

Heat Pump Quality Installation Adder Executive Summary

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Executive Summary

ComEd contracted with Tierra Resource Consultants, Apex Analytics, and Ennovara (i.e., the research team) to assess the influential factors of Quality Installation (QI) practices on heat pump efficiency and performance, and to identify recommendations for program design modifications and additional research tasks to support the claiming of additional savings from implementation of QI protocols.

ComEd currently offers incentives for central, ducted heat pump systems and mini-split, ductless heat pump systems across multiple EE programs, including Home Heating & Cooling, Home Energy Savings, Multi-family Energy Savings, and Whole Home Electric. As part of the ComEd Energy Efficiency Service Providers (EESPs) and Heat Pump Trained Contractor (HPTC) network, all contractors receive access to training on essential QI elements including system sizing and design, ductwork assessment and sizing, and controls. However, the IL TRM¹ currently requires a derate factor of 10% be applied to all heat pump systems installed with unknown quality to account for improper sizing, refrigerant charge, and airflow². This effectively assumes that almost 98% of systems are not installed according to QI protocols associated with sizing, refrigerant charge, and airflow and reduces claimed savings for program heat pumps. This presents ComEd with a potential savings opportunity, which is the primary motivation for this research. The specific research objectives for this project include:

1. Understand typical components of heat pump QI protocols and the opportunities and strategies for ComEd to integrate heat pump QI practices into program offerings.
2. Understand the relative importance of different aspects of quality installation (QI) practices.
3. Understand the potential for claiming energy savings from improved installation practices.
4. Understand any barriers or challenges that contractors installing heat pumps within ComEd's territory may experience when following QI protocols or specific components of those protocols.
5. Identify strategies, resources, and/or tools for ComEd to help overcome the barriers and challenges to broad use of heat pump QI practices.

The project's research methodology required three primary tasks: 1) a literature review, 2) modelling of energy impacts for control settings and sizing, and 3) market actor interviews. A **Literature Review** was the first task completed to build an understanding of current QI programs, practices, and savings opportunities. The task included a review of 11 QI programs offered by other utilities and 18 relevant studies to define QI practices, identify QI-related savings opportunities for ComEd, document current and past heat pump programs, and summarize value propositions for utility programs, participating contractors, and customers.

¹ This report references the 2025 IL TRM (Version 14.0).

² The 2024 WHE program evaluation found all HPs installed through the program received quality installation. The project team assumes this to be true for 2025, however the evaluation had not been completed at the time of this research.

The **Heat Pump Commissioning Spreadsheet Model Analysis** task included development of a spreadsheet-based model to estimate savings from heat pump commissioning protocols related to controls settings and heat pump sizing. The **Market Actor Research** task included a total of 14 interviews across three groups of industry professionals. The topics covered during the interviews with each group include:

- **HVAC Industry experts (3):** Typical elements of QI, contribution to energy savings, technical underpinnings, data available to support modelling, and programs to interview.
- **Residential HVAC program administrators and implementers (5):** Program goals and objectives, program design approach, QA/QC requirements and verification protocols, and tools and training provided.
- **ComEd HVAC contractors and distributors (6):** QI training provided; Frequency, perceived difficulty, relative effort (time and cost), and tools used to complete QI elements; typical barriers and relevant solutions; common control settings and sizing practices to inform modelling, and opportunities for ComEd program support.

Key Findings

The following summarizes key findings from each chapter in this report.

What is Quality Installation?

Quality Installation, as defined by the academic literature, includes five key elements that ensure the heat pump performs to its rated efficiency³:

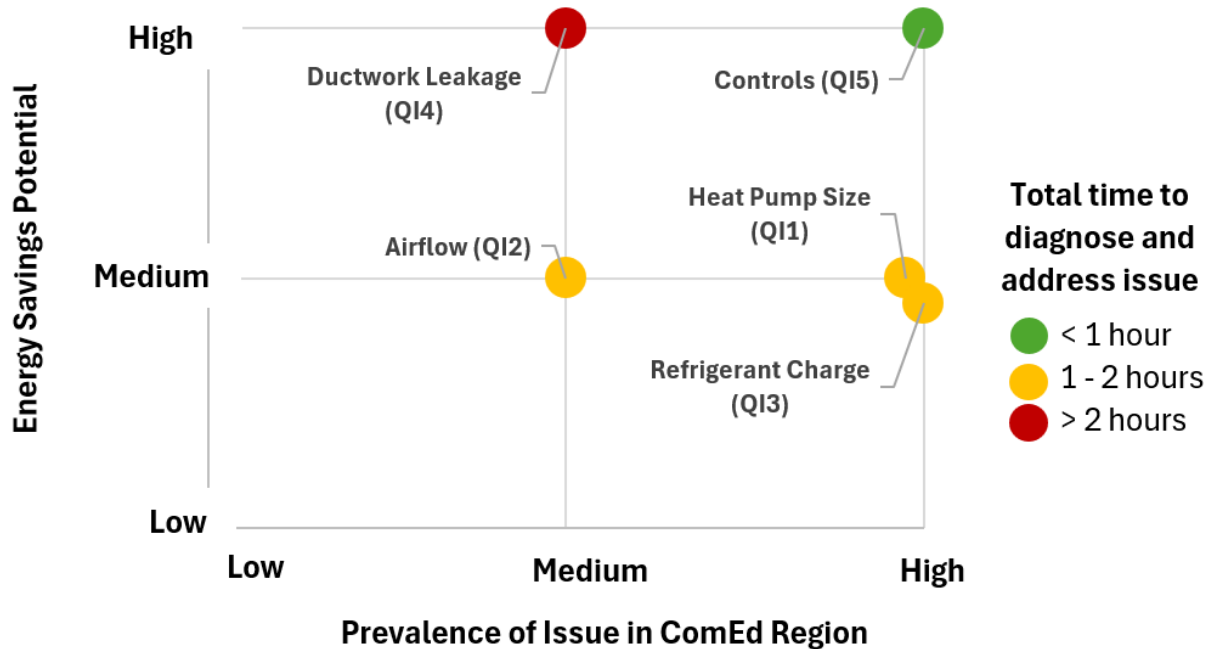
- **Heat pump size (Q11):** the heat pump is sized to meet the building’s heating and cooling loads and is not over- or under-sized (within ½ ton).
- **Airflow (Q12):** the airflow at the air handler is within ±15% of the design airflow.
- **Refrigerant charge (Q13):** the refrigerant charge matches the manufacturer’s specifications and leaks have been eliminated/avoided.
- **Ductwork leakage (Q14):** Duct leakage to the outside is minimized (applicable only to homes with ducts outside the conditioned space).
- **Controls (Q15):** switchover temperature (for dual-fuel systems) and auxiliary and compressor lockouts (for all-electric systems) are optimized to minimize the use of the backup heating system.

Figure 1 shown below summarizes the relative prevalence, energy impact, and required time to address each QI element. This indicates that Controls (Q15) issues are prevalent in ComEd territory, that they represent the highest opportunity for energy savings compared to other QI elements, and that they can be addressed with less than an hour of effort. Heat Pump Sizing (Q11) represents the next best opportunity given the high prevalence of sizing issues in ComEd territory, moderate energy savings yield, and moderate effort required. Rectifying ductwork issues (Q14) represents a high energy savings opportunity, but it is only moderately common, and it requires more labor to resolve.

³ While academic literature cites these 5 elements of QI, the derate factor for residential heat pumps included in the IL TRM only accounts for sizing, airflow, and refrigerant charge.

While refrigerant charge (Q13) issues are likely common in ComEd territory, they yield moderate energy savings opportunities and require greater effort to check for leaks. Lastly, airflow (Q12) is moderately prevalent across ComEd territory, and it offers moderate energy savings potential for a moderate time expenditure.

Figure 1. Prevalence of QI Issues vs. Energy Savings Potential⁴



Quality Installation Programs

The research team conducted a literature review of 11 current and past heat pump programs and interviewed five program administrators that offer QI to gain deeper insights into their current practices and past experiences. The literature review explored key trends and findings related to program/entity size, income eligibility, types of incentives, use of tools, contractor networks, training, and more. The following findings are presented in order of relative importance for ComEd to consider when implementing program design modifications.

- Financial Incentives:** Program incentives ranged from \$75 to \$300 per project for QI-specific programs. For two-thirds of these programs, incentives went to the consumer, while contractors received the remaining third. For programs with QI embedded into the heat pump program, financial incentives specific to performing QI were not identified.
- Smart Diagnostic Tools:** Some utilities with QI-specific incentives required the use of MeasureQuick, which helps automate data collection and performance analysis. Notably, none of the utility programs that embedded QI within their overall heat pump program incentive required smart diagnostic tools.

⁴ For Prevalence, Low: <20%; Medium: 20-50%; High: >50%, For Energy Savings, Low: <5%; Medium: 5-10%; High: >10%, The graph reflects energy savings for a VSHP

- Contractor Networks and Certifications:** Most of the programs researched required heat pump installers to be in a closed contractor network. To join a contractor network, typical contractor training includes completing a heat pump training sponsored by the utility or completing a manufacturer-specific heat pump training (e.g., by any manufacturer selling ENERGY STAR® heat pumps).
- Programs in States with QI TRM Measures:** Most entities that offer a QI-focused heat pump program are in states that have a QI measure in their respective TRM. For programs located in states with a QI TRM measure, it is unknown if they are claiming savings across all QI elements.
- Duct Leakage:** While duct leakage is included in industry standard HVAC QI protocols (e.g., ACCA Standard 5), duct leakage testing was noticeably not required across any heat pump programs reviewed. Heat pump programs typically recommend visual inspection of ductwork to check for obvious leaks. While important to heat pump performance, duct leakage is typically treated separately from heat pump installations from a programmatic standpoint.
- Entity Size:** The research team was asked to identify trends between entity size (i.e. program participation or utility customer base) and QI program requirements. Entity size was not found to be a driver of the number of QI elements required. However, utilities with greater QI requirements can offer higher heat pump rebates to compensate contractors for the associated, additional effort.
- Income Eligibility:** Among the programs reviewed, the QI requirements and associated incentive levels did not vary based on customer income eligibility (i.e. market rate vs. income eligible). However, among those programs with QI embedded into their overall heat pump incentive, many did offer higher heat pump incentives to their income eligible customers, rather than offering higher QI-incentives.

The research team conducted interviews with representatives from Efficiency Maine, Arizona Public Service (APS), Tucson Electric Power (TEP), National Grid / Mass Save, and Xcel Energy. Each program model is summarized in Table 1.

Table 1. Downstream Program Summary Table

Provider	Model Philosophy	Primary QI Requirement	QA/QC Method	Key Takeaway
Efficiency Maine	Partnership & Simplicity	Attestation to a checklist (submission not required)	25% random post-install virtual QA	Reducing friction by removing prerequisites is key to broad contractor uptake. Note: QI is secondary to increasing electrification.
APS	Enforcement & Standards	Submission of detailed test-in/test-out data for 100% of jobs	100% desk audit, 30% random field inspections, with penalties for failure	Focus incentives on verified installation quality, not just equipment efficiency.

Provider	Model Philosophy	Primary QI Requirement	QA/QC Method	Key Takeaway
TEP	Technology & Automation	Use of MeasureQuick software for 100% of installs	Review of geolocated, timestamped data from MeasureQuick; 20% random field inspections	Technology can reduce contractor burden while dramatically increasing data reliability.
National Grid /Mass Save	Tiered Network for Market Differentiation	Adherence to advanced practices for voluntary, higher-tier leaders network	25% random QA for base network; planned "enhanced inspections" for leaders	A tiered network can drive quality through market differentiation and lead generation.
Xcel Energy	Increasing Rigor	Submission of a detailed commissioning form	Random post-install inspections (minimum 1 per contractor/season)	Transitioning from a simple to rigorous QI program requires careful contractor management.

Quality Installation Treatment in Illinois TRM

The Illinois TRM currently applies individual derate factors to both the cooling (Derating_Cool) and heating efficiency (Derating_Heat) ratings for heat pumps installed in Illinois programs. The derate factors are set to 10% for the baseline equipment, 10% for efficient equipment installed without quality installation, and 0% for efficient equipment installed with quality installation. The derating factors do not cite a rigorous study, and are stated to include "refrigerant charge, evaporator airflow, and unit sizing." Neither the TRM, nor the literature review conducted by the research team, identified the influence of each individual QI element on the overall derate factor or claimable savings opportunity. In the absence of additional data, the research team believes that it is reasonable to assume that each element (refrigerant charging, airflow, or sizing) provides approximately 3.3% savings. In addition, the derate factors do not account for controls or duct sealing measures. The derate factors are applied by multiplying the consumption by $1/(1-\text{derate factor})$. This means that the derate factors effectively increase savings for heat pump measures installed without quality installation by 11% relative to not including factors (i.e., $1/(1-10\%) - 1/(1-0\%) = 1.11 - 1 = 11\%$).

The TRM includes a separate HSPF2_ClimateAdj factor that is separate and is only a function of climate. This should not be confused with the heating and cooling derate factors that account for quality installation.

The TRM does not include any impact adjustments for controls in all-electric heat pumps. There are no stated control assumptions for cold climate heat pumps installed as full-displacement systems. In this case, the heat pump is assumed to cover the entire load, with annual heating load calculated using a table of effective full load hours (EFLH) and the heat pump heating capacity at 47 °F. For dual-fuel, partial displacement heat pumps, the TRM does state different Heat Load Factors as a function of switchover temperature.

The TRM does not state different assumptions for midstream vs downstream. However, it does include baseline efficiency assumptions for midstream and an early retirement fraction for programs where the early retirement fraction is not known.

The early replacement rates listed in the TRM do not include treatment of the fraction for program-induced conversions from gas furnaces to heat pumps. This implicitly means that for programs that do not track baselines, dual fuel heat pumps have dual fuel heat pump baselines and all-electric heat pumps have all-electric heat pump baselines.

Quality Installation Savings Opportunities

The research team developed a spreadsheet model to assess savings potential from QI elements. To align with how savings are currently captured in the Illinois TRM, we summarize our findings for savings opportunities in three groups 1) Refrigerant Charge, Airflow, and Sizing, 2) Duct Sealing and Insulation, and 3) Heat Pump Controls Commissioning.

- **Refrigerant charge, airflow, and sizing.** The Illinois TRM currently includes a “derate factor” within HVAC calculations for improper refrigerant charge, airflow, and sizing, which can be eliminated with quality installation of program equipment.
 - The 10% derate factor for conventional heat pumps installed with typical controls is reasonable.
 - Based on engineering judgement and modeling, we recommend dropping the heating and cooling derating factors for variable speed heat pumps to 3.3% and 5% from 10% and 10%, respectively. There are limited savings from improvements to refrigerant charge, airflow, and sizing of variable speed cold climate heat pumps, because these systems are more resilient to variations in airflow and sizing practices. Refer to Section 6 for additional detail.
 - The team suggests further research to develop more robust estimates of VSHP. heating and cooling derate factors, starting with a focused review of recent academic literature focused on airflow impacts, comparing those to airflow impacts on single speed heat pumps.⁵
- **Duct sealing and insulation.** Duct sealing and insulation is a separate measure in the Illinois TRM. The research team conducted a cursory review of the duct sealing savings in the TRM which did not result in any actionable recommendations to savings algorithms or assumptions for this measure.

In the IL TRM, when the 10% derate factor was under development, duct leakage was considered but ultimately not included in this derate factor (e.g., the derate factor is based on proper refrigerant charge, airflow, and sizing only).
- **Heat pump controls commissioning.** The Illinois TRM does NOT include any measure associated with heat pump control commissioning. The research team modeled a wide variety of auxiliary heat lockout, compressor lockout, and switchover temperatures for both conventional equipment and variable speed cold climate equipment.

⁵ The existing source cited in IL TRM v14.0 does not include specific study citation and is identified in the TRM as an assumption that would benefit from further study or evaluation.

Based on the results of the modelling, controls commissioning offers the highest savings opportunity, with expected savings of 8-37% for dual fuel heat pumps and 13-19% for all-electric heat pumps, assuming 75% compliance among program contractors. Refer to Section 6 for additional information.

Stakeholder Challenges and Opportunities

The literature review and market actor interviews uncovered the following barriers to QI adoption for market actors, customers, and utilities.

Market actor barriers include:

- **Knowledge and Skill Gaps:** The most significant barrier we identified is the gap between performing a task and performing it correctly for optimal energy performance. The most prominent example being controls settings where significant savings are consistently lost due to contractor knowledge gaps.
- **Technical and Data Hurdles:** In many cases, the effectiveness of foundational QI software for Manual J and Manual S calculations is being undermined by poor input data, such as a lack of manufacturer data available in general and "even less available for inverter-driven units."
- **Economic and Business Pressures:** Contractors must balance technical requirements and best practices with the economic realities of running a business. Certain QI tasks, such as air flow and duct testing, present a conflict between time, cost, and perceived customer value.
- **Customer Awareness and Education:** Contractors often bear the primary responsibility for educating consumers about heat pumps. The challenge becomes all the greater when the contractor must then also upsell the value of a quality installation. This feedback points to a market-level barrier that ComEd can address through a broad, trusted education campaign.
- **Programmatic Barriers:** In addition to the market wide barriers, there are several programmatic barriers including:
 - **Level of effort required to obtain the rebate:** Trade ally complaints frequently focus on rebate amounts that do not adequately cover the extra paperwork and labor costs associated with extra time required for QI.
 - **Training Costs and Time Considerations:** Training costs and the time commitment for the training are often perceived as a burden, particularly for smaller firms. Even if training costs are subsidized, the time spent learning takes time away from income-earning pursuits.
 - **Upfront Costs:** Contractors must be willing to invest in the cost of physical and digital tools needed to do so. A contractor new to QI must be prepared to spend several thousand dollars to acquire tools beyond those needed for standard installations.
 - **Ongoing Fees:** Ongoing fees associated with QI include: (1) certifications, and (2) software subscriptions. Although these software fees become more economically feasible as contractors use them for more jobs, contractors may hesitate to begin paying for subscription fees when they don't know the volume of projects they will use them for.

Customer barriers include:

- **Cost:** The financial barrier is compounded for jobs involving quality installation. Because customers are unaware that contractor installation practices vary, let alone being aware of the benefits of QI, they are frequently unwilling to pay higher prices for it.
- **Time:** Conducting QI practices requires additional time onsite, which may be a burden to some customers. Added time onsite, and the associated cost of that time, varies depending on which QI elements the program focuses on.
- **Lack of Information:** The cost and time barriers to QI are underlaid and exacerbated by a lack of public awareness about the benefits of quality installation.

Utility barriers include:

- **Incentive structure:** Incentives can apply to the completion of QI, or QI can be required to receive any heat pump incentive. They can be paid on a per-project basis to the customer or to the contractor, and/or they can also include contractor reimbursements for tools or certifications.
- **Administrative burden:** Conducting QI requires both additional steps in the heat pump installation process and more data collection. If ComEd wants verification, this also adds to the administrative overhead. The amount of overhead depends on the number and type of QI practices required, as well as on the processes and tools used for data collection.

Recommendations

Based on the findings above, the research team developed a set of recommendations grouped into two areas: 1) next steps for updating the IL TRM to claim additional savings and 2) program design considerations for further integrating QI concepts and protocols into existing heat pump programs.

The team recommends pursuing a comprehensive QI offering that focuses on heat pump controls and refrigerant charge, with airflow and sizing impacts from the TRM QI derate factors mitigated for VSHPs via an update to the existing TRM algorithm. These offer the best combination of relatively high savings without significant incremental work from contractors to perform and document the QI. The team also recommends that ComEd explore additional sizing and airflow offerings, which would position ComEd to claim more savings from conventional heat pumps. These approaches would benefit both midstream and downstream programs.

The research team identified three pathways for claiming additional savings related to HP performance and QI protocols.

Pathway #1 - Adjust the current savings calculation for all-electric heat pumps in the IL TRM for non-optimized heat pump control settings (High Savings, Moderate Effort). The TRM does not currently account for different control settings for all-electric heat pumps. The team recommends adding a controls derate factor to the existing TRM algorithm for all-electric heat pumps. This recommendation has significant savings potential backed by evidence from industry experts and modelling. It would require relatively low contractor effort to implement and record optimal settings, while maintaining customer comfort and satisfaction.

Additional research – including a baseline study, additional contractor interviews, and field testing - is recommended to refine assumptions, inform program design, and verify savings. The additional research would better document current distribution of auxiliary lockout and compressor lockout temperatures.

These assumptions could then be used with the controls modeling results in this study to derive controls derate factors that would be applied to the baseline and efficient equipment in the absence of a controls QI protocol being followed.

We recommend exploring the possibility of adding a controls derate factor to the IL TRM with the Stakeholder Advisory Group (SAG) before conducting the additional research that will be used to derive a new controls derate factor. The proposal should include a proposed algorithm change, the justification for that change, and a summary of the proposed research that will be used to develop the initial controls derate factor.

In addition, ComEd should formulate a proposed controls QI protocol and gather feedback from contractors. The controls QI protocol should include removal of compressor lockout (except for built-in low pressure cutout on the compressor) and a maximum aux lockout for VSHP and conventional HPs.

Adding this controls derate factor would increase savings, even before doing this additional research to get better controls installed. Just like the existing non-zero QI derate factors increase savings relative to a case with zero QI derate factors in the baseline and efficient cases, adding a non-zero controls derate factor to the heating savings equation would increase savings by increasing consumption of the baseline (and efficient case) equipment.

Pathway #2 - Reduce the IL TRM QI derate factor applied to VSHPs because their performance is less impacted by QI issues related to sizing and airflow restrictions (Moderate Savings, Low Effort). This recommendation has a moderate level of savings potential because it only applies to VSHPs and does not impact program administrators or work performed by the contractor.

Modeling showed that VSHPs being sized larger produced significant decreases in consumption, rather than increases, as assumed in the TRM. Engineering analysis showed that VSHPs are less likely to have significant losses due to low airflow, because they run at part load (with lower airflow and lower duct static pressure) most of the time, when airflow impacts will be minimal or non-existent, while conventional single stage heat pumps run at full output all the time and will suffer from high duct static pressure limiting airflow and decreasing efficiency. The team recommends pursuing refrigerant charge training and documentation through downstream program offerings of VSHPs, which should support reducing the QI heating derate factor to 0% and the QI cooling derate factor to 2% for downstream program VSHPs.

The additional effort includes building consensus among utility evaluation teams and working group members to support this modification in the TRM. The team recommends sharing either this report or an excerpt from this report with a group of IL TRM stakeholders, adding a TRM update request to the IL TRM v15 update request tracker, then presenting the recommendation and rationale for updating the VSHP QI derate factors.

The specific request should be to reduce the QI heating and cooling derate factors for VSHPs from 10% to 3% and 10% to 5% respectively, and specifying that a refrigerant-only QI protocol is sufficient to achieve 0% and 2% derate factors for VSHPs, for heating and cooling, respectively.

The team also recommends building out refrigerant charging protocol and documentation and additional training of contractors to follow the protocol.⁶

Pathway #3 - Explore adjustments to the IL TRM QI derate factor for heat pumps installed through ComEd programs to reflect the baseline refrigerant charge, airflow and sizing practices in ComEd territory and differences between programmatic and non-programmatic installations (Moderate Savings, High Effort). This would apply to all heat pumps rebated through the program, and not just VSHP as noted. This recommendation has moderate savings potential and additional baseline research and lab testing is required to refine assumptions, inform program design, and verify savings.

In addition, the team recommends requesting a TRM update to add a derate factor option for equipment with a QI protocol that includes refrigerant charge only (6.7% derate factor). With this adjustment and the controls and VSHP options identified above, ComEd could add quality installation requirements focused on controls and refrigerant charge and apply these to both VSHPs and conventional high efficiency equipment. While the refrigerant charge and controls version of QI is what the research team recommends pursuing first, there are still benefits of sizing and airflow QI in conventional HPs, if ComEd offers incentives for that equipment.

The research team suggests that ComEd consider integrating the following recommended elements into its heat pump program design to support QI adoption and realize additional energy savings. These recommendations represent a process to follow rather than a list to choose from.

- **Program Objectives:** Align QI requirements with overall program objectives to maximize savings and/or encourage HP adoption. Programs prioritizing heat pump performance and energy savings – such as ComEd - should consider more stringent QI requirements.
- **Value Proposition:** Construct a comprehensive value proposition that defines the QI benefits for contractors (e.g., greater customer satisfaction, fewer call backs), customers (e.g., bill savings, increased comfort), and ComEd (e.g., energy savings, increased net benefits to customers) to encourage adoption of QI practices and achieve program objectives.
- **Contractor Network Structure and Incentives:** Establish an elite or preferred contractor tier that distinguishes and rewards contractors that consistently meet QI requirements, including preferential placement on service provider directories and incentives for top performers.

⁶ The team recommends that the protocol should include measuring the required refrigerant line length, then following manufacturer's recommendation to determine proper charge, then weighing in the proper charge. The documentation should include the line length and the manufacturer's recommended charge, and either that the shipped charge is within 5% of the recommended or the charge weighed in is within 5% of the recommended.

- **QI Protocols and Data Requirements:** Define QI protocols and associated data requirements for controls, sizing, refrigerant charge, and airflow that will yield energy savings while minimizing contractor burden.
- **Tools:** Require contractors to use a standardized digital tool set to perform the required QI activities and measurements and consider subsidies (partial or full) to address financial barriers and encourage adoption.
- **Training:** Provide multiple training options (third-party, manufacturer/distributor, and ComEd-specific) for contractors that focus on high-impact gaps in current QI practices and provide a clear pathway to qualify for elite/preferred contractor status.
- **QA/QC Processes:** Amend existing ComEd quality assurance protocols to focus attention on newly mandated QI practices that will increase savings. Specifically, establish QA/QC protocols that require 100% desk audits of rebate applications and randomized field inspections of 25% of projects per contractor per year to ensure implementation of QI protocols and provide supporting evidence for savings claims.

While the elements addressing QI protocols and Data Requirements, Tools, and Training will be most central to realizing the additional savings opportunities discussed in this report, the earlier steps, including Program Objectives, Value Proposition, and Contractor Network Structure and Incentives are foundational to realizing those savings. Each of these brief recommendations are explored in more depth in Section 8.0 Recommendations, including discussions of the central role of each element, how that element supports increased savings, recommended research and next steps.