and maintenance are superior and align with manufacturer's specifications. Program support from a utility reinforces the sales message from the contractor, as utilities are seen as credible sources of information.

Another added benefit of QI and QM programs are the resulting decrease in warranty claims in the long-term. Equipment that is installed, measured and verified to have optimal levels of static pressure, airflow and temperature, alleviates unnecessary strain on the equipment while

[2] An Update on 2016 Regulations. January 2017. Accessed at https://www.achrnews.com/articles/134293-an-update-on-2016-regulations.

operating, therefore extending its overall life. This can lead to greater customer satisfaction with manufacturers and contractors alike. Additionally, homeowners save money in the long term on costly services and repairs.

Homeowners who opt to have their equipment installed or adjusted by a contractor that has been trained in QI/QM practices enjoy more comfortable home. Since the equipment is performing optimally, it has an easier time maintaining temperatures, thus improving customer satisfaction. Additionally, since the equipment is operating to its fullest potential, homeowners benefit from a decrease in their energy usage, enabling them to save money on their utility bills overtime.

Market Transformation

ACEEE defines market transformation as "the strategic process of intervening in a market to create lasting change in market behavior."[3] Intervening in how HVAC contractors install and calibrate HVAC equipment creates a lasting effect on a local market. Given that HVAC contractors often learn best practices and techniques from one another, new contractors are introduced to QI/QM practices as they enter the market. The more installers and technicians that are trained, the more installers and technicians this approach encompasses, ultimately driving the market forward and raising the baseline for standard installation practices in that particular market.

How to Implement a QI/QM Program

The specific steps that are required to implement a QI/QM program include:

- Establishing a means to capture and calculate savings
- Developing a training curriculum, or identifying a previously developed training and offering courses to HVAC contractors within the territory
- Establishing a program design, such as offering contractors incentives for QI/QM jobs or requiring QI/QM to be performed on all rebated equipment
- Establishing a means to verify that equipment is performing optimally and that the QI/QM practices were applied for each job
- Establishing a Quality Assurance, Quality Control (QA/QC) protocol and working to ensure contractor needs and resources are available

Each of these steps are detailed in the remainder of this document, leveraging MEEA's experience implementing the HVAC SAVE program and relaying how each implementation step was applied to result in over 130,000 quality installations.

Getting Measures into a Technical Reference Manual

Technical Reference Manuals (TRMs) are reference guides that offer prescriptive savings equations or deemed savings values that can be used by utilities and implementers running energy efficiency programs to calculate the energy savings associated with an energy

[3] Market Transformation. Retrieved from https://aceee.org/portal/market-transformation.

efficiency measure. TRMs enable program administrators to calculate energy efficiency savings as accurately as possible. They also ensure consistent program evaluation across utilities and other program operators within a state. The measures found within TRMs are extremely useful for utility forecasting and planning purposes.[4]

Helpful Resources

MEEA recently created a Midwest TRM Inventory in an effort to catalog existing TRMs within the Midwest. It includes a review of TRM purposes, development, update processes and applications in Midwest states. Two Midwest state TRMs even include guidance on how to calculate savings from a QI/QM program.

Adding a QI and/or QM measure into the TRM is not crucial to incentivizing these practices through a program, however, it does make achieving buy-in much easier, particularly if a third-party impact evaluation has not been conducted on a particular program. Many studies and resources have been developed which outline the energy savings potential associated with QI and QM practices, providing much-needed guidance when incorporating QI/QM programs into a TRM. Many of these resources can be found within the accompanying toolkit.

TRM Schedules

A crucial consideration when submitting a TRM measure is the timeline followed during TRM updates, which vary by state. Most TRM updates occur annually, but at times they are updated outside of the regular cycle to adjust values based on completed impact evaluations. Illinois, Michigan and Minnesota update their TRMs annually. Wisconsin implements a two-step update process. First, a deemed savings report is published. Then, a full TRM including deemed savings updates is published. For some TRMs, the update cycle isn't as clear. Ohio and Indiana, for example, do not have clear update cycles due to the uncertainty of available funding. A regular update cycle makes it easier for new measures to be added to the TRM and for deemed savings calculations to be updated based on completed studies and/or evaluations.

Stakeholder Involvement

Another important aspect of getting a new measure into a TRM is for program advocates to get involved as stakeholders. Some states, such as Michigan, Minnesota and Illinois, allow for an open stakeholder process, which provides an opportunity for individuals to suggest emerging products and measures for consideration in the TRM and future programs. Iowa recently completed the state's first TRM and adheres to an open stakeholder process. Currently, there is both an established oversight committee along with a technical committee that has assisted in the development of the manual.

However, not all states have an open process. In Wisconsin, for instance, the TRM is considered an internal document, so unfortunately, external stakeholder input is not voiced.

In those states that do allow for stakeholder input and involvement in the development of their TRMs, typically once the appropriate stakeholders have been identified, a work plan will be created to steer the development. A key component of the plan and ultimate credibility of the

---

[4] Midwest TRM Inventory. February 2017. Accessed at http://www.mwalliance.org/sites/default/files/media/Midwest-TRM-Inventory-Feb2017.pdf?current=/taxonomy/term/11

TRM is the accuracy of the sources used to derive the data and calculations. Therefore, when trying to submit an HVAC QI and/or QM measure, it is important to be armed with resources and data to justify the proposed savings levels. Once a savings algorithm has been established and justified, it can be submitted to the oversight committee for review and approval. Typically, all adjusted or introduced measures go through a review period where other stakeholders can comment or dispute the algorithms.

Savings Algorithms and De-Rating

MEEA has successfully submitted QI measures to TRMs in Iowa and Illinois. For the gas measures in both versions, the accepted measures use a 6.4% derating factor for natural gas furnaces that do not receive an HVAC SAVE quality installation performed. This savings algorithm is supported by a study that was prepared for the US DOE's Building America program by the Partnership for Advanced Residential Retrofit (PARR) titled "Improving Gas Furnace Performance: A Field and Laboratory Study at End of Life." PARR collected on-site performance data from Iowa homes. These furnaces were transported to the Gas Technology Institute's (GTI) labs where steady state efficiency testing was performed, providing the as-found performance data, and then were tested the tuned-up conditions typical of the HVAC SAVE program. The delta between the two efficiencies was 6.4%.[5] In the Iowa TRM, the accepted measure for central air conditioners uses a 10.5% derating factor for units that do not receive an HVAC SAVE QI. This percentage came from a 2005 Cadmus report titled "Energy Savings Impact of Improving the Installation of Residential Central Air Conditioners." Other accepted electric measures in the Iowa TRM de-rated equipment that is not installed using HVAC SAVE quality installation practices, with the heating performance of air source heat pumps and geothermal source heat pumps de-rated by 11.8%, and the cooling performance de-rated by 10.5%. Although electric quality installation measures have not yet been submitted and accepted in the Illinois TRM, they are expected to be included in the next version. Sample approved TRM algorithms can be found in the appendix and can be used as starting points for others to establish a savings algorithm.

A benefit to algorithms using the de-rating approach is that it does not put previously claimed savings at risk, since it can be assumed that the established baseline assumptions were not installed using HVAC SAVE quality installation principles. Therefore, these de-rating factors that are applied to both the baseline measures and the newly installed equipment are actually cancelled out, resulting in additional savings claimed for new equipment that is installed following HVAC SAVE quality installation principles rather than a loss of savings if equipment is not installed using quality installation principles. Each instance that a utility claims savings for an HVAC equipment upgrade without realizing the savings of an accompanied quality installation, energy savings are being left on the table.

Though having deemed or prescriptive savings equations outlined in a TRM is useful, it is not required. If a state does not have or use a TRM or it is not possible to introduce a new measure to a TRM, savings can still be claimed by utilities as long as data supporting this claim is accepted by the regulatory body. For examples of research supporting energy savings associated with

[5] Brand, L., Yee, S., and Baker, J. February 2015. Improving Gas Furnace Performance: A Field and Laboratory Study at End of Life. Accessed at: https://www.nrel.gov/docs/fy15osti/63702.pdf

quality installation practices, see the associated Residential HVAC Quality Installation and Quality Maintenance Toolkit.

Impact Evaluations

One of the most effective ways to justify energy savings associated with a measure is to have an impact evaluation performed. According to the State and Local Energy Efficiency (SEE) Action Network, an impact evaluation is defined as "assessments that determine and document the direct and indirect benefits of an energy efficiency program."[6] Impact evaluations often assess not only the energy and demand savings associated with a portfolio, program or measure, but also the non-energy benefits. They also contain important cost-effectiveness calculations.

Unfortunately, having impact evaluations performed for HVAC quality installation and quality maintenance programs can be costly. One hurdle evaluators face is attributing the energy savings to the installation itself, since there are other potential factors, such as proper sizing of the equipment and environmental factors, that can contribute to the overall performance of the HVAC equipment. MidAmerican Energy Company recently had an impact (and process) evaluation performed by Tetra Tech for their residential equipment programs and their residential HVAC tune-up program. The evaluation ultimately supported the approach taken by the Iowa TRM for the HVAC SAVE quality installation measure.[7] However, for the HVAC SAVE quality maintenance measure, the evaluation pointed out that though the Iowa TRM does include a measure for the HVAC SAVE test protocol, it does not capture savings associated with ductwork improvements. Additionally, since the associated measure life is one year, it does not account for the lasting effects of ductwork airflow improvements. This evaluation recommends an algorithm be developed to capture the specific results of residential HVAC SAVE tests and to incorporate the effect of duct improvements.[8] An impact evaluation is also currently being performed for Commonwealth Edison (ComEd), who recently launched an HVAC SAVE pilot program.

Training and Certification

One of the most important components of a successful QI and/or QM program is the contractor training. Initially, MEEA's HVAC SAVE training was a two-day training that covered the fundamentals of HVAC performance testing. However, based on sponsor utility and contractor feedback, the training was condensed into a single day.

The $600 HVAC SAVE course trains contractors on both proper installation techniques and ways to determine the installed efficiency of the HVAC systems, directly addressing the critical need for quantifying and optimizing how systems deliver heating and cooling. Contractors are educated on all necessary testing skills, reference tables and charts, formulas and engineering data to perform a comprehensive system performance rating report after the training. The fundamental principles taught in HVAC SAVE include:

---

[6] State and Local Energy Efficiency Action Network. December, 2012. Energy Efficiency Program Impact Evaluation Guide. Accessed at https://www4.eere.energy.gov/seeaction/system/files/documents/emv_ee_program_impact_guide_0.pdf
[7] Tetra Tech. July, 2017. Residential Equipment Program Impact and Process Evaluation (Iowa). Accessed at https://efs.iowa.gov/cs/groups/external/documents/docket/mdax/njqz/~edisp/1643815.pdf
[8] Tetra Tech. July, 2017. Residential HVAC Tune-up Program Impact and Process Evaluation. Accessed at https://efs.iowa.gov/cs/groups/external/documents/docket/mdax/njqz/~edisp/1643814.pdf

- Measurement and interpretation of static pressure
- Identification and plotting of airflow
- Airflow and temperature measurements
- Diagnostics
- Pressure measurements and duct design
- Equipment replacement
- Verifying final performance compared to manufacturer published potential performance

The training prepares contractors to implement HVAC QI/QM practices for new and existing systems and enables participants to measure the installed operating efficiency of almost any residential or light commercial heating or cooling system.

Certification & Renewal

After students attend the training, they must successfully complete and pass a quiz that goes through the fundamental principles taught in class. Upon successful completion of the quiz, the students are issued an HVAC SAVE certification that is good for two-years and access to the software, that does much of the calculations for the contractors and generates the HVAC SAVE score.

Once the two-year mark approaches, students are provided the opportunity to recertify. In order to be eligible to recertify, the student must be in good-standing with the program and be considered an active participant, which is defined as having completed at least four equipment tests within the previous 12 months. This provides assurance that students recall the testing fundamentals. If students are eligible to recertify, they are sent a short recertification quiz that can be completed online to verify retention of program concepts. If they are ineligible, students must complete to a one-day HVAC SAVE course in order to obtain their certification.

Instruction

MEEA's HVAC SAVE course is taught in a classroom setting and contractors are provided with a course workbook that is theirs to keep. However, for some contractors, this single-day classroom training may not be sufficient for applying the principles in the field. MEEA has historically, based on needs recognized by contractors and/or sponsor utilities, offered a small-group, hands on training opportunity as well. This enables contractors to take the principles taught in the classroom and apply them in a field setting with the direction and supervision of an instructor. This is particularly important for pilot programs or new programs where the concepts may be foreign in that market.

To become an instructor, HVAC SAVE uses a "train the trainer" approach. The trainer is required to be a seasoned HVAC training and support professional currently employed by an HVAC training company or manufacturer/wholesaler. From there, becoming a trainer includes an on-boarding process where trainers run through the program, move into the field and process a handful efficiency tests on their own and finally review their work and materials directly with MEEA.

Technical Assistance

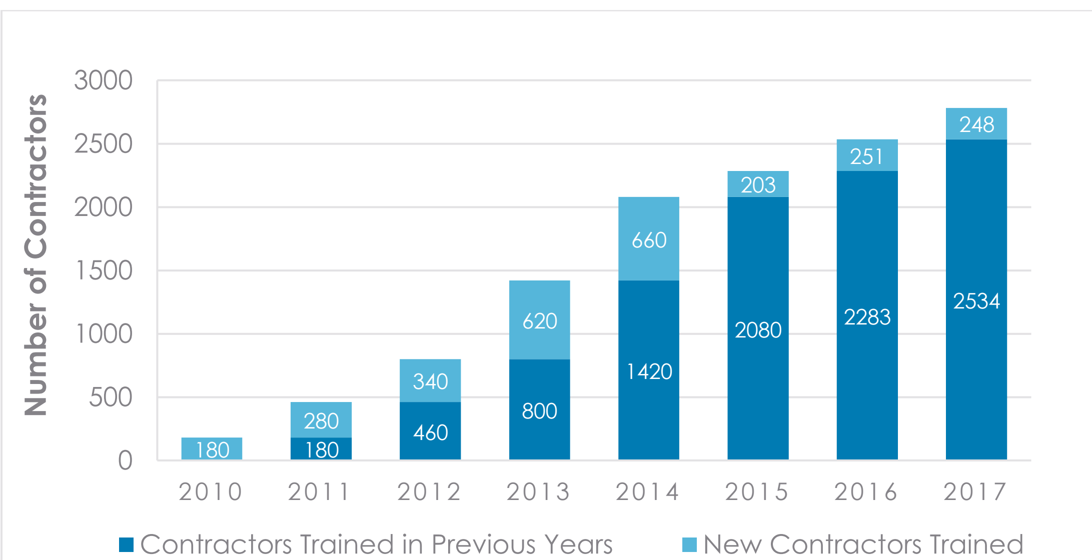
After students become HVAC SAVE certified and begin to apply the principles in the field, they may face hurdles specific to a particular piece of equipment or simply need a refresher. The HVAC SAVE program has remote technical assistance available to contractors. If faced with a technical challenge or issue, they can call a toll-free number and be provided with expert assistance to walk them through, step-by-step, what needs to be done for that particular piece of equipment. This type of remote mentorship is recommended for any entity seeking to offer a quality installation and/or quality maintenance program to ensure continuous program participation.

Many distributors see the value in the program and have held HVAC SAVE trainings at their facilities and see the trainings as a substantial additive for their customers. The distributors realize with proper installation of the equipment as well as increased diagnostic knowledge via testing, service calls to the distributor decrease. Additionally, it is conceivable that their equipment life will be extended since the equipment is being installed properly and therefore operating as the manufacturer has intended, potentially resulting in a decrease of warranty claims. One thing that makes the training more marketable is that both the course and all instructors are approved for continuing education credits through Building Performance Institute (BPI), North American Technician Excellence (NATE) and the Iowa Plumbing and Mechanical Systems Board (PMSB). The target audience for the course are HVAC technicians, installers, designers and business owners.

Number of Contractors Trained

Since the program launched in 2010, HVAC SAVE has trained 2,334 contractors in Iowa and 448 outside the state. The graph below shows the number of contractors who have received an HVAC SAVE certification since the program's inception.

Figure 1: Contractors Trained by HVAC SAVE, 2010 – 2017



There are many other national examples of HVAC quality installation courses available. Many manufacturers, such as Carrier and Johnson Controls, offer trainings both in-person and online.

Local distributors often offer installation trainings to their customers. ACCA also offers trainings of their established quality installation standard. Additionally, there are national training organizations that have course offerings, such as the National Comfort Institute (NCI), Nexstar and others. Local community colleges often have trainings available as well. Therefore, when incorporating QI or QM practices into a program, it may not be necessary to develop a new curriculum, as a substantial amount of work in this space has already been conducted from various respected organizations in the industry.

Program Design

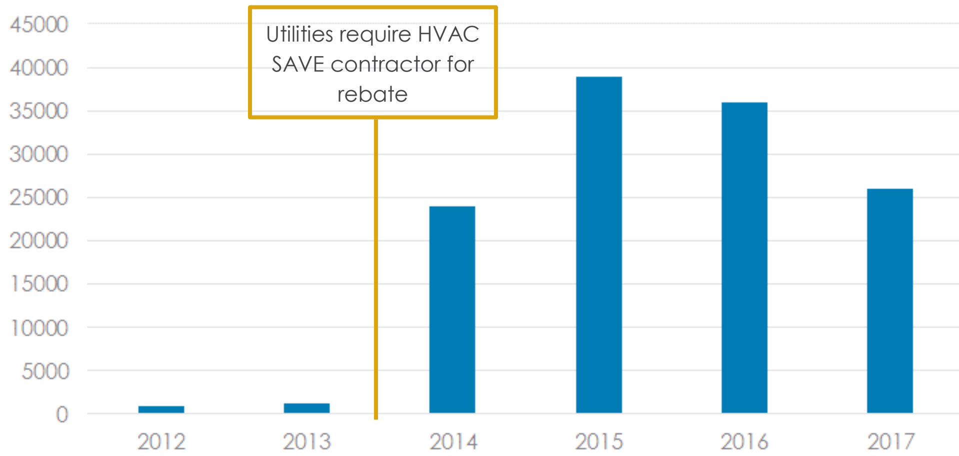
Iowa Model

Like any energy efficiency program, when implementing a QI and/or QM program, it is important to have an incentive model that is cost-effective yet drives program participation. The HVAC SAVE program launched in Iowa in 2010 and has since been supported and implemented, first on a voluntary basis and then as a requirement for rebate programs, throughout Iowa by three investor-owned utilities and one municipal utility. Initially, the Iowa utilities subsidized the HVAC SAVE training tuition and promoted the program, with contractors paying for their own software access to verify the installation. After three years of trainings, only a small portion of installations were being entered into the diagnostic software, which equates the field operating performance of HVAC equipment based on inputted data points related to pressures, airflows and temperatures. Based on the low software utilization, the utilities concluded that requiring contractors to pay for the software was the largest barrier to program participation. Therefore, the utilities purchased unlimited software access for their contractors. In turn, the contractors began paying the cost of the tuition for the training ($600).

Starting January 1, 2014, participating utilities required that in order for a customer to be eligible for an equipment rebate, the heating or cooling equipment must be installed and verified by an HVAC SAVE certified contractor. Alliant Energy, Cedar Falls Utilities and MidAmerican Energy added an additional requirement that the installation must undergo performance testing and achieve an HVAC SAVE score of 85 or higher for rebate eligibility. For maintenance of existing equipment, MidAmerican offers a performance tune-up rebate if the tune-up results in at least a 10-point improvement of the HVAC SAVE score for the equipment and/or a 12-point improvement for the ductwork.

Since the utilities began requiring HVAC SAVE testing and verification to receive rebates, the number of quality installations increased dramatically. This type of program design is recommended for entities hoping to see the largest amount of production. The below graph shows the number of quality installations by year:

Figure 3: Number of Quality Installations Submitted by Year



Utilities have, at times, paired the homeowner HVAC rebates, which range from $200 - $650 for central air conditioners and $500 - $700 for natural gas furnaces, with contractor bonus incentives and/or training reimbursements in order to drive program participation.

Illinois Model

As HVAC SAVE expands into Illinois, Commonwealth Edison and Nicor Gas have launched pilot and program initiatives following a volunteer-approach. The utilities heavily subsidize the HVAC SAVE training, pay for access to the verification software and offer contractor incentives for all jobs submitted through the HVAC SAVE software that meet the program requirements. However, the program is currently only available to a closed network of contractors.

The utilities offer contractor incentives for furnaces and central air conditioners for verified quality installations that meet their program efficiency requirements of a 95% or higher AFUE furnace and/or a 15 SEER or higher central air conditioner. Each utility is offering a $200 contractor rebate per quality installation. One of the utilities is offering a $100 quality maintenance rebate, which also is paid to the contractor. Initially, the quality maintenance rebate was set at $300, but has since been lowered as it may have been set too high initially. Additionally, homeowners are entitled to receive an equipment rebate from each utility, which range from $150 - $450 depending on the equipment type and efficiency rating.

One challenge associated with a volunteer-only program approach, even with the availability of the incentives, is getting contractors to participate. When the busy heating and cooling seasons strike, it is often difficult for contractors to find time to integrate a new practice into their business model. It can also be difficult to find the right audience for recruiting program participants. HVAC owners and service managers are a key audience to reach when marketing the training. Having program staff help them understand that although program participation will require additional field time by their contractors, the investment will be well worth it with savings associated with fewer callbacks, happy customers and a better product is a useful recruitment tactic. That said, the additional field time required for a contractor to perform a QI or QM will range from 1-1.5 to 2-3 hours, respectively, so providing a contractor incentive that is high enough to account for this extra work is essential to the success of the program.

Verification

A crucial component of any QI and QM program is to have a means of verification. This ensures that the resulting operational improvements of the contractor's work are measurable and quantifiable for each piece of equipment. Verification is also essential in justifying the additional energy savings associated with the incorporation of these practices.

For the HVAC SAVE program, MEEA ensures participating contractors have access to the HVAC SAVE software, which is web-based and allows contractors to input the various measures, including temperatures, pressures and airflow. Based on the inputted data, the software generates, in real time, an HVAC SAVE score which is commensurate to the current operating efficiency of a particular piece of equipment. The software also provides guidance to the contractor on what may need to be adjusted in order to improve the equipment's efficiency. When a less than desirable score is achieved, the contractor has the necessary information to take the next steps to raise the score and the operating efficiency. These scores are defined below.

Equation 1. Heating Equipment HVAC SAVE score

$$= \frac{CFM\ x\ Equipment\ Delta\ T\ x\ Equipment\ Density\ Correction\ Factor}{Installed\ Input\ x\ (Rated\ Output/Rated\ Input)}\ \mathrm{x}\ 100$$

Equation 2. Cooling Equipment HVAC SAVE score

$$= \frac{\boldsymbol{CFM\ x\ Equipment\ Delta\ H\ x\ Air\ Density\ Correction\ Factor}}{\boldsymbol{The\ OEM\ rated\ capacity}}\ \boldsymbol{x\ 100}$$

In addition to the Heating and Cooling Equipment HVAC SAVE Score, the HVAC SAVE program provides diagnostic data related to distribution system efficiency (typically a duct system). Distribution system metrics are important indicators of how well the HVAC system is performing as a whole. The heating distribution system HVAC SAVE score is defined below in Equation 3 and cooling distribution system HVAC SAVE score is defined below in Equation 4.

Equation 3. Heating System HVAC SAVE score

$$= \frac{CFM\ x\ System\ Delta\ T\ x\ Air\ Density\ Correction\ Factor}{Adjusted\ input\ x\ AFUE}\ \mathrm{x}\ 100$$

Equation 4. Cooling System HVAC SAVE score

$$= \frac{CFM\ x\ System\ Delta\ H\ x\ Air\ Density\ Correction\ Factor}{The\ OEM\ rated\ capacity}\ \mathrm{x}\ 100$$

The HVAC SAVE program methodology allows contractors to adjust the HVAC system as necessary based on their expert knowledge, as long as it achieves the goal efficiency score based on the ratio measured BTUs for the equipment or the system to the adjusted output. An example of an adjustment that may be made is installing the correct size filter rack.

Other Verification Tools

In addition to the HVAC SAVE methodology, a contractor may wish to utilize a third-party equipment or system efficiency verification software. NCI's ComfortMaxx™ software is an example, which allows contractors to input measurements and verify efficiency. CheckMe!® is another example, which is a product that analyzes the performance and detects possible faults at the equipment level. Many of these verification platforms can generate customer-facing reports that can be customized to a particular utility or program's branding. This is a learning opportunity for the customer and an add-on to the contractor's suite of services.

The US Department of Energy (DOE) recently released a matrix that outlines the various HVAC verification tools broken out by product type, which serves as a selection guide. This matrix goes beyond system analysis software, and features sensors, ACCA manual software and more.[9] Included in this matrix is the iManifold product, which is a wireless measurement tool that integrates with smart phones and delivers system performance calculations to contractors.

Some programs may wish to include a form of remote monitoring or continuous verification. Technology such as Emerson's Comfort Guard product can be integrated into programs to offer in-depth analysis on a system's performance over time and may contribute to the extension of the measure-life of equipment over time.

Quality Assurance and Quality Control

As with all good energy efficiency programs, quality assurance and quality control (QA/QC) is a crucial aspect to ensure proper installation practices and program guidelines are being followed. An HVAC QI/QM program is no different, and it is important that guidelines are established, communicated and followed throughout the life of the program.

For the HVAC SAVE program, MEEA enforces a tiered approach to QA/QC, which is defined as follows:

- Tier 1: File Review – Automated through the HVAC SAVE software – This review consists of the software generating a report for the contractor and utility administrator that qualifies the installation or flags potential problems. The contractor can download this report so they have the opportunity to rectify any potential problems before final submission to the utility. When problems are detected during the tier 1 file review and not fixed by the contractor, jobs are escalated to the tier 2 review.
- Tier 2: Context File Review – Involves a program administrator reviewing and evaluating the underlying numbers that have been inputted, which generate the performance score – This includes a verification of the manufacturer-defined specifications and confirmation of a logical interrelationship between each of the data inputs. If problems

[9] Accessed at https://rpsc.energy.gov/sites/default/files/publication/C-1587_HVAC%20Verification%20Tools%20_Selection%20Guide_FINAL.PDF

are found to continue during this review, the contractor is provided the opportunity to justify the underlying data inputs. If the identified problems are unresolvable, the job is escalated to a tier 3 verification.

- Tier 3: In-Field Verification – Involves a QA verifier to complete an additional performance test to verify the contractor's work – During the in-field verification, a verifier conducts a duplicate, but independent test on the HVAC system in question. If the verifier's data does not fall within the acceptable range of variance, the contractor will have the option to adjust and re-test the equipment.

The QA/QC occurs for the HVAC SAVE program at the following minimum frequency:

Figure 4: QA/QC Frequency Requirements

Tier 1: File Review	Tier 2: Context File Review	Tier 3: In-Field Verification
100% of all jobs	10% of all jobs	3% of all jobs

If an insufficient number of jobs are escalated to receive a tier 2 or 3 review, jobs are randomly selected. The HVAC SAVE program requires contractors to perform repairs and corrections that have been identified through any of the QA/QC tiers at no additional cost to the customer and as expeditiously as possible. They are also instructed to keep the designated utility administrator informed of the efforts being made to address the problem. Contractors who have repeated infractions of the policies and requirements of the HVAC SAVE program are subject to corrective action.

HVAC SAVE uses a three-strike corrective track program, which is outlined as follows:

- Strike 1 – Notification – Contractor is made aware of quality finding(s) and is issued a formal warning
- Strike 2 – Probation – Contractor, who has previously been made aware of a quality finding and issued a second formal warning, is now on a formal probation and is subject to additional QA review
- Strike 3 – Suspension/Expulsion – Contractor who continues to deviate from the HVAC SAVE program guidelines and has been given multiple opportunities to correct and/or improve is suspended for a certain amount of time or is removed from the program altogether

Violations meriting strikes include, but are not necessarily limited to: disparagement, fraud, false entries, incorrect/incomplete data and lack of good faith effort. The HVAC SAVE program reserves the right to take immediate action, forfeiting the tracks mentioned above, in the instance of egregious activity. Additionally, strikes may occur at either the individual contractor-level or at the firm-level if a pattern of activity is seen amongst multiple employees from one firm.

Achieving Contractor Buy-In

Contractors are crucial to energy efficiency programs, but particularly integral to QI and QM program delivery. This type of program requires contractors to verify their installation and maintenance practices and potentially modify longstanding methods. Therefore, achieving their buy-in is crucial.

Contractor Benefits

A bonus to the HVAC SAVE program is that it allows for a certain degree of flexibility. The program sets standards for the minimum operating efficiency of equipment while allowing the contractor to determine the best way to achieve that level of efficiency. Still, some contractors have voiced that the required testing is onerous. Others have expressed concerns about confusing homeowners who may be accustomed to a traditional equipment-efficiency rebate model. MEEA has been successful in ameliorating these concerns by gathering feedback from contractors through roundtable meetings. Incorporating contractor feedback has enabled contractors to feel a sense of inclusion and ownership in the HVAC SAVE program design. These types of meetings also provide an opportunity educate contractors on the benefits of incorporating QI/QM practices into their business models.

By ensuring HVAC equipment is performing optimally, HVAC SAVE contractors receive fewer customer complaints. Since the equipment is installed as intended, customers benefit from increased comfort, lower utility bills and can expect a longer overall life for their equipment. This leaves satisfied customers who are likely to recommend their HVAC contractors to others. Additionally, contractors can anticipate fewer warranty claims and returns to customer homes.

Another significant advantage to incorporating QI/QM practices is the opportunity for contractors to differentiate themselves from their competitors. Contractors also have a third party backing their overall installation or maintenance work, and they have quantifiable data to back up their performance.

For the HVAC SAVE program, certified contractors are listed on the HVAC SAVE website, and Iowa utilities use this site to connect homeowners with participating HVAC contractors. Contractors have leads generated for them by the utility and enjoy greater visibility with potential customers.

Contractors who incorporate QI/QM practices into their business offerings also gain the long-term benefit of improving the way future employees install and maintain equipment. Since many contractors receive training and best practices on the job from seasoned employees, the lessons of a QI/QM training will typically filter down to new employees through in-field mentorship.

Identified Barriers

There are numerous obstacles program administrators face to getting contractor buy-in. As previously mentioned, one obstacle contractors face is the additional field time required for testing and verification. This extra field time allows for companies to schedule approximately one quality installation and three quality maintenance jobs per day, and program administrators need to ensure the additional field time is communicated to owners, operators, dispatchers, schedulers and any personnel that may be impacted.

Another difficulty for contractors is the required administrative time associated with entering test data. Ideally, contractors enter test data while in the field to avoid having to later return to the home to make adjustments. Since the software that is used to enter the test data is web-based, contractors are encouraged to use a tablet or smartphone while in the field. The computer proficiency of installers and field technicians tends to vary, and some are not accustomed to navigating these types of devices. Therefore, it is recommended that regular training is offered, and that program support is readily available to assist contractors in getting the jobs submitted.

HVAC SAVE also requires contractors to take field measurements for central air conditioners when the external temperature is above 65 degrees Fahrenheit or higher. Therefore, many contractors are forced to return to the equipment during warmer months for installs that occur outside of the summer months, since the program is run in cooler climates. This can be burdensome to the contractors and can delay homeowner rebates. Program administrators can help by providing contractors talking points to explain the need to return to a home and the reason their incentive may be partially delayed. Additionally, administrators can allow for jobs installed in the previous calendar to be submitted well into the next year so that contractors have plenty of time to conduct the necessary testing.

Program administrators and utilities need to ensure they are leveraging and communicating the myriad of benefits of QI/QM measures to contractors. They also need to be transparent about the challenges contractors may face and be proactive in providing solutions to these challenges. After all, the program's success is contingent on contractor participation.

Summary

In summary, there are many models and avenues that can be taken when incorporating quality installation and quality maintenance into an HVAC program. Of highest consideration should be utility expectations, savings needs and what is realistic to ask of a contractor. Clear expectations and guidelines should be communicated to contractors and customers alike.

Necessary program elements for success include training, technical support, a strong contractor network, incentives, a method to calculate energy savings, a means for verification, and a strict Quality Assurance and Quality Control protocol. Taking this all-encompassing approach and utilizing an extensive runway and education timeline can help utilities claim additional savings to meet energy efficiency goals before equipment savings are diminished with increasing efficiency baselines.

Illinois

<u>Gas High Efficiency Furnace</u>

Natural Gas Savings

Time of sale:

ΔTherms = Gas_Furnace_Heating_Load * HF * ((1/(AFUE(base)*(1-Derating(base)))) – (1/(AFUE(eff)*(1-Derating(eff)))))

Early Replacement:

ΔTherms for remaining life of existing unit (1st 6 years):

= Gas_Furnace_Heating_Load * HF * ((1/(AFUE(exist)*(1-Derating(exist)))) – (1/(AFUE(eff)*(1-Derating(eff)))))

ΔTherms for remaining measure life (next 14 years):

= Gas_Furnace_Heating_Load * HF * ((1/(AFUE(base)*(1-Derating(base)))) – (1/(AFUE(eff)*(1-Derating(eff)))))

Where:

AFUE(exist) = Existing Furnace Annual Fuel Utilization Efficiency Rating

= Use actual AFUE rating where it is possible to measure or reasonably estimate.

If unknown, assume 64.4 AFUE% 294.

AFUE(base) = Baseline Furnace Annual Fuel Utilization Efficiency Rating

=Dependent on program type as listed below

Program Year	AFUE (base)
Time of Sale	80%
Early Replacement	90%

AFUE(eff) = Efficent Furnace Annual Fuel Utilization Efficiency Rating

= Actual. If unknown, assume 95%

Derating(base) =Baseline furnace AFUE derating

= 6.4%

Derating(eff) =Efficent furnace AFUE derating

=0% if verified quality installation is performed

=6.4% if verified quality installation is not performed299

Example

Time of sale:

For example, a 95% AFUE furnace purchased and installed with verified quality installation for an existing home near Rockford::

ΔTherms = 873 * ((1/(0.8*(1-6.4%))) – (1/(0.95*(1-0%))))

= 247 therms

For example, a 95% AFUE furnace purchased and installed without verified quality installation for an existing home near Rockford:

ΔTherms = 873 * ((1/(0.8*(1-6.4%))) – (1/(0.95*(1-6.4%))))

= 184 therms

Early replacement:

For example, an existing functioning furnace with unknown efficiency is replaced with an 95% furnace using quality installation in Rockford:

ΔTherms for remaining life of existing unit (1st 6 years):

= 873 * ((1/(0.644*(1-6.4%))) – (1/(0.95*(1-0%))))

= 529 therms

ΔTherms for remaining measure life (next 14 years):

= 873 * ((1/(0.9*(1-6.4%))) – (1/(0.95*(1-0%))))

=117 therms

Iowa

Central Air Conditioner

Electric Energy Savings

Time of sale:

For units with cooling capacities less than 65 kBtu/hr:

$$\Delta kWh = \left[\frac{EFLH_{cool} * Capacity_{Coolee} * \left(\frac{1}{(SEER_{base} * (1 - DeratingCool_{base}))} - \frac{1}{(SEER_{ee} * (1 - DeratingCool_{eff}))}\right)}{1000}\right]$$

For units with cooling capacities equal to or greater than 65 kBtu/hr:

$$\Delta kWh = \left[\frac{EFLH_{cool} * Capacity_{Coolee} * \left(\frac{1}{(IEER_{base} * (1 - DeratingCool_{base}))} - \frac{1}{(IEER_{ee} * (1 - DeratingCool_{eff}))}\right)}{1000}\right]$$

Early Replacement:

For units with cooling capacities less than 65 kBtu/hr:

ΔkWH for remaining life of existing unit (1st 6 years):

ΔkWH for remaining measure life (next 12 years):

$$\Delta kWh = \left[\frac{EFLH_{cool} * Capacity_{Coolee} * \left(\frac{1}{(SEER_{base} * (1 - DeratingCool_{base}))} - \frac{1}{(SEER_{ee} * (1 - DeratingCool_{eff}))}\right)}{1000}\right]$$

For units with cooling capacities equal to or greater than 65 kBtu/hr:

ΔkWH for remaining life of existing unit (1st 6 years):

$$\Delta kWh = \left[\frac{EFLH_{cool} * \left(Capacity_{Coolexist} * \frac{1}{(IEER_{exist} * (1 - DeratingCool_{base}))}\right) - \left(Capacity_{Coolee} * \frac{1}{(IEER_{ee} * (1 - DeratingCool_{eff}))}\right)}{1000}\right]$$

ΔkWH for remaining measure life (next 12 years):

$$\Delta kWh = \left[\frac{EFLH_{cool} * Capacity_{Coolee} * \left(\frac{1}{(IEER_{base} * (1 - DeratingCool_{base}))} - \frac{1}{(IEER_{ee} * (1 - DeratingCool_{eff}))}\right)}{1000}\right]$$

= Actual installed - If actual size unknown, assume 36,000

$Capacity_{Coolexist}$ = Cooling capacity of existing equipment in Btu/hr (note 1 ton = 12,000Btu/hr)

= Actual - If actual size unknown, assume same as new installed unit

SEERbase = Seasonal Energy Efficiency Ratio (SEER) of baseline unit (kBtu/kWh)

= 13[10]

SEERexist = Seasonal Energy Efficiency Ratio (SEER) of existing unit (kBtu/kWh)

= Use actual SEER rating where it is possible to measure or reasonably estimate. If unknown, assume:

Existing Cooling System	SEER exist[11]
Air Source Heat Pump	9.12
Central AC	8.60

SEERee = Seasonal Energy Efficiency Ratio (SEER) of efficient unit (kBtu/kWh)

= Actual installed or 15 if ENERGY STAR

$Derating_{eff}$ = Efficent Central Air Conditioner Cooling derating

= 0% if Quality installation is performed

= 10.5% if Quality installation is not performed[12]

$Derating_{base}$ = Baseline Central Air Conditioner Cooling derating

= 10.5%

IEERbase = Integrated Energy Efficiency Ratio (IEER) of baseline unit (kBtu/kWh)

= 11.4[13]

IEERexist = Integrated Energy Efficiency Ratio (IEER) of existing unit (kBtu/kWh)

= Use actual IEER rating where it is possible to measure, or reasonably estimate

IEERee = Integrated Energy Efficiency Ratio (IEER) of efficient unit (kBtu/kWh)

---

[10] Based on Minimum Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

[11] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren IL PY3-PY4 (2010-2012). The utilities should collect this information if possible to inform a future update.

[12] Based on Cadmus assumption in IPL TRM– results in a QI savings that is within a feasible range.

[13] Based on IECC 2012 requirements.

= Actual installed

Example

Time of sale:

For a 3-ton unit with SEER rating of 15, in unknown location with quality installation:

ΔkWH = (811 * 36,000 * (1/(13 * (1-10.5%)) – 1/(15 * (1-0%)))) / 1000

= 562.9 kWh

For a 3-ton unit with SEER rating of 15, in unknown location without quality installation:

ΔkWH = (811 * 36,000 * (1/(13 * (1-10.5%)) – 1/(15 * (1-10.5%)))) / 1000

= 334.6 kWh

Early replacement:

For a 3-ton unit, with SEER rating of 15 replacing an existing unit with quality installation with unknown efficiency in a single family home in Burlington, IA:

ΔkWH(for first 6 years) = (918 * 36,000 * (1/(10* (1-10.5%)) – 1/(15 * (1-0%)) / 1000

= 1,489.3 kWh

ΔkWH(for next 12 years) = (918 * 36,000 * (1/(13* (1-10.5%)) – 1/(15 * (1-0%)) / 1000

= 637.2 kWh

Therefore, record a savings adjustment of 43% (637.2/1489.3) after 6 years.