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# HVAC SAVE

## A Case Study in the Next Evolution of Residential Quality Installation Programs

*A Midwest Energy Efficiency Alliance White Paper*

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December 2015

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## 1. Executive Summary

At a time when most of the low hanging fruit of residential energy efficiency programs has been picked and savings are becoming harder to capture, HVAC Quality Installation (QI) programs show potential for increased savings. There is evidence that the potential energy savings resulting from higher efficiency equipment is not being fully realized in the field due to a variety of factors, including the skill of the installation contractor and the lack of in-field visibility on installed performance. HVAC System Adjustment & Verified Efficiency (SAVE) is a Verified Quality Installation/Quality Maintenance program that combines contractor training on quality installation practices and verification through performance testing. It is through this data-driven approach that market transformation of installation practices and additional energy savings can be achieved.

MEEA partnered with Energy Stewards International (ESI) to develop the HVAC SAVE program to train and certify HVAC contractors in the skills necessary to determine in-place efficiency of functioning HVAC systems. There are two main components to the HVAC SAVE program: contractor training and field performance testing. The goal of the combination of these two elements is to have the contractors take what they have learned in the classroom, apply it in the field by optimizing installed equipment, and then verify their installation through real time web-based diagnostic testing.

The impetus for the program in Iowa came from the Iowa regulators' interest in Quality Installation programs. While the utilities were familiar with QI programs, they were looking for a program that would produce the energy savings of a traditional QI program with a more flexible contractor process. The IOUs in Iowa decided to include HVAC SAVE in their 2014-18 Energy Efficiency plan filings and began their support of the HVAC SAVE program in 2010. Beginning January 1st, 2014, the participating utilities required that in order for a customer to be eligible for a rebate, the heating or cooling equipment must be installed by an HVAC SAVE certified contractor. The program has trained over 2,300 contractors since 2010 and has had over 40,000 Verified Quality Installations completed.

HVAC SAVE provides flexibility by allowing the contractor to determine the best way to improve the efficiency of the system, but then verifying that the approach they selected results in the expected energy savings for each installation. Without contractor participation in the HVAC SAVE program, the prevalence of Verified Quality Installations and increased energy savings would not be possible. Contractors often leave the training having experienced "a-ha" moments regarding the approach to making HVAC systems run more efficiently and appreciating the additional level of knowledge and performance data that is provided to them. In an industry where technical skills and processes are handed down from one technician to the next, the HVAC SAVE program is increasing the baseline level of Iowan HVAC contractors' technical skills.

## 2. Introduction

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]. These programs have relied on increasing heating and cooling equipment efficiency, weatherization measures, and homeowner education. These efforts, in addition to increasing consumer electronic plug load, have had the cumulative effect of reducing space conditioning's share of residential load from 53 percent in 1993 to 48 percent in 2009[2]. Despite these strides, there remains great opportunity for achievable energy savings from residential heating and cooling systems.

Traditional prescriptive residential energy efficiency programs provide rebates to end users for purchasing and installing incrementally more efficient equipment. This approach works because utilities can typically claim energy savings for the difference in energy consumption between an established baseline and the new equipment. For example, if in Iowa the Investor Owned Utilities (IOUs) provided rebates for consumers installing 95% Annual Fuel Utilization Efficiency (AFUE) furnaces using a 78% AFUE baseline, there would be claimed energy savings of 17% for each furnace installed.

While these programs benefit from this intuitive, straightforward approach, as these programs reach maturity, the available marginal energy savings are diminishing. Part of this has to do with higher baselines resulting from increasingly strict regulatory standards or market-wide adoption of more efficient equipment. In addition, as technology has improved, the cost of higher efficiency equipment is more affordable, creating the opportunities for increased free-ridership. At the same time, while new technology continues to become more efficient, it is doing so more slowly as large gains have already been made. Working together, these factors reduce the amount of energy savings that can be claimed from the traditional prescriptive approach.

One way to achieve additional energy savings is through traditional HVAC Quality Installation and Quality Maintenance (QI/QM) programs. These programs focus on following specific installation standards for quality so that heating and cooling equipment is installed as intended based on industry-accepted guidelines. The energy savings results from following procedures designed to ensure that new, efficient equipment is operating as it should. This approach is an improvement over prescriptive rebate programs because it incentivizes proper installation. Contractors following a QI/QM protocol are more likely to install equipment to standard and to achieve ex-ante operating efficiency and subsequent energy savings. The majority of QI/QM programs, however, do not verify the in-situ efficiency of the equipment, but instead project energy savings based on following normative laboratory procedures.

Some QI/QM programs focus on both the quality of the equipment installation as well as testing and verifying the performance of these installations. These programs combine an

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

emphasis on increased technical skill during installations with actual measured data of what the contractor has done and how that has affected the performance of the equipment by utilizing performance testing on each job, leading to Verified Quality Installations/Verified Quality Maintenance (VQI/VQM). Performance testing focuses on analyzing performance processes, commissioning, and equipment sizing, which yield higher than traditional levels of efficiency if implemented correctly.

HVAC System Adjustment & Verified Efficiency (SAVE) is one such VQI/VQM program that combines contractor training on quality installation practices with in-field measurement and verification through performance testing. It is through this data-driven approach that market transformation of installation practices and additional energy savings can be achieved.

## 3. Program Background

### 3.1 Iowa and MEEA's HVAC SAVE Program History

Iowa's HVAC SAVE program emerged from the notion that operating performance of heating and cooling equipment does not equate to out-of-the-box rated performance. Because these appliances can't simply be plugged into the wall and perform as designed, a contractor can deliver greater levels of efficiency by optimizing and verifying the performance of the installed equipment. The concept of an HVAC performance program was envisioned by the Midwest Energy Efficiency Alliance (MEEA) before the launch of the HVAC program in Iowa. As the key resource and champion for energy efficiency in the Midwest, MEEA helps a diverse range of stakeholders understand and implement cost-effective energy efficiency strategies that provide economic and environmental benefits.

Although federal, state, and utility programs have increased the market penetration of residential high efficiency furnaces, there is evidence that the potential energy savings resulting from higher efficiency equipment is not being fully realized in the field. Installed equipment operating efficiency is largely dependent on the efficiency rating of the equipment, the skill of the installation contractor, the degree to which the equipment has aged or drifted off its initial settings, and the system level constraints. This directly applies to furnaces, air conditioners, air source heat pumps, and ground source heat pumps. When one or more of the key dependencies are operating sub-optimally, the overall efficiency of the equipment is degraded. Some of these factors, such as air flow adjustments are simple to correct while others, such as fixes to the duct distribution system, require extensive renovation. Contractor training in diagnostics and repair is a critical success factor in optimum system performance and a vital component of a VQI/VQM program.

To address the challenges highlighted above, MEEA partnered with Energy Stewards International (ESI), a company that has years of experience in training HVAC professionals on how to use static pressures, system temperatures, and airflows to identify existing system deficiencies, allowing them to make targeted repairs or adjustments. Together, MEEA and ESI developed the HVAC SAVE program to train and certify HVAC contractors in the skills necessary to determine in-place efficiency of functioning HVAC systems. The HVAC SAVE program launched in Iowa in the fall of 2010 and has trained over 2,300 contractors throughout Iowa and Illinois on VQI and performance testing practices. This paper will provide an overview, analysis, and summation of best practices of the program as it has evolved since 2010 through the fall of 2015.

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There are two main components to the HVAC SAVE program: contractor training and field performance testing. The goal of the combination of these two elements is to have the contractors take what they have learned in the classroom, apply it in the field, and then verify their installations through testing. The specific principles taught in HVAC SAVE include: measurement and interpretation of static pressure, identification and plotting of airflow, airflow measurement, temperature measurement and diagnostics, pressure measurements and duct design, equipment replacement, and verifying final performance compared to manufacturer published potential performance. The one-day, nine-hour training prepares contractors to implement HVAC VQI/VQM 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. The objective of the HVAC SAVE program is to explore the energy savings potential of maximizing heating and cooling equipment and system performance by adjusting operating, installation, and distribution conditions.

The format of the training is a combination of classroom instruction using presentations, white-board diagrams, explanations, examples, case studies, and interactive workbook exercises to prepare contractors to integrate these concepts into their regular business activities. The training also educates and equips HVAC contractors with a software diagnostic tool that combines measurement and verification with commissioning principles. This software tool calculates efficiency at both the equipment and system level and issues a corresponding HVAC SAVE score for each level. The intent of the HVAC SAVE program is that contractors will apply the information they have learned in the classroom when they install equipment in the field, resulting in energy savings.

HVAC technicians, installers, designers, and business owners comprise the target audience for these HVAC SAVE trainings.  At the conclusion of the training, students take a certification exam. Upon successful completion of the exam, students receive the HVAC SAVE certification from MEEA, complete with a wall certificate and wallet identification card. The certification is on a per-student basis and stays with the individual. The certification is valid for two years and then the contractor must recertify in order to stay HVAC SAVE certified. Using these methods, MEEA has trained over 2,300 HVAC contractors across the states of Iowa and Illinois to date, as shown in Figure 1.

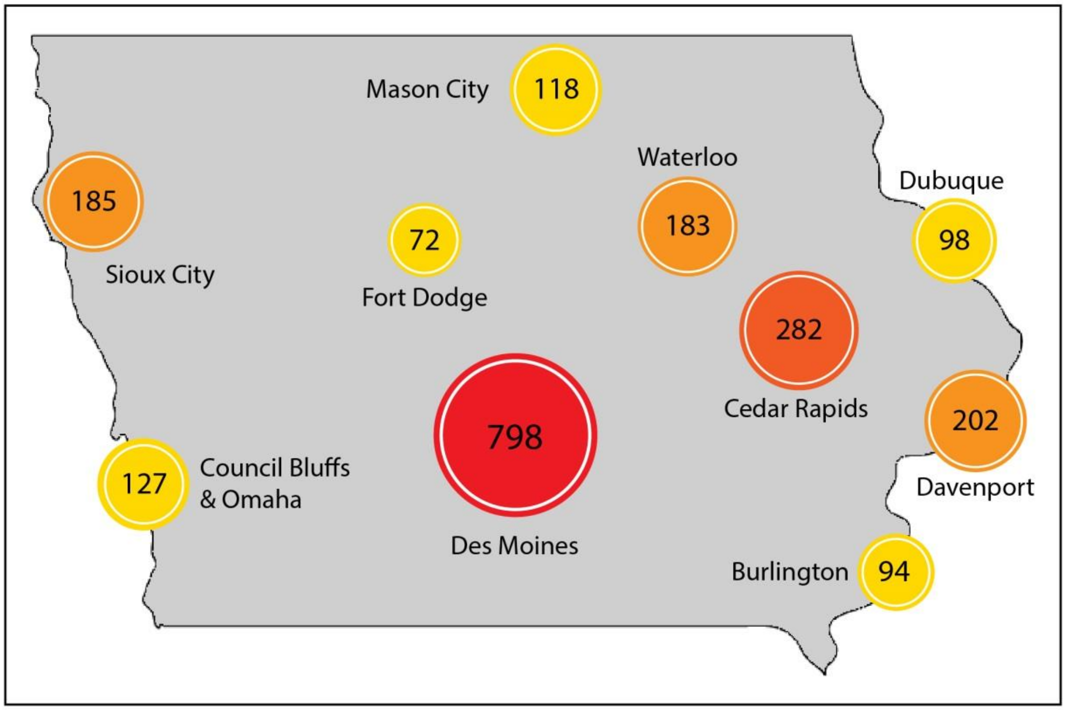


*Figure 1. Distribution of HVAC SAVE certified contractors throughout Iowa*

### 3.2 Program Stakeholders

The HVAC SAVE program began 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 the three IOUs and one municipal utility. This occurred after the Iowa regulators had expressed interest in a QI program, and the IOUs decided to include HVAC SAVE in their 2014-18 Energy Efficiency plan filings. The Iowa IOUs (Alliant Energy, Black Hills Energy, and MidAmerican Energy) began their support of the HVAC SAVE program by subsidizing contractor training tuition and promoting the program, with the contractor paying for access to the diagnostic software. Cedar Falls Utilities (CFU) is a municipal utility that also became integrally involved in the program. HVAC SAVE was a natural fit for CFU's programs as they already required load calculations for their rebates, and many of their contractors also worked in the IOU territories. After three years of trainings, only a small portion of installations were being entered into the diagnostic software. Based on the low utilization of the software, the utilities identified that payment for the software was the largest barrier to program participation and that moving sponsor support from training subsidies to job verification would have a greater impact. In 2013, the Iowa IOUs and CFU bought unlimited software access software for their contractors; in turn, contractors began paying the cost of tuition for the training.

Beginning January 1st, 2014, the participating utilities required that in order for a customer to be eligible for a 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. The installation is evaluated by the software after the contractors measure airflow, static pressure, and temperature across the system to determine how the equipment is performing and to verify the efficiency of the actual equipment as installed. In many cases, the contractor must make adjustments to the equipment or system in order to meet this level of performance. For maintenance of current equipment, there is a Performance Tune-Up rebate available from MidAmerican Energy 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.

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Rebates are available from both Alliant Energy and MidAmerican Energy in relation to their new construction programs. CFU also offers a duct modification rebate for certain comprehensive duct redesign projects. Additionally, in homes where ductwork is largely inaccessible due to finished space, CFU offers rebates for the installation of plenums and returns that improve the static pressure and air flow throughout the home, hence improving the HVAC SAVE score.

Contractor involvement in the program began with quarterly roundtable meetings with MEEA, ESI, and the participating utilities that enabled contractors to have a voice in this process as the HVAC SAVE program ramped up to a requirement for customer rebates. High contractor program participation has resulted in a robust set of data regarding HVAC equipment and system operating conditions.

### 3.3 Residential and Light Commercial HVAC Systems

The residential and light commercial heating and cooling systems evaluated through this program consist of gas combustion furnaces, air conditioning units, air source heat pumps, ground source heat pumps, air distribution duct systems, and system controls. These specific components work as a system to deliver the conditioned air to the living space. Only HVAC systems utilizing ductwork are analyzed through this program. The HVAC SAVE program instructs contractors on how to diagnose and measure the efficiency of the system as a whole. Combustion furnaces consist of a heat exchanger, electric fan, and controls. In addition to these components, a contractor can add an air conditioning coil and an air filter that the manufacturer hadn't accounted for when determining the equipment efficiency.

### 3.4 Achievable Standards

Contractors who participate in the HVAC SAVE training receive instruction on how to install equipment so that it performs as close to the rated efficiency as possible. In a variety of research projects, HVAC QI methods have been shown to be effective in increasing the operating efficiency of heating and cooling equipment and systems.

### 3.4.1 Department of Energy's Building America Research

Previous research conducted by MEEA in partnership with the Department of Energy's Building America Partnership for Advanced Residential Retrofit studied the energy savings potential of improvements to the air distribution system and the equipment installation. To properly gauge changes in energy efficiency, a baseline was developed from 48 existing homes. This analysis of baseline operating efficiency determined that approximately 10 percent of the energy was lost at the equipment level[3]. An additional 10 case study homes that received HVAC SAVE VQIs and system retrofits were analyzed for installation efficiency and system efficiency[4]. Analysis of case study homes found that, through system tune-ups associated with the HVAC SAVE program, it is possible to deliver up to 23 percent more space heating energy to the conditioned space[5]. This research found that the baseline installed efficiency of the HVAC equipment in those homes was approximately 70 percent of normative levels.

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In a second research project conducted for DOE's Building America program, MEEA examined the impact that age-induced equipment degradation, improper distribution systems, and oversized equipment have on furnace Steady-State Efficiency, a proxy for AFUE. MEEA performed HVAC SAVE testing and recorded the inputs for operational furnaces that were removed during HVAC SAVE furnace installations. MEEA partnered with the Gas Technologies Institute (GTI) to collect these furnaces from the field and test the furnaces in a laboratory. In a controlled laboratory setting, these furnaces were tested under standard manufacturer conditions and then conditions mimicking what was found in the field. It was determined that with proper tuning, the in-situ Steady-State Efficiency can be improved by 6.4 percent[6]. AFUE is one component of the equipment operating efficiency verified by HVAC SAVE. This research showed that the HVAC SAVE program results in real energy savings through proper installation methods.

### 3.4.2 Sensitive Analysis of Installation Faults on Heat Pump Performance

The National Institute of Standards and Technology (NIST) assessed and quantified efficiency losses in air conditioning equipment due to common installation errors in a report released in October 2014 titled *Sensitive Analysis of Installation Faults on Heat Pump Performance*. The report summarized that common installation errors by the contractor could increase equipment energy consumption by 30 percent. These common installation errors included restricted

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[3] Yee et al. "Energy savings from system efficiency improvements in Iowa's HVAC SAVE program." (2013).
[4] Ibid.
[5] Ibid.
[6] Brand et al. "Improving Gas Furnace Performance: A Field and Laboratory Study at End of Life." (2013).

airflow, leaky ducts and oversizing of systems[7]. NIST found that sizing, selecting, and installing HVAC equipment to industry-recognized procedures is critical to ensuring energy efficiency in the residential space. This research again reinforces a main component of HVAC SAVE, which is that equipment that is installed properly with QI practices can lead to greater efficiency from equipment and real energy savings.

## 4. Methodology

Iowa's HVAC SAVE program is based on certified contractors utilizing proper equipment installation techniques. Participating contractors verify their QI by submitting diagnostic data on in-situ efficiency. This required verification has resulted in a substantial data set corresponding with heating and cooling equipment that have been installed in Iowa by HVAC SAVE contractors.

Analysis of HVAC installation efficiency and system-level efficiency is measured using common techniques and tools focused around airflow, temperature, and external static pressure. Depending on whether the contractor is evaluating equipment performance or duct performance, the tools used to measure HVAC installation and system efficiency include a manometer, static pressure tip, hot wire anemometer, hygrometer, flow hood, and a digital thermometer. The primary way in which these measurements are used is to develop an HVAC SAVE score for both the equipment and ductwork. Based on the heating or cooling equipment that is being tested, there is a distinct HVAC SAVE score created specific to the space conditioning mode that is being assessed; the same occurs at the system level. As for heat pumps, testing only needs to be completed in one mode to ensure efficiency, based on the principle that heat pumps have the same operating efficiency in both heating and cooling modes.

Once the data has been collected, it is inputted into the real time web-based measurement and verification diagnostic HVAC SAVE software, which then reports back the HVAC SAVE score, as well as prepares guidance to the contractor on what may need to be adjusted in order to improve the equipment's efficiency. The heating equipment HVAC SAVE score is defined in Equation 1 and the cooling equipment HVAC SAVE score is defined in Equation 3 (Appendix 1).

**Equation 1. Heating Equipment HVAC SAVE score**

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

[7] Domanski et al. "Sensitive Analysis of Installation Faults on Heat Pump Performance." (2014).

**Equation 3. Cooling Equipment HVAC SAVE score**

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

In addition to the Heating and Cooling Equipment HVAC SAVE Score, the HVAC SAVE program provides diagnostic data related to distribution system efficiency. Distribution system metrics are important indicators of how well the HVAC system is performing as a whole. Heating distribution system HVAC SAVE score is defined below in Equation 2 and cooling distribution system HVAC SAVE score is defined below in Equation 4 (Appendix 1).

**Equation 2. Heating System HVAC SAVE score**

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

**Equation 4. Cooling System HVAC SAVE score**

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

The methodology associated with the HVAC SAVE program allows contractors to adjust what they deem as necessary based on their expert knowledge, as long as it achieves the goal efficiency score based on the ratio measured Btu's for the equipment or the system to the adjusted output.

## 5. Results

HVAC SAVE as a program has grown dramatically from 2010 to present. The program began as a voluntary measure for contractors in Iowa and was then required by the utilities to offer customer rebates on January 1, 2014. As can be seen in Figure 2, there has been substantial growth in participating contractors from the beginning of the program.

The program began with training 185 contractors in 2010, and by fall of 2015, 2,235 contractors have been trained, as can be seen in Figure 2.  In total, 1,021 different contracting firms employ a professional who is HVAC SAVE certified.  In the first year of the new rebate program, 633 different firms processed jobs in the software. To date, 741 contracting firms have produced over 31,500 jobs across all four participating utilities.

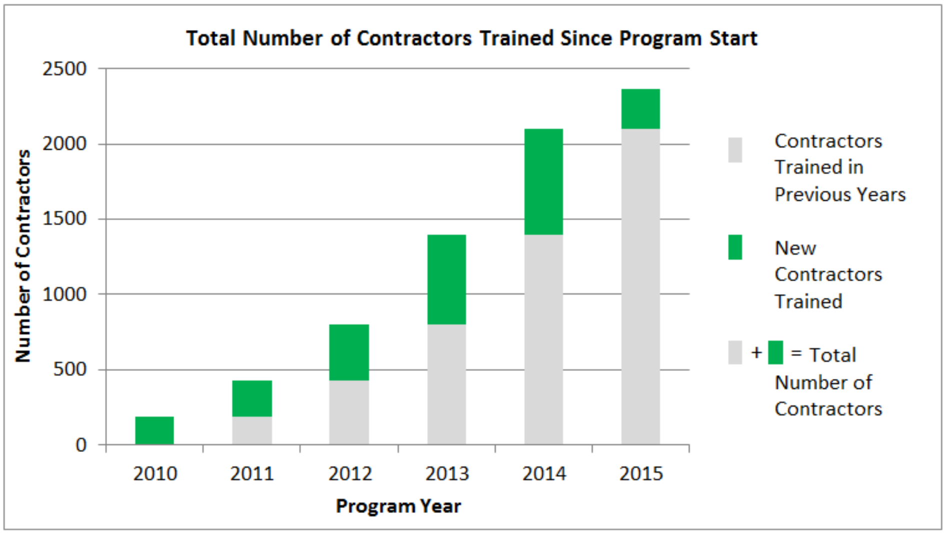


*Figure 2. Growth of trained contractors*

The number of installations that have been completed as a result of the HVAC SAVE program has grown substantially through the years as well, as seen in Figure 3. In 2012, there were 1,156 VQIs submitted in the software, whereas in 2014, the first year HVAC SAVE was required for customer rebates, there were 24,000 HVAC SAVE VQIs completed. There were 39,112 VQIs completed for calendar year 2015. The installations completed in 2014 have an average HVAC SAVE equipment score of 95.8 and have an average HVAC SAVE system score of 76.8. The average equipment score of 95.8 is over 25 points higher than the baseline equipment average of 70.

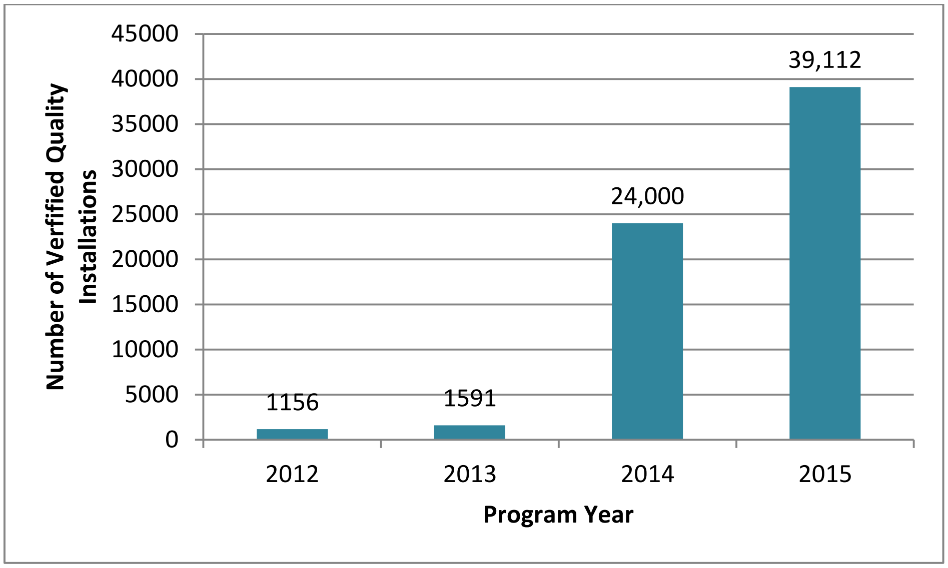


*Figure 3. HVAC SAVE VQIs completed per year*

There have been reported financial benefits of HVAC SAVE. In MidAmerican Energy's 2014 Energy Efficiency Plan Filing Measure Level Statistics, it was found through the societal benefit/cost test that HVAC SAVE was cost effective for VQI/VQM related programs (Appendix 2). As of December 2015, third party evaluations of the first requisite program year from Alliant Energy and MidAmerican Energy are forthcoming; after these evaluations have been completed, MEEA is looking forward to making modifications to ensure continued programmatic success. MEEA is also looking toward growth in the program due to the potential for capturing energy savings with each VQI.

## 6. Discussion

### 6.1 Implications for Gas and Electric Utilities

All HVAC SAVE stakeholders, MEEA, ESI, the participating utilities, and the contractors have learned a great deal as the program evolved. The impetus for the program came from the Iowa regulators' interest in QI programs. While the utilities were familiar with QI programs, they were looking for a program that would produce the energy savings of a traditional QI program with a more flexible contractor process. HVAC SAVE provided this flexibility by allowing the contractor to determine the best way to improve the efficiency, but then verifying that the approach they selected resulted in the expected energy savings for each installation.

Without contractor participation in the HVAC SAVE program, the prevalence of Verified Quality Installations and increased energy savings would not be possible. While this approach provided more flexibility to the contractors, some contractors still thought it was too onerous. There was vocal opposition from contractors who were concerned about the new expectations of them and the potential for confusion from homeowners who were accustomed to the previous rebate program. Prior to the HVAC SAVE program, contractors could earn rebates for their customers based on manufacturer ratings solely; now with the possibility of not achieving a passing HVAC SAVE score, the contractors could no longer guarantee rebates.

In order to ameliorate these concerns, roundtable meetings were held with contractors multiple times a year for several years after the announcement of the program. These meetings served as a space for contractors to voice their concerns about the program as well as a time to educate them on the background of HVAC SAVE, the mechanics of the program, and the ways in which it would benefit them, their businesses, and their customers. Contractors are the linchpin of HVAC SAVE, and contractor engagement was a priority throughout the roll out process to create program buy-in. Tweaks were made to the training and in-field verification processes based on contractor feedback which led to an increased sense of ownership of HVAC SAVE by the contractors.

Participation in the program transformed from 801 certified contractors trained in the three years prior to 2013 to 2,100 total contractors trained by the end of 2014 as contractors prepared for required rebate program participation. The four year ramp up phase allowed ample time for contractors to adjust their business models and to decide which employees needed to be trained in HVAC SAVE. The watershed moment for the contractor participation occurred the in 2013 when the participating utilities transitioned their sponsor support from training subsidies to unlimited access to the measurement and verification diagnostic software.

The majority of contractors weren't interested in paying for software access as it represented an added expense that cut into their bottom line. Once there was unlimited access to the software provided by the utilities, this financial barrier no longer existed between the contractors and the software, thus allowing HVAC SAVE testing to become a routine part of their business practices. This widespread access to the software was crucial in ensuring the desired high number of VQIs being entered into the software and the increased efficiency that was associated with these jobs. The commitment from the utilities and from early-adopter contractors dramatically accelerated the frequency of optimally performing new equipment installations.

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Many of the most vocal contractor opponents of the program became the greatest advocates once they determined how they could sell HVAC SAVE as part of their business plan, realized the benefit of having on-site performance data, and saw the value in VQIs for their customers. An owner of one of the largest HVAC firms characterized HVAC SAVE as an "eye opening experience." The contractors who participate in the HVAC SAVE program have differentiated themselves from other contractors in Iowa by performing higher quality work based on their newly acquired skills and access to real-time diagnostic software. The data-driven element of HVAC SAVE has been a large motivator towards contractor buy-in. Finally there is data provided by a separate party to support the claim that their installations and maintenance are superior and energy efficient. There is real value in being able to provide factual evidence of the quality of an installation, especially in direct comparison to competitors not participating in the program. In addition, the program support from the utility reinforces the sales message from the contractor as the utility is also deemed as a credible source of information. The contractors are leaning on the HVAC SAVE certification and in-field performance testing to prove themselves and their worth over their competition.

HVAC SAVE Verified Quality Installations in the state of Iowa increased from 1,591 in 2013 to 24,000 in 2014. As all stakeholders had four years to prepare for the 2014 HVAC SAVE requirement, the ramp up was fairly smooth. During this ramp-up period, it became evident that a more robust system for quality assurance (QA) needed to be developed. Because HVAC SAVE was a statewide program, the QA process had to be consistent from one utility service territory to the next due to the amount of crossover of contractors between utility territories.

Previously, QA was performed on the front end: a verifier went out with each contractor on the first job site to ensure that program practices were being followed. As the program expanded, a tiered QA system became necessary to scale the program as there were exponentially more jobs being completed once participation became obligatory to offer rebates. The system needed to catch obvious fraud while also providing coaching to well-intended contractors that may have had difficulty with the software or procedures in the field. With MEEA's guidance, a

QA protocol for HVAC SAVE was designed collaboratively with all utilities and implemented statewide in late 2014.

When transitioning to a new type of utility rebate program for contractors and homeowners, marketing is essential for contractor involvement as well as homeowner education about the new programmatic expectations. Combined efforts among contractors, participating utilities, MEEA, and ESI diffused the possible confusion that this type of transition could cause. A particularly successful element of the marketing plan was program branding. Every element of the program is called HVAC SAVE, not a different name for each component; this includes the certification itself, the software where the jobs are inputted, the equipment and system scores given, as well as the website. This branding, in addition to the multiple-year rollout of the program, has led to a high level of contractor recognition of HVAC SAVE. The participating utilities continue to strive for greater customer program recognition and demonstration that the program and its contractors have the full support of the participating utilities behind it for their customers.

As with any newly implemented program, HVAC SAVE hasn't been without challenges. One of the main difficulties has been the lag between when some air conditioners are installed and when the installed equipment can be tested due to the air temperature requirement from the manufacturers. Contractors have stated that it is difficult for them to return to the homes to test after the equipment is installed. The IOUs had set a deadline of June 30, 2015 for all rebates to be submitted for air conditioners installed in 2014, but they decided to push back the deadline to September 30, 2015 due to the mild spring and summer that created an additional hurdle for the testing to be completed. This challenge was most prevalent with new construction homes and with contractors who perform a high number of equipment replacements. This deadline extension allowed contractors to have more time to return to the home for testing while ensuring that homeowners will still receive a rebate in a timely fashion. The 2014 program year and its deadlines will likely shape future program years as HVAC SAVE evolves.

Another challenge to program participation and success has been access to the internet computer proficiency for contractors. Some contractors were not accustomed to navigating computers and so there has been a learning curve when using the diagnostic software. As time goes on and general population proficiency in computers increases, it is anticipated that this issue will decrease. A separate software training could be designed specifically for office administrators which may alleviate some of the issues with rebate and job submittal by contractors.

Quality Maintenance goes beyond the "run-to-fail" mentality that is often associated with heating and cooling equipment and systems. QM focuses on how to elevate the performance of the current operating HVAC equipment and systems, not limiting these increased technical skill practices to installations. MidAmerican Energy has embraced and supported this forward-thinking approach by incentivizing QM for their customers. However, there has been a low amount of participation in the newly introduced QM or Performance Tune-Up rebate. The contractors have the appropriate tools, skills, and desire to participate and have acknowledged that a large population of installations exists that can be improved, but they have yet to do so in a consistent manner. They have also been concerned about how the introduction of QM would disrupt their current annual service agreement business. This disconnect is also likely an issue of customers not recognizing the value of maintenance on their systems, and it is anticipated that once the contractors determine how to sell this service to their customers, there will be increased participation in the Performance Tune-Up program.

## 6.2 Pathways into the Market

An additional pathway into the HVAC market has been through local distributor support of the program. This midstream support was unexpected when the program began, but local distributors have seen the HVAC SAVE training as substantial additive for their customers. Many distributors throughout the state have held trainings at their facilities and have helped with the promotion of these trainings to their customers. In addition to being active supporters of the training, they also promote participating in the actual testing and proper installation of their equipment. With proper installation of the equipment as well as increased diagnostic knowledge via HVAC SAVE testing, it is possible that service calls to the distributor will decrease. Also, it is conceivable that their equipment warranties will last longer as the equipment is being installed properly and should be operating as the manufacturer has designed.

*Contractors often leave the training having experienced “a-ha” moments regarding the approach to making HVAC systems run more efficiently and appreciating the additional level of knowledge and performance data that is provided to them.*

## 6.3 HVAC SAVE Market Transformation

From the beginning of the training component of HVAC SAVE, over 2,300 contractors have been trained. 741 companies have submitted a job in the HVAC SAVE software since the transition to the new rebate program in 2014, and that number continues to grow with each additional training. 1,100 companies participated in the previous prescriptive rebate program in 2013, prior to HVAC SAVE. It can be inferred that 67 percent of companies operating in the participating utility territories are now participating in the HVAC SAVE program and have an HVAC SAVE certified contractor on staff.

Contractors who haven’t been HVAC SAVE certified are working alongside those who have been HVAC SAVE certified, leading to an additional transfer of knowledge of VQI methods. Many HVAC SAVE contractors perform jobs in territories where HVAC SAVE is not part of the local rebate program (i.e. smaller municipal utility territories); in these cases, an HVAC SAVE qualified technician may be applying the VQI practices they learned. Instructing contractors on these VQI methods has had reaching impacts on consumers’ comfort as well as future HVAC technicians. Contractors often leave the training having experienced “a-ha” moments regarding the approach to making HVAC systems run more efficiently and appreciating the additional level of knowledge and performance data that is provided to them. At HVAC SAVE contractor meetings, participating contractors often share the feedback that HVAC SAVE has greatly improved their technical skills as HVAC professionals and the experience of their customers. In an industry where technical skills are handed down from one technician to the next, the HVAC SAVE program is increasing the baseline level of Iowan HVAC contractors' technical skills.

### 6.4 Additional Research Needs

Additional research on HVAC SAVE and VQI/QM practices would be advantageous to support future program growth. Other areas of research interest are continued data collection outside the state of Iowa, an increase in data within the small commercial segment, and looking at the potential for an HVAC performance assessment as part of a whole home performance assessment. Furthermore, we would like to create additional case studies of homes that have received VQIs, Performance Tune-Ups, or system improvements from an HVAC SAVE contractor would be helpful in continuing to communicate the successes of the program to consumers. Another interest in potential research would be the effect of HVAC SAVE installation methods on peak demand reduction as this becomes a larger focal point in the energy efficiency sector.

## 7. Conclusion

In conclusion, the HVAC SAVE program in Iowa has successfully implemented a residential energy efficiency program that combines the concepts of increasing efficiency of HVAC equipment, increasing quality of installations, and verifying the performance results of these high efficiency installations. The delta in energy consumption between the old, inefficient, potentially inappropriately installed, or possibly degraded equipment, and the new, more efficient, quality installed equipment becomes the new measured, claimable energy savings for the participating utilities. Several elements have led to the program's success, specifically the foundational base of a thorough training and certification focused on VQI techniques, as well as contractor involvement in program design and implementation that created greater program buy-in; this has ultimately led to market transformation of the technical skills of Iowan HVAC contractors.

## 8. References

Brand, L., Yee, S., and Baker, J. 2013. “Improving Gas Furnace Performance: A Field and Laboratory Study at End of Life.” Building Technologies Office. National Renewable Energy Laboratory.

Domanski, P, Henderson, H., and Payne, W. 2014. “Sensitivity Analysis of Installation Faults on Heating Pump Performance.” NIST Technical Note 1848.

U.S. Energy Information Administration. 2009. “Residential Energy Consumption Survey.”

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## Appendix 1: HVAC SAVE Equations

### Equation 1. Heating Equipment HVAC SAVE Score

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

- CFM: Cubic feet per minute
- Equipment Delta T: Equipment return air temperature is measured where it enters the furnace. Equipment supply air temperature is measured out of sight of the furnace typically 1’ – 2’ down the trunk from the plenum. If more than one trunk then temperatures are taken in each and averaged.
- Equipment Air Density Correction Factor: Determined by altitude and temperature of the equipment return air
- Installed Input: Measured by clocking the gas meter with only the furnace running. Assumes 1000 Btu/h per foot of gas. 3600 / seconds per turn x Btu per turn

### Equation 2. Heating System HVAC SAVE Score

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

- CFM: Cubic feet per minute
- Delta T: Change across the distribution system
- Air Density Correction Factor: Determined by the altitude and air temperature of the locations the CFM was measured
- Adjusted input: Measured by clocking the gas meter
- AFUE: Annual Fuel Utilization Efficiency

### Equation 3. Cooling Equipment HVAC SAVE Score

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

- CFM: Cubic feet per minute
- Equipment Delta H: Change across the equipment
- Equipment Air Density Correction Factor: Determined by altitude and temperature of the equipment return air

**Equation 4. Cooling System HVAC SAVE Score**

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

- CFM: Cubic feet per minute
- Delta H: Change across the distribution system
- Air Density Correction Factor: Determined by the altitude and air temperature of the locations the CFM was measured

# Appendix 2: MidAmerican Energy Company 2014-2018 Iowa Energy Efficiency Plan

## Measure Level Statistics

| *Program* | *Measure* | *Effective Life* | *Average Customer Cost* | *Average Rebate* | *Participation Statistics 2014* | *Participation Statistics 2015* | *Participation Statistics 2016* | *Participation Statistics 2017* | *Participation Statistics 2018* | *kWh Savings 2014* | *kWh Savings 2015* | *kWh Savings 2016* | *kWh Savings 2017* | *kWh Savings 2018* | *Therm Savings 2014* | *Therm Savings 2015* | *Therm Savings 2016* | *Therm Savings 2017* | *Therm Savings 2018* | *Utility Test* | *Societal Test* | *Net System Benefits* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Residential Equipment | CAC | 15 | $ 610.58 | 531.54 | 5,314 | 5,322 | 5,330 | 5,338 | 5,346 | 1,315,428 | 2,632,835 | 3,952,224 | 5,273,592 | 6,596,941 | | | | | | 1.31 | 1.77 | $ 11,952,568.00 |
| Residential Equipment | CAC-QI | 11 | $ 300.00 | 300 | 5,314 | 5,322 | 5,330 | 5,338 | 5,346 | 1,067,955 | 2,137,517 | 3,208,687 | 4,281,465 | 5,355,851 | | | | | | 1.5 | 2.12 | $ 8,510,160.00 |
| Residential Equipment | ASHP | 18 | $ 939.58 | 624.38 | 1,455 | 1,588 | 1,661 | 1,764 | 1,867 | 2,290,301 | 4,742,733 | 7,357,297 | 10,133,991 | 13,072,817 | | | | | | 2.28 | 2.57 | $ 11,637,639.00 |
| Residential Equipment | ASHP-QI | 14 | $ 300.00 | 300 | 1,455 | 1,558 | 1,661 | 1,764 | 1,867 | 2,098,954 | 4,346,494 | 6,742,619 | 9,287,330 | 11,980,627 | | | | | | 3.6 | 5.55 | $ 10,781,849.00 |
| Residential Equipment | GSHP | 18 | $ 11,353.67 | 2,500.00 | 546 | 581 | 617 | 652 | 688 | 6,284,597 | 12,977,790 | 20,079,579 | 27,589,965 | 35,508,947 | | | | | | 3.06 | 1.13 | $ 4,404,369.00 |
| Residential Equipment | GSHP-QI | 14 | $ 300.00 | 300 | 546 | 581 | 617 | 652 | 688 | 958,287 | 1,978,878 | 3,061,772 | 4,206,970 | 5,414,471 | | | | | | 4.38 | 6.75 | $ 5,062,441.00 |
| Residential Equipment | Furnace | 20 | $ 1,140.02 | 600.00 | 11,809 | 12,272 | 12,736 | 13,199 | 13,662 | | | | | | 1,824,191 | 3,719,945 | 5,687,263 | 7,726,145 | 9,836,591 | 2.25 | 2.01 | $ 69,756,574.00 |
| Residential Equipment | Furnace-QI | 15 | $ 300.00 | 200 | 7,000 | 8,000 | 9,000 | 10,000 | 10,000 | | | | | | 279,930 | 599,850 | 959,760 | 1,359,660 | 1,759,560 | 0.97 | 1.48 | $ 6,035,221.00 |
| Residential Equipment | Furnace Fan | 15 | $ 200.00 | 75 | 5,335 | 5,372 | 5,410 | 5,447 | 5,486 | 2,502,382 | 5,022,118 | 7,559,679 | 10,114,594 | 12,687,803 | | | | | | 2.13 | 1.3 | $ 1,543,806.00 |
| Residential HVAC Tune Up | CAC Tune Up | 5 | $ 200.00 | 180 | 1,500 | 2,000 | 3,000 | 3,500 | 4,000 | 257,580 | 601,020 | 1,116,180 | 1,717,200 | 2,404,080 | | | | | | 1.1 | 1.21 | $ 548,687.00 |
| Residential HVAC Tune Up | ASHP Tune Up | 5 | $ 200.00 | 150 | 150 | 200 | 300 | 350 | 400 | 145,389 | 339,241 | 630,019 | 969,260 | 1,356,964 | | | | | | 1.93 | 1.77 | $ 203,725.00 |
| Residential HVAC Tune Up | Furnace Tune Up | 5 | $ 200.00 | 180 | 1,500 | 2,000 | 3,000 | 3,500 | 4,000 | | | | | | 45,255 | 105,595 | 196,105 | 301,700 | 422,380 | 0.49 | 0.53 | $ (1,242,244.00) |
| Residential HVAC Tune Up | Duct Sealing- E.H + E.C. | 18 | $ 960.13 | 550 | 15 | 20 | 30 | 40 | 45 | 31,436 | 73,350 | 136,221 | 220,050 | 314,357 | | | | | | 3.52 | 3.4 | $ 326,195.00 |
| Residential HVAC Tune Up | Duct Sealing- G.H.+ E.C. | 18 | $ 960.13 | 550 | 150 | 200 | 300 | 350 | 400 | 51,516 | 120,204 | 223,236 | 343,440 | 480,816 | 13,577 | 31,679 | 58,832 | 90,510 | 126,714 | 3.39 | 3.19 | $ 2,774,213.00 |

This is just a portion of the plan relevant to HVAC SAVE. The measure level statistics in their entirety are located on the Iowa Utility Board's Electronic Filing Portal (https://efs.iowa.gov/efs/).