Staying Tuned: Understanding HVAC Business Practices that Enable Commissioning

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ABSTRACT

Commissioning residential HVAC systems saves money for consumers, reduces energy-wasting faults, and improves system reliability; however, despite these clear benefits, contractors rarely commission residential systems. To better understand current practices, as well as benefits and barriers to commissioning, researchers at the Pacific Northwest National Laboratory (PNNL) and Focus on Energy® conducted complementary research examining perspectives on residential HVAC commissioning practices. PNNL conducted a detailed survey of residential HVAC professionals to assess their current commissioning practices, how they define commissioning, perceived barriers to implementation, and recognized benefits. The survey investigated contractors' experiences with commissioning protocols, training needs, customer demand, and business considerations. Additional insights from in-depth interviews conducted by Focus on Energy with Wisconsin contractors, training instructors, and equipment distributors were gathered to understand barriers and opportunities for wider utilization of technology-assisted commissioning methods. This paper presents findings from the survey and interviews, as well as opportunities and barriers for implementing technology-assisted commissioning.

Introduction

Many Americans rely on properly functioning heating and cooling systems to keep their homes at a comfortable temperature, while inefficient systems are costly to operate and hinder energy affordability. Yet, most residential heating, ventilation, and air conditioning (HVAC) systems are operating inefficiently, largely due to improper installation, which can include improper equipment and duct sizing, incorrect airflow rate, and incorrect refrigerant charge (Allen-Magande et al. 2024; Domanski et al. 2015; Winkler et al. 2020). According to the U.S. Department of Energy (2018), 70-90% of residential HVAC systems have at least one performance-compromising fault that occurred at installation or due to improper maintenance. These faults can degrade equipment performance, energy efficiency, and the ability to deliver comfort while increasing repair and maintenance costs, and increasing overall energy demand (Allen-Magande et al. 2024; Butzbaugh et al. 2020; Winkler et al. 2022; Rogers et al. 2019). Simulation studies of residential HVAC equipment in U.S. single-family detached homes by Winkler et al. (2020) estimate that installation faults can lead to a 9% national increase in additional energy use, which equates to $2.5 billion annually on utility bills. Many homeowners are not even aware that their systems are not operating properly (Steiner and Malinick 2015). In addition to impacting homeowners, faults in residential HVAC systems also harm HVAC businesses' bottom lines due to increased callbacks, service warranty claims, and reduced customer satisfaction.

One solution to combat widespread and costly performance-compromising faults is to employ commissioning (Valoria et al. 2024). Commissioning refers to a "quality control practice that involves verifying that a building's systems are functioning properly, meeting design intent, and satisfying owner project requirements" (Valoria et al. 2024). Figure 1 shows where commissioning fits within the larger process of a residential HVAC installation or retrofit.

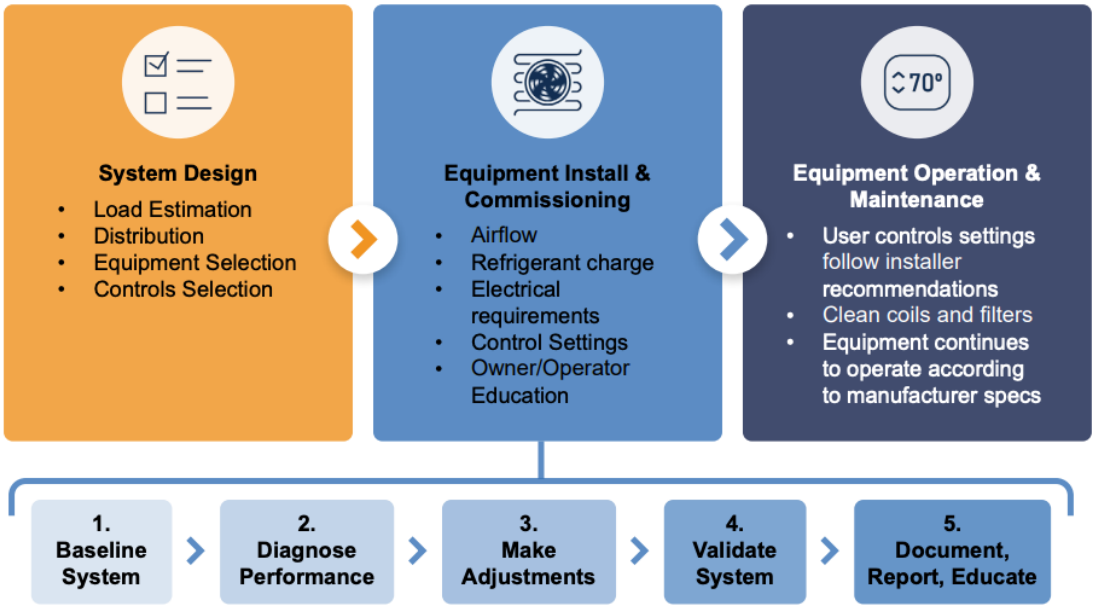

Figure 1: The process of quality residential HVAC retrofits. The boxes at the top describe the stages of the process. The tasks within each stage are listed as bullet points within each box. The more specific steps of Equipment Install & Commissioning as listed below as numbered items. Source: Midwest Collaborative 2026.

Despite increased utilization of commissioning for commercial HVAC systems, there has been limited utilization for residential buildings. In the residential sphere, equipment start-up is typically performed, and only basic system operation is verified, while performance-related verifications or optimization of airflow, refrigerant charge, and control settings are often omitted (Valoria et al. 2024). Emerging technology-assisted commissioning tools may increase the frequency of commissioning in the residential HVAC space. Technology-assisted commissioning refers to solutions such as smart diagnostic tools and embedded diagnostics that identify faults and help commission HVAC systems at the point of installation. Smart diagnostic tools can "monitor HVAC equipment over a finite timeframe using a combination of smart gauges, sensors, and a mobile app to diagnose performance issues to ensure quality installation and tune-ups" (Butzbaugh et al. 2020). Embedded diagnostics are tools that are built into HVAC equipment and "can identify and communicate system faults digitally to building owners or maintenance personnel, notifying these market actors of issues with HVAC operation" (Butzbaugh et al. 2020). However, residential contractors may be unaware of processes for diagnosing HVAC faults or may not trust fault detection technology, opting to use "rules of thumb" rather than common industry practices (Butzbaugh et al. 2020; Valoria et al. 2024). Winkler et al. (2022) identified a series of barriers associated with the broad utilization of residential HVAC fault detection technologies, which include evaluating the technology's accuracy and capabilities, lack of relevant field data for HVAC faults and documented energy savings potential of the technology, cost barriers, technological shortcomings and

implementation barriers, and barriers related to the existing sales structure of HVAC equipment and market awareness of these technologies.

Researchers at the Pacific Northwest National Laboratory (PNNL) and Focus on Energy aimed to understand the perspectives of market actors regarding the integration of commissioning as part of their typical service offering. As such, PNNL and Focus on Energy performed two complementary research efforts to document how residential HVAC contractors, companies, trainers, and distributors define and utilize commissioning as well as understand barriers and benefits to wider implementation of residential commissioning, specifically technology-assisted commissioning.

Residential HVAC Contractor Survey

Survey Design and Dissemination

To examine commissioning practices among residential HVAC companies, researchers at PNNL designed an exploratory survey using SurveyMonkey, which received approval from PNNL's Institutional Review Board (IRB). The survey consisted of questions related to company background, management priorities, team training, commissioning practices, implementation, and commissioning benefits. PNNL collected survey responses from May to December 2025. The researchers conducted multiple rounds of outreach, first to contacts that the PNNL team had engaged with through previous efforts, then leveraging industry and organizational connections. There was a total of 85 responses; of these, 39 respondents completed the survey. Two respondents operate outside of the U.S.; therefore, only 37 complete survey responses are reported here. It is important to note that this survey is not broadly representative of residential HVAC companies due to our low sample size. Additionally, outreach methods have resulted in sampling bias, leading to an overrepresentation of residential HVAC companies that utilize commissioning. Despite these limitations, the authors believe these results are still meaningful and begin to address critical knowledge gaps within the research.

The 37 survey respondents represent a variety of experience levels, company sizes, and roles. The majority of companies (62%) have been operating for more than 20 years, followed by companies that have been operating for 1-5 years (16%), 6-10 years (14%), and 11-20 years (8%) (Figure 2). No companies reported operating for less than one year. Most respondents represent small (62%) companies, while the remainder represent both medium and large companies with over 20 employees. Six respondents represent companies with 21-50 (16%) employees, while four respondents (11%) represent companies with both 51-100 and over 100 employees (Figure 3). The 37 respondents represented the following roles in their respective HVAC companies: 22 business owners or managers, five in sales and customer engagement, one installer or technician, two training and education, and one respondent in multiple roles.

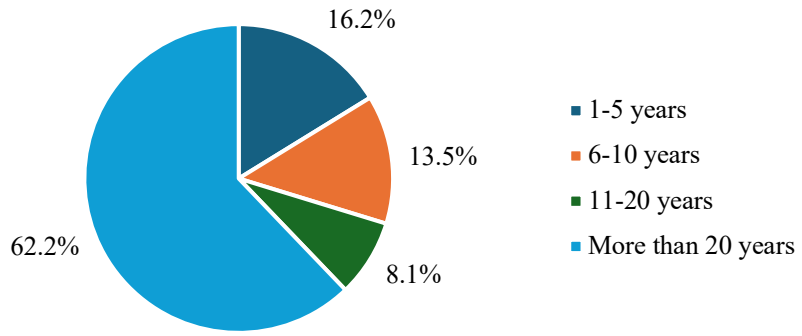

Figure 2: Amount of time HVAC companies that responded to the survey have been in operation.

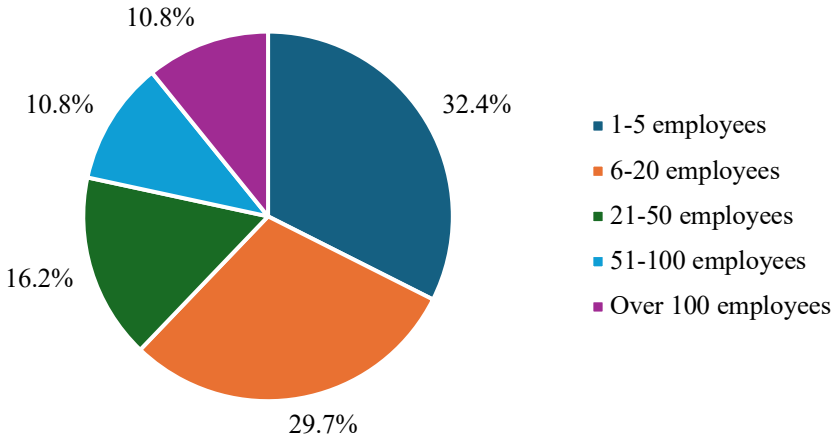

Figure 3: Size of HVAC companies that responded to the survey.

Company Priorities

Key performance metrics varied across residential HVAC companies. When asked to rank the importance of different metrics, customer satisfaction and retention were ranked the highest by the majority of our sample, followed by installed system performance, quality of workmanship, and profitability. Installation speed and callback reduction were ranked the lowest. Callbacks refer to expensive, no-charge, no-profit service visits that may result from manufacturer/warranty issues, technician errors, or communication errors (Valoria et al. 2024). Although callback reduction was ranked among the lowest priorities, 29 companies (78%) tracked callbacks, with the vast majority (72%) reporting a callback rate of 0-10%. Seven companies (24%) reported a callback rate of 11-20%, while one company reported a callback rate of over 30%. The industry standard for manufactured parts failure is approximately 2 to 2.5%, with an acceptable callback rate of between 2 and 2.75% (Grandy 2014).

Residential HVAC companies also had a high level of familiarity with various industry manuals and guidelines. Contractors had the highest familiarity with industry manuals related to

residential load calculation, residential duct design, and residential equipment selection. They had the lowest familiarity with HVAC quality installation verification (QIV), grading the installation of HVAC systems, residential zoning systems, and residential systems overview, while three respondents indicated that they were not familiar with any of the manuals listed (Figure 4).

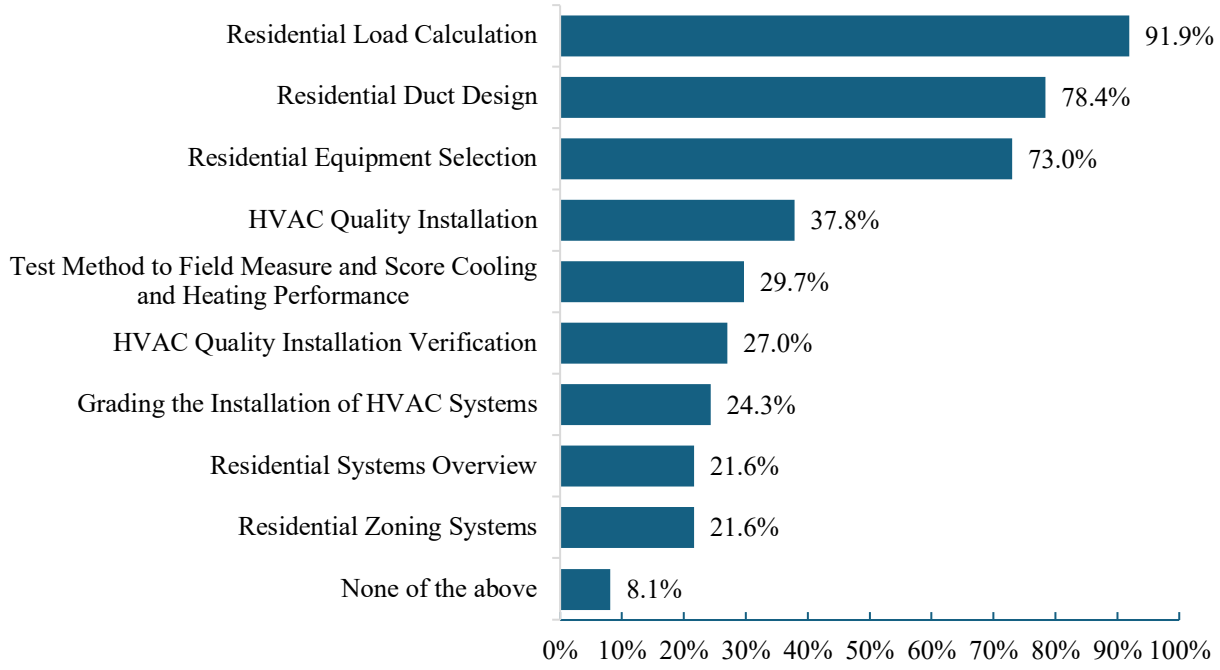

Figure 4: Familiarity of industry manuals by residential HVAC companies.

Commissioning Practices

All companies represented in the survey reported a variety of procedures included within their typical installation testing scope, with the majority conducting refrigerant system pressure testing (97%), refrigerant charge (92%), controls setting verification (89%), refrigerant system vacuum decay testing (87%), airflow measurement (68%), and total external static pressure (68%). Spot efficiency testing was conducted the least by our sample, with four respondents (11%) including it in their typical installation scope.

Commissioning is considered a typical practice at 31 respondent companies; however, commissioning practices are 'well-defined' at 26 respondent companies. Of the 11 respondents who believe that commissioning is not well-defined at their company, nine were business owners or managers. 29 respondents believe that technicians at their company are very aware/aware of commissioning, while five respondents believe technicians are neither aware nor unaware of commissioning. Three respondents believe that technicians at their company are unaware of commissioning, all of whom were business owners or managers. Therefore, technicians were more likely to believe that commissioning practices are well-defined compared to business owners and managers.

Survey respondents were also asked how their company defines commissioning, and key terms included in these definitions are visualized in Figure 5. Examples of definitions provided

include: "*ensuring that new systems are delivering the capacity and efficiency that the customer paid for, which has plenty of other benefits including system longevity," "bringing the equipment to proper operating guidelines based on manufacturer guidelines and the home's needs,"* and *"a robust set of measures/checks to ensure we are delivering the performance that was purchased/promised."* In addition to the example definitions, many contractors defined commissioning based on their company process, while others defined commissioning based on measureQuick and ACCA Verified Equipment Operation (VEO). The most common themes addressed in commissioning definitions include system testing procedures, system performance evaluation, and system sizing and verification.

Figure 5. Word cloud containing key terms included in company definitions of commissioning.

Regarding training, 32 respondents (86%) indicated that it was very or somewhat common for employees to receive training on HVAC system commissioning, while five respondents (14%) stated that training was not at all common. For companies that commonly train employees on commissioning, 24 (75%) utilized an in-house trainer. Eight respondents (25%) utilized an external trainer, with the most common venues being through distributors, supply houses, or manufacturers, virtual training, conference workshops, trainers brought in by the company, commissioning app or tool trainings, or at association meetings. Respondents did not report receiving training at trade schools, community colleges, or vocational colleges. All eight respondents believe that the external training they receive is adequate.

Implementation and Contractor Benefits of Commissioning

Respondents reported that commissioning is typically completed during new installations (89%), while others also commission systems during major repairs (46%), when working with high-efficiency systems (40%), in response to client requests (37%), or when participating in a utility quality installation (QI) program (23%). Companies also typically receive very positive (34%), positive (14%), or neutral (51%) feedback from clients regarding commissioning.

33 respondents (89%) believe that commissioning is valuable to their company, while four respondents (11%) were neutral. Some respondents elaborated further, indicating that commissioning is considered valuable due to callback and cost reductions, installation quality

and system efficiency assurance, system performance verification, customer experience enhancement, and system and home safety.

Most survey respondents perform commissioning on a regular basis. 20 companies (54%) always perform commissioning, and 10 companies (27%) frequently perform commissioning. However, some respondents reported commissioning less often, with three companies commissioning sometimes (8%), two companies rarely commissioning (5%), and two companies never commissioning (5%). The four companies that rarely or never perform commissioning indicated that they would do so more often if the process took less time, was more profitable, was easier to train employees, or reduced callbacks. Three of these companies reported that they would be willing to spend an additional 1-2 hours per job to perform commissioning if it led to a reduction in callbacks, while one company was willing to spend less than an hour to perform commissioning. According to those who commission more frequently, a typical commissioning process typically adds 1-2 hours to a company's installation time (63%), while some companies reported spending under an hour (15%) or 2-4 hours (21%) on commissioning. Two of the four companies that rarely or never commission track callbacks, and one of these companies reports a callback rate of 0-10% while the other reports an 11-20% callback rate. A larger sample size is required to determine a correlation between performing commissioning and callback rates.

The 33 companies that always or frequently commission systems have experienced several benefits because of this practice. The most cited benefits from commissioning include reduced callbacks (88%), improved HVAC system performance (85%), increased customer satisfaction (79%), and enhanced reputation (67%). One company reported not experiencing any noticeable benefits from implementing commissioning (Figure 6).

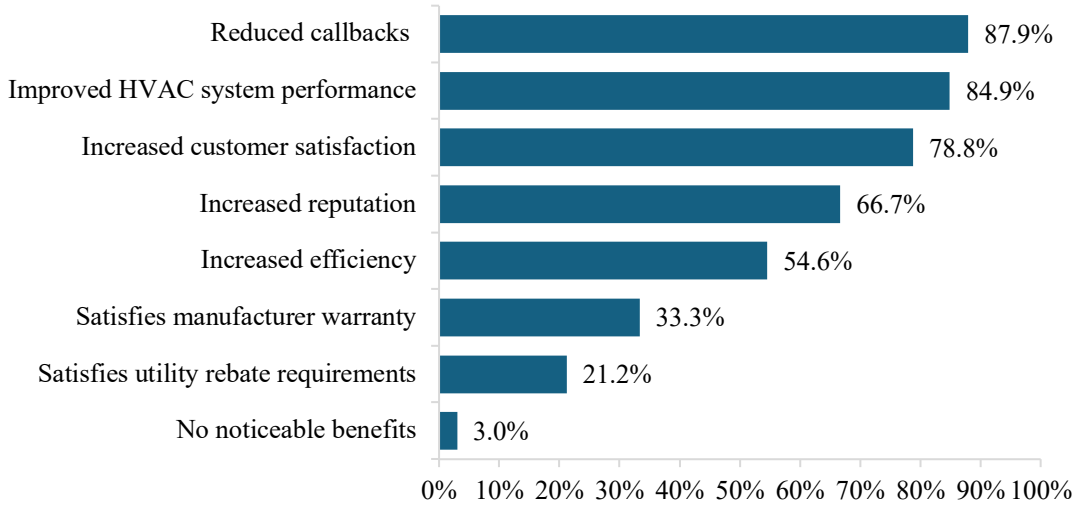

Figure 6: The benefits companies have experienced from implementing commissioning.

In terms of pricing, 24 companies (73%) that always or frequently commission systems do not charge extra for commissioning. Nine companies (27%) charge extra for commissioning, either by including the additional cost in the overall service cost or through a flat or hourly fee. Most companies (57%) document and report commissioning results to their clients through a digital report, while others utilize written reports (21%) or verbal communication (21%). Most companies (58%) provide tools to their employees outright, while others provide a tool budget

(17%), provide a partial reimbursement for tools (8%), or require technicians to provide their own tools (17%). Companies utilize a variety of technological tools or software to aid in commissioning, with measureQuick being the most common. Other companies utilize Fieldpiece Instruments, digital gauges or manometers, or combustion analyzers.

Although most survey respondents believe that commissioning is valuable to their company and have integrated it into their business practices, several respondents also identified key barriers to incorporating commissioning as a company practice (Figure 7). Barriers include lack of time (47%), additional costs (39%), lack of training (33%), lack of customer demand (28%), and technician reluctance to learn new technology (25%). Some respondents elaborated further by discussing the lack of customer understanding and willingness to pay for what commissioning is worth, under-performing companies that devalue the industry, and challenges associated with newer technologies. One-third of respondents do not believe their company faces obstacles related to commissioning.

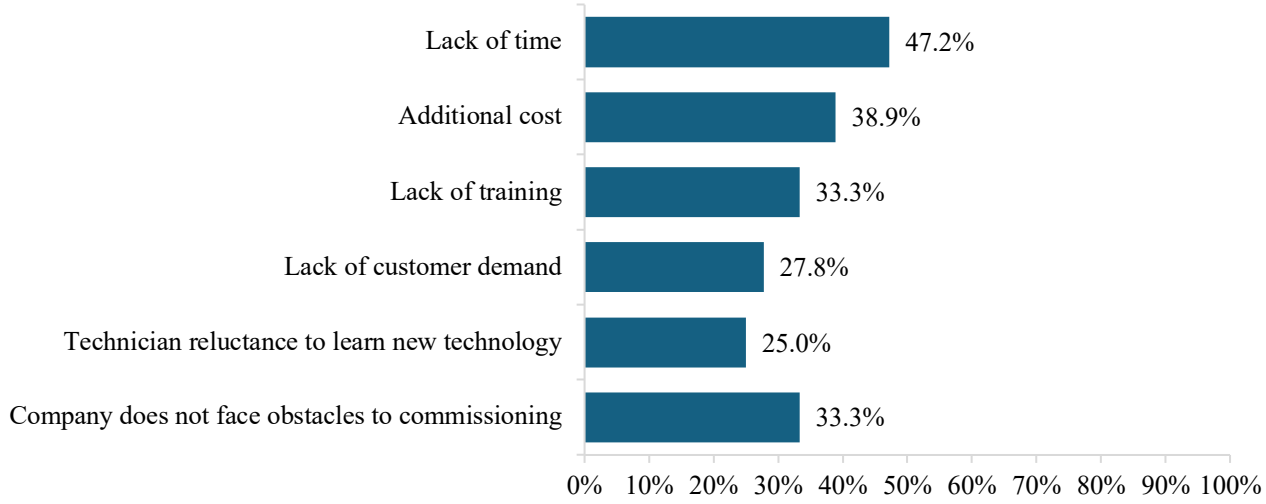

Figure 7: Major obstacles to including commissioning as a company practice.

Interview Methods and Results

Interview Design and Implementation

Focus on Energy, a utility-funded statewide program in Wisconsin, held in-depth, semi-structured interviews with HVAC contractors, distributors, and instructors to understand the barriers and opportunities for technology-assisted commissioning, using either smart diagnostic tools or embedded diagnostics. Interviews were conducted from February to April 2026. While distributors and instructors were recruited through organizational, industry, and professional networks, contractors were more difficult to reach. To recruit contractors, Slipstream conducted an email campaign through measureQuick that targeted active Wisconsin users and obtained industry contact referrals to recruit non-users. In total, eight interviews were conducted with the following groups of market actors: three HVAC contractors (one contractor that regularly uses smart diagnostic tools and two who were familiar with smart diagnostic tools but not regular

users), three distributors, and two HVAC instructors at Wisconsin community colleges.

Interviews focused on contractor perspectives on barriers, opportunities, and current use of technology-assisted commissioning, as well as distributor and HVAC instructor training practices. Four key themes emerged from the interviews, which are described in greater detail below: 1) awareness, availability, and procurement; 2) perceptions of technology-assisted commissioning; 3) training and education, and 4) installation guidance. Interviews averaged one hour and were transcribed, coded, and analyzed to identify barriers to wider uptake of technology-assisted commissioning. While not a representative sample of Wisconsin or the national market, these results provide qualitative insight into emerging opportunities, barriers, and implementation considerations related to technology-assisted commissioning.

Awareness, Availability, and Procurement

Interviewees were asked about their familiarity with smart diagnostic tools and embedded diagnostics, their availability, and the typical procurement process in the Wisconsin market. Smart diagnostic tools are widely available across Wisconsin, suggesting availability is not a barrier to uptake. All interviewees were aware of smart diagnostic tools, though some confused them with digital HVAC measurement tools that do not connect to web applications, indicating the need for clearer communication on the difference between smart diagnostic tools and other digital tools to encourage broader utilization. HVAC diagnostic tool procurement varied widely by employer, with technicians often expected to provide some personal tools while employers typically supply larger refrigerant management equipment. For example, an employee may be responsible for bringing HVAC diagnostic tools and hand tools on their first day of employment, and in other cases, the employer may provide HVAC diagnostic tools but require technicians to bring general hand tools like nut drivers and wrenches. Though there was no clear relationship between company size and smart diagnostic tool utilization, distributors mentioned that younger technicians may be more tech-savvy and interested in smart diagnostic tools compared to older technicians. One distributor observed that larger HVAC firms may have more capital to purchase tools, though outfitting and training a larger crew makes company-wide rollouts more expensive and harder to execute. Smart diagnostic tool integration was more closely tied to technician interest and company implementation strategy than company size, with larger firms facing higher rollout and training costs while smaller firms can more easily standardize uptake across staff.

Use of embedded diagnostics for commissioning is less widespread. Interviewees reported limited use of embedded diagnostic features in residential HVAC systems, despite one distributor noting that these capabilities have existed in higher-tier equipment for over a decade. As this distributor explained, "*the solution [embedded diagnostics] is there,"* suggesting that uptake has lagged behind availability. One HVAC instructor noted that while some systems they use may include embedded sensors, those capabilities are not incorporated into training because accessing manufacturer applications and interpreting data falls outside the core curriculum, and students still need to learn fundamental probe placement and measurement skills.

Although residential HVAC equipment with embedded diagnostics is being installed, barriers remain to using that data for QIV or technology-assisted commissioning. The data is being generated but not retrieved, as noted by all three HVAC contractors, in part because they were unmotivated to initiate a data permissions conversation with customers. Technicians didn't feel equipped to facilitate the conversation and were uncertain of how they would use the data if given access. Overall, interviewees recognized the potential benefits of embedded diagnostics for commissioning but viewed the technology as an emerging area of interest rather than a mature

business opportunity. The sections below focus on technology-assisted commissioning using smart diagnostic tools.

Perceptions of Technology-Assisted Commissioning

All groups of market actors acknowledged that technology-assisted commissioning is likely to play a growing role in the residential HVAC sector. While all respondents were broadly enthusiastic about the transition away from "rules of thumb" toward measured performance, HVAC contractors expressed mixed views compared to other groups.

Contractors reported two primary benefits of technology-assisted commissioning: improved customer trust through transparent diagnostic reports and enhanced remote troubleshooting capabilities. On the other hand, contractors also identified several drawbacks of smart diagnostic tools. The most cited drawback was the higher upfront and subscription costs, and to a somewhat lesser extent, training needs to ensure data quality, which is not guaranteed by using smart diagnostic tools. Accurate use of smart diagnostic tools still requires training on proper sensor placement and ongoing maintenance and calibration of the tools, which may be a large hurdle for contractors with limited commissioning experience. The contractor who uses smart diagnostic tools mentioned logistical issues like battery-related costs, Bluetooth connectivity challenges, and durability concerns compared to analog tools. In terms of batteries, this interviewee stated, "*[smart diagnostic tools] eat batteries on the tools and eat batteries on your iPad. So, you gotta constantly charge. That is the biggest complaint from my technicians.*" Smart diagnostic tools often require paid features for the full benefits, adding more costs compared to conventional tools. Additionally, smart diagnostic tools are limited by Bluetooth connectivity, which can restrict remote monitoring duration and technician mobility on jobsites. For example, technicians may lose connectivity when monitoring an outdoor condenser while working on an indoor air handler. Lastly, there is a durability concern with electronic tools with screens compared to durable analog gauges that may not get damaged during transit between jobsites.

Transparent commissioning reports can help build customer trust by improving understanding of HVAC system performance and repair needs for homeowners while also promoting consistent quality across technicians. Customer transparency was particularly important for the contractor interviewee currently using smart diagnostic tools. According to this contractor, "*The more data you provide a customer builds trust and confidence in who you are. It speaks to you as a company and your level of professional integrity*." Distributors were also widely enthusiastic about enhanced transparency. From their perspective, properly commissioned equipment improved customer satisfaction and performance while also simplifying warranty claims and providing manufacturers with data to improve product design.

Contractors and distributors valued not only customer-facing data, but also the enhanced troubleshooting capabilities smart diagnostic tools provide through remote access to real-time system performance data. One contractor noted, *"If they have a good cell signal, I can remote into their device and see live data and give coaching, which is a big benefit over a phone call,"* highlighting the efficiency and value of remote expert support during commissioning.

Training and Education for Technology-Assisted Commissioning

The overarching goal of distributors and HVAC instructors is to prepare technicians for the future, though distributors focus on best practices while instructors focus on preparing

students for real-world HVAC work across a wide range of field conditions. Both groups consistently emphasized that training and education are essential to the successful integration of smart diagnostic tools. Distributors consistently supported the transition to smart diagnostic tools because they can improve the quality and consistency of installation and service work. Both distributors interviewed mentioned they have conducted live training on smart diagnostic tools in recent years, where they were able to project live system data to demonstrate common issues and troubleshooting approaches. They also highlighted that these tools are increasingly incorporated into continuing education on emerging HVAC technologies, sometimes accompanied by incentives such as discounted smart tools for participants. Lastly, they noted that these tools are beneficial because technical support staff can remotely review system data with field technicians during service calls.

Because HVAC students are likely to encounter both analog and smart HVAC tools when they are in the field, HVAC instructors stressed the importance of proficiency with both. Despite the need to prepare students for varied field conditions, instructors, like distributors, saw value in data-driven commissioning and described a shift away from "rules of thumb" toward verified measurements. One instructor said, "*Data is the only thing we care about. I don't want to hear 'the pipe felt very cold.' I want to hear 'the pipe was 54 degrees.'"* Like distributors, HVAC instructors viewed smart diagnostic tools as valuable training aids and mentioned the benefits of projecting live system data during class to troubleshoot collaboratively with students, observe measurements in real time, and build pattern recognition for common system issues. Both HVAC instructors mentioned the value of guided workflows available in some applications and QIV support. One instructor noted that these workflows can reduce student wait times for instructor assistance during lab work and provide a more reliable learning resource than internet searches or AI tools.

Instructors also identified barriers to broader utilization of technology-assisted commissioning in HVAC education, particularly the higher upfront cost of smart diagnostic tools and administrative purchasing constraints. One instructor noted that large purchases trigger administrative approval, which schools often avoid. Another barrier was the learning curve and effort to integrate these technologies into curriculum delivery.

Interaction with ACCA Quality Installation Guidelines

Interviews also included a discussion of ACCA manuals and guidelines with each participant to assess their awareness and opinions on QIV protocols in general. While the interview guide referenced "ACCA QI/QV" broadly rather than a specific ACCA document, interviewees were generally familiar with ACCA guidance and concepts, though none reported formally integrating them into their training or workflow. Only one contractor reported being familiar with ACCA Quality Install and Verification guidance, and most preferred manufacturer guidance because it more directly addresses equipment-specific requirements and warranty considerations, suggesting the ACCA QIV guidelines play a more limited role in day-to-day field practice.

Discussion

Limitations

There are limitations with both the survey and interview due to the exploratory nature of

this research. First, because the survey was disseminated through individuals who had previously engaged with a commissioning or diagnostic-related project, as well as organizations within the authors' networks, the sample is not representative of the broader industry, which has led to sampling bias within the results. Additionally, the survey has a small sample size due to both low response rates and overall low survey completion rates. This may be a result of the survey length or the timing of data collection, which occurred in the midst of the industry's busier season.

The interview sample, particularly among HVAC contractors, was small and non-random. Because contractor recruitment partially relied on industry contacts, participants were more aware of or interested in smart diagnostic tools than the broader contractor population. In addition, the findings reflect perspectives specific to Wisconsin's residential HVAC market and cold-climate context and should not be interpreted as broadly representative. Rather, the interviews were intended to provide qualitative insight into emerging opportunities, barriers, and implementation considerations for technology-assisted commissioning.

Both the survey and interview encountered challenges related to recruitment. PNNL was unable to widely distribute the survey and therefore relied on targeted outreach with known contractors and industry connections. For future outreach efforts targeting residential HVAC contractors, alternative outreach efforts may be worthy of exploration, particularly engaging and completing data collection during training events or industry meetings. Because there exists an overwhelming bias toward contractors and organizations familiar with or actively using technology-assisted commissioning solutions, future work could focus on sampling the broader contractor population.

Opportunities for Future Research and Skill Development

Compared to the commercial sector, residential HVAC commissioning practices have not been well documented. Therefore, additional insights into these practices can fill critical knowledge gaps. Although there has been previous analysis and identification of business models in the residential buildings and HVAC industry (Better Buildings Neighborhood Program 2012; Brown 2018; Moore 2017), additional research can be conducted to understand how the identified commissioning practices feed into specific business models. Within these business models, innovative practices may be highlighted as best practices for companies interested in integrated commissioning as a typical service offering. While there are resources available to support HVAC businesses in implementing best practices for integrating technology-assisted commissioning solutions (Midwest Collaborative 2026), technology-assisted commissioning using smart diagnostic tools appears to be represented mostly by early adopters. Additional research could analyze the drivers of HVAC commissioning uptake and how factors like company size, access to capital, technical education, demographics, and customer demand may influence implementation. Deeper exploration of approaches for better integrating and communicating the value of commissioning within HVAC sales and service practices may result in mechanisms to improve customer and contractor engagement. Lastly, research can also be conducted to understand the potential for and success of incentives to encourage commissioning implementation, including evaluation of pilot QIV programs, contractor participation dynamics, and the effectiveness of training and incentive strategies across different contractor types.

Research can also be conducted to explore emerging systems to streamline HVAC commissioning. Connected commissioning capable systems, for example, have the potential to reduce the burden associated with commissioning on installing technicians. Connected commissioning utilizes embedded diagnostics, including sensors, and a mobile application to

assist the installing technician in the verification of proper HVAC commissioning, culminating in a connected commissioning report with pass/fail criteria on key commissioning tests. This concept is being explored through collaborations with the Northeast Energy Efficiency Alliance (NEAA), PNNL, the National Laboratory of the Rockies (NLR), and original equipment manufacturers. Uptake of connected commissioning capable equipment can alleviate many of the barriers HVAC companies face when including commissioning as a company practice.

There are also opportunities for skill development related to residential HVAC commissioning practices. Professional development may support business owners and managers integrate commissioning as a part of their typical process, including the potential tools, processes, and staffing structures. Hands-on commissioning training and broader exposure to diagnostic tools may create a stronger foundation for emerging technicians.

Conclusion

This paper presents the findings from two complementary research studies related to residential HVAC commissioning practices. According to the exploratory survey led by PNNL, residential HVAC companies across the U.S. demonstrated variation in commissioning practices. Additionally, commissioning was largely considered a common practice within the survey sample; however, a slightly smaller number of respondents, particularly business owners and sales managers, believe commissioning practices were not well-defined at their company. Commissioning was largely performed on a regular basis, with most respondents performing commissioning during new installations. The authors also identified a series of perceived benefits to commissioning, including reduced callbacks, improved HVAC system performance, and increased customer satisfaction, as well as barriers, including lack of time, additional cost, and lack of training.

Based on the interviews conducted by Focus on Energy, technology-assisted commissioning is viewed as an emerging but increasingly important approach to improving residential HVAC installation, troubleshooting, and training practices. Smart diagnostic tools were widely recognized and valued for their ability to support data-driven commissioning, improve customer transparency, enhance remote troubleshooting, and strengthen technician training, while use of embedded diagnostics for commissioning was viewed as promising but still an early-stage technology in practice. Contractors, distributors, and HVAC instructors all described a broader industry shift away from “rules of thumb” toward verified measurements and performance-based practices, though utilization remains constrained by costs, training requirements, logistical challenges, and limited integration into existing workflows and educational criteria. Together, the interviews suggest that wider integration of technology-assisted commissioning will likely depend on continued training, reduced technology barriers, and stronger integration into both contractor practice and education.

Combined, the survey and interview present a mixed-methods examination into the barriers and opportunities associated with the implementation of commissioning and use of smart diagnostic tools in both a national and state-specific context. Both studies found overall strong awareness of commissioning and associated technologies, as well as benefits including improved customer trust and satisfaction. Key barriers identified through both efforts include those related to costs and training.

Without proper commissioning, homeowners may also face increased energy costs and encounter greater system inefficiencies. Commissioning can serve as a valuable practice to mitigate inefficiencies and faults; however, there are several barriers to implementing these

practices. Identifying how residential HVAC contractors perceive commissioning, as well as the benefits and obstacles associated with performing commissioning, can support the implementation of commissioning in residential HVAC companies.

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