Workforce Readiness to Decarbonize the Building Sector While Improving Efficiency and Affordability

Lauren Bates, E Source
Jen Loomis, PhD, E Source

ABSTRACT

Successful building decarbonization at scale requires a workforce that is knowledgeable and skilled at replacing gas end-uses with electric ones and conducting work in a way that minimizes increased costs to customers. This paper synthesizes research and evaluation findings from different facets of residential building decarbonization—heat pumps, weatherization, and home electrical systems—derived from studies completed in three different states. We summarize contractor practices for sizing and installing heat pumps, weatherizing homes, and managing increasing home electrical loads, as well as training associated with these practices in the three states. We also describe contractors' preferences for training sources and the effectiveness of different training formats. Together, these findings illustrate workforce strengths and training needs to advance home decarbonization while avoiding unnecessary costs like electrical panel and service upgrades.

Introduction

Building decarbonization is a high priority for states and municipalities across the nation, but electric end-uses, such as heat pumps, can be more expensive than their gas alternatives, work less efficiently in poorly weatherized buildings, and may require costly electrical panel upgrades (Opinion Dynamics 2025c). Successful building decarbonization at scale requires a workforce that is knowledgeable and skilled at replacing gas end-uses with electric ones and conducting work in a way that minimizes increased costs to customers. Yet, decarbonization technologies and strategies are new to contractors in several areas of the United States (Opinion Dynamics 2022). If states and municipalities are to reach their decarbonization goals, then a trained workforce that is skilled and knowledgeable about essential topics such as how heat pumps differ from other heating systems, how well sealed and insulated homes promote efficiency and heat pump performance, and ways to manage increasing electrical loads in homes is essential.

This paper synthesizes research and evaluation findings from different facets of residential building decarbonization: heat pumps, weatherization, and home electrical systems. Our data sources are Opinion Dynamics' recent evaluations of residential heat pump programs in multiple US states, including California, New York, and Illinois, as well as market research studies in the same states. In California, we completed evaluations and market assessments for the TECH Clean California program. TECH Clean California, launched in late 2021, is a market transformation program that incentivizes installations of space-conditioning and water-heating heat pumps in existing residential buildings (Energy Solutions 2026). It also promotes no-cost heat pump trainings to contractors. We are also conducting research on tradesperson knowledge, practices, and training on Power Efficient Design (PED, also known as electrical panel optimization, low-power electrification, or the Watt Diet approach) in the state. From Illinois, we provide findings derived from a 2025 market research study (Bates 2025) of residential HVAC

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

contractors conducted alongside our portfolio-wide evaluation of Ameren Illinois Company's energy efficiency programs. New York findings, which can inform cold climate areas, come from our 2025 evaluation of the New York State Energy and Research Development Authority's (NYSERDA) Comfort Home Program. This program aims to make homes "heat pump ready" by addressing building envelope and weatherization deficiencies (NYSERDA 2026). Across these studies, we used a combination of surveys and interviews with contractors, literature reviews, and analysis of secondary data.

Based on these data sources, we first summarize contractor practices for sizing and installing heat pumps, weatherizing homes, and managing increasing home electrical loads. Second, we illustrate challenges getting weatherization contractors to support heat pump installations and to contractors using Power Efficient Design (PED) strategies to reduce the need for costly electrical panel upgrades. Third, we describe contractors' preferences for training sources, the effectiveness of training formats, and the availability of training on PED. Together, these findings inform the state of the workforce installing heat pumps, coordination among trades, and what is needed to advance building decarbonization while avoiding unnecessary costs.

All three of these states have decarbonization goals driving climate policies and utilities programs. California has some of the most comprehensive and ambitious clean energy policies in the world. For example, in 2018, the state adopted aggressive greenhouse gas emission reduction targets, including returning to 40% below 1990 by 2030, and carbon neutrality by 2045 (State of California 2026). More recently, in June 2025, the CPUC issued Decision 25-06-034 directing staff and the commission's TECH Clean California program implementer to begin creating educational resources about alternatives to electric and service panel upsizing that can later be used by the state's electric utilities as part of their customers' application for service upsizing. These actions are intended to help Californians avoid service and panel upgrades and help utilities avoid front-of-the-meter upgrades. In Illinois, the 2021 passage of Illinois Public Act 102-0662 (the Climate and Equitable Jobs Act or CEJA), increased market focus on electrification and prompted utilities to embark upon decarbonization efforts (https://dceo.illinois.gov/ceja.html). In 2019, New York State signed the Climate Leadership and Community Protection Act (Climate Act) to address climate change threats. The Climate Act, effective January 1, 2020, established energy savings and carbon reduction goals, including 100% carbon-free electricity generation by 2040, and at least an 85% reduction in emissions compared to 1990 levels (The New York State Senate 2019). Despite these drivers, research and evaluation studies illustrate remaining needs for contractor training.

Contractor Decarbonization Practices

In this section, we address contractor practices for sizing and installing heat pumps, weatherizing homes, and managing increasing home electrical loads.

Heat Pump Practices

Proper sizing of HVAC heat pump systems is essential to ensure occupants receive the expected thermal comfort and that the systems deliver the energy performance specified by manufacturers (Kaltreider et al. 2024). Manual J load calculations Tare the recognized method for sizing HVAC heat pumps because they systematically estimate heating and cooling loads based on building characteristics. In practice, however, they can be time-consuming, sensitive to

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

input assumptions, and prone to oversizing when contractors add safety margins or use simplified approaches. Our evaluation study findings show that in practice, contractors are mixed in how often they invest time in completing the more robust sizing practices found with Manual J calculations.

According to survey data collected in December of 2023 from 64 HVAC contractors enrolled in TECH Clean California, just over half (39 of 64; 61%) always or often perform Manual J load calculations when sizing a heat pump in a replacement project (Opinion Dynamics 2024a); twenty percent (12 of 64) rarely or never do. This is despite load calculations being required in California for several years.

California contractors surveyed in 2024 were fairly confident in their ability to sell, size, install, service, and maintain HVAC heat pump equipment in single-family homes (Figure 1; Opinion Dynamics 2025a). Over two-thirds of all contractors (between 64% and 79%) reported being "extremely confident" in selling, sizing, installing, servicing, and maintaining heat pumps. This was an improvement in their level of confidence compared to the market assessment one year before. With the exception of installing HVAC heat pumps, Opinion Dynamics' (2024b) Time 1 Market Assessment found that less than half of contractors (between 33% and 48%) were "extremely confident" in selling, sizing, servicing, and maintaining heat pumps in single-family homes. Sizing of HVAC heat pumps, however, was one of the lower-rated skills, with 67% extremely confident in their abilities. It is hard to know whether these highly confident contractors are using proper techniques, such as the Manual J calculations.

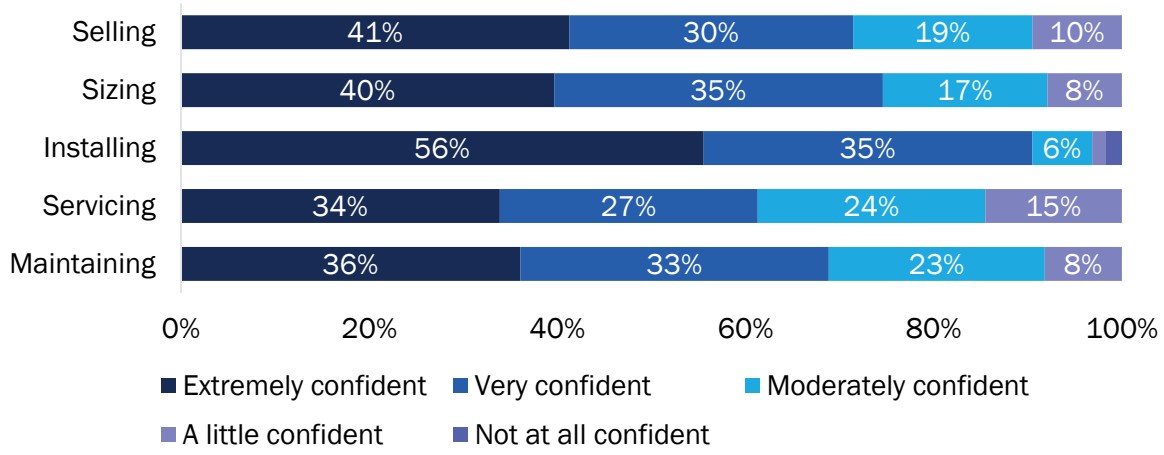

Figure 1. California Contractors' Self-Reported Confidence with HVAC Heat Pumps

In Illinois, HVAC systems need to contend with low temperatures that can persist for days and even weeks. Gas furnaces are the preferred HVAC system in most homes, but HVAC contractors have begun to embrace cold climate heat pumps (ccHPs) to meet their customers' needs and to take advantage of utility incentives, such as those offered by Ameren Illinois. Interviews with 15 HVAC contractors working across Ameren Illinois' territory in central and southern Illinois showed that two-thirds of contractors would recommend a natural gas furnace to a customer 80% of the time or more (Bates 2025). However, all the contractors interviewed reported selling and installing heat pumps, even if they didn't necessarily recommend them to every customer. Table 1 shows the systems each of the interviewed contractors reported selling and installing. Four of the contractors sold and installed only ccHPs, including with hybrid

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

systems. All four said they only install ccHPs for performance reasons. For instance, one contractor emphasized they would not want to sell someone a heating system that could not heat in 25°F weather or below. Another contractor said they don't like customer callbacks and would rather have a heat pump that works in the event of an extreme cold snap.

Table 1. Traditional heat pumps, ccHPs, and hybrid systems sold and installed (n=15)

Contractor	Heat Pump Systems			Dual Fuel/Hybrid Systems	
	Traditional Heat Pumps[a]	Ducted ccHPs	Ductless ccHPs	With Traditional HP	With Ducted ccHP
1		✓	✓		✓
2		✓	✓		✓
3		✓	✓		✓
4		✓	✓		✓
5	✓	✓	✓	✓	Rarely
6	✓	✓	✓	✓	Rarely
7	✓	✓	✓	✓	Rarely
8	✓	✓	✓	✓	Rarely
9	✓	✓	✓	✓	Sometimes
10	✓			✓	
11	✓		✓	✓	
12	✓			✓	
13	✓			✓	
14	✓		✓		
15	✓		✓		
TOTAL:	11	9	12	9	9

Note: Contractor names have been removed for anonymity, and arbitrary numbers have been assigned instead.

[a] All contractors who reported installing traditional heat pumps installed ducted and ductless systems.

As shown in Table 1, three other contractors did not sell or install ccHPs at all, while an additional three contractors did not sell ducted ccHPs but nonetheless sold *ductless* ccHPs. We asked the six contractors who did not sell or install ducted ccHPs their reasons for avoiding these systems. Two were unfamiliar with the latest ccHP technology. One contractor was especially surprised to learn there are heat pumps currently on the market that can heat a home with outdoor temperatures at or below 20°F. Two other contractors mentioned the high cost of ducted ccHPs. One of these contractors said cold climate ductless heat pumps are more affordable than ducted cold climate heat pump systems and work as effectively and efficiently for customers looking to install heat pumps. One contractor said they are fairly limited in the types of systems they can sell and install for their customers. As a participant in a state incentive program, this contractor claimed they could only install a new system of the same type as the existing one to qualify for the state rebate, and none of their customers already had a ccHP. The final contractor said they are aware of the technology and will consider selling it once it becomes more prominent on the market.

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

Thirteen of the contractors explained the circumstances when they would recommend a heat pump to a customer as well as when they would not. Contractors typically recommended heat pumps to customers interested in transitioning away from natural gas, propane, or oil heating (5 contractors) or to customers who want to lower their energy bills (4). Other reasons were customers' homes already being all electric (3), availability of rebates (3), the customer already had a heat pump (2), or the customer has or will install solar (2). In contrast, contractors described circumstances when they would *not* recommend a heat pump. The most frequent reason was customer budget constraints (6), followed by unsuitable home configurations or specifications (such as poor home insulation, 5 contractors). Four contractors mentioned concerns about cold climate performance, while two were far less likely to recommend a heat pump when the home already had a gas furnace.

Weatherization Practices

A key objective of NYSERDA's Comfort Home program is to prepare homes to be "heat pump ready." The Program aims to create a strong market for the transition to heat pumps by incentivizing building shell improvement packages designed to reduce homes' heating and cooling loads in preparation for heat pump installation and offering pathways for customers to install heat pumps.

At the time of our program evaluation, Comfort Home offered incentives for implementing standard load reduction packages, primarily focused on envelope improvements. There were three load reduction packages: A ("Good"), B ("Better"), and C ("Best").

- Package A (Good): Air seal attic, insulate attic, and/or seal and insulate rim joists. Customers must install at least one of these improvements, and the end condition of the home must meet minimum envelope performance criteria.
- Package B (Better): Option to either insulate above-grade walls and floors to achieve 100% insulation of wall and floor area or insulate the basement foundation walls to extend at least 18 inches below exterior grade level. This package also included sealing and insulation of various interstitial spaces found in homes that can contribute to heat loss and air infiltration and projects that redefine the thermal envelope of the home by moving the air and thermal barrier from the ceiling to the roofline to "bring the attic inside."
- Package C (Best): Replace windows with new ENERGY STAR® or equivalent windows so that the end condition of the home has a minimum of 80% ENERGY STAR® rated windows.

For customers to be eligible for Package B, their homes were required to also meet Package A requirements, such as by already having an insulated attic. To be eligible for Package C, homes had to also meet Package A and B requirements. Figure 2 shows measure installation rates from January 2020 to April 2023 (Flanders, Bates, and Siddiqui 2025).

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

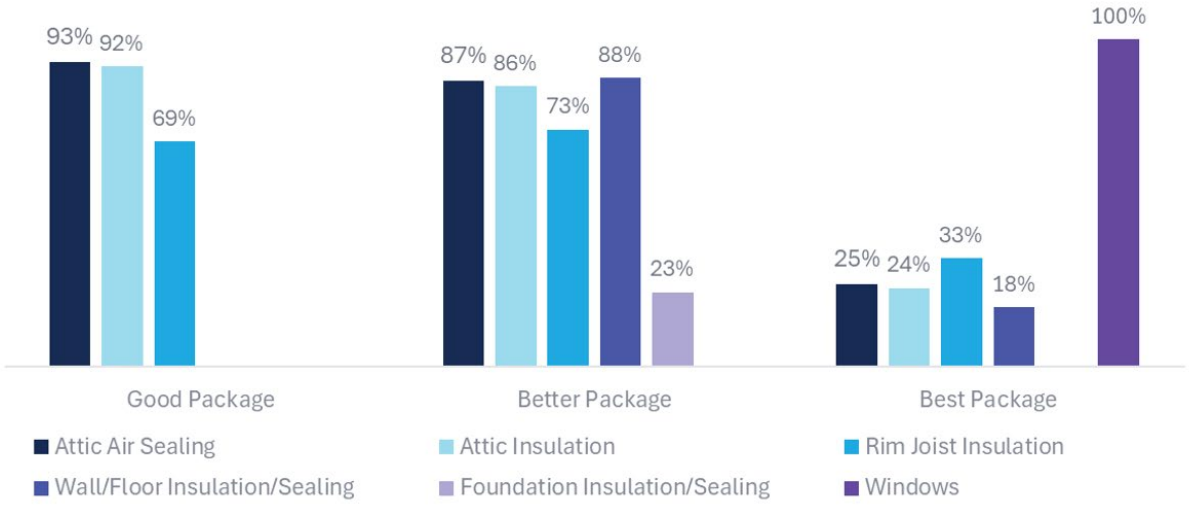

Figure 2. Installation Rates for Comfort Home Measures by Package (n=1,939 households)

Crucially, the program seeks to educate customers about heat pump technologies and connect interested participants with qualified heat pump installers. Participating contractors either delivered both envelope improvements and heat pump installations or focused solely on envelope upgrades to prepare the home for a future heat pump installation, after which they could refer the customer to a qualified air source or ground source heat pump installer. Contractors who referred customers to a qualified heat pump installer were eligible for an additional heat pump referral incentive. To qualify, the heat pump had to be installed within 24 months of the load reduction package completion. These incentives were paid to the contractor, who could choose to pass them on to the customer.

A critical question for the program staff was how frequently the weatherization contractors referred customers to heat pump installers. The evaluation team interviewed 11 weatherization contractors (out of the 39 such contractors participating in the program between January 2020 and April 2023). We asked Comfort Home contractors if they discussed heat pumps with customers at the time of the Comfort Home upgrade and why they may or may not discuss this with customers. While six of the eleven interviewed contractors offered heat pump installation services, only one contractor indicated they discussed heat pump readiness as part of their general customer education for the program at the time of the audit. In contrast, more contractors said they discussed heat pumps after the customer signed the contract and they began the upgrade work: three contractors reported that they rarely mentioned heat pumps, five said it depended on the situation, and three contractors stated they always discussed heat pumps with customers. Three contractors refrained from discussing heat pumps extensively, as they were concerned about overwhelming customers with additional costs.

Several factors influenced contractors' decisions about whether it was worthwhile to address heat pumps with customers:

- Home factors: Five contractors said that aspects of individual homes, like the age of existing equipment, fuel type, and home size, determined whether they thought it was worthwhile to discuss heat pumps with customers. Contractors said that discussing heat pumps was generally easier if customers were on oil or propane or had older systems that needed an upgrade soon.

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

- Homeowners' goals and interest: Four contractors noted that if a customer expressed interest in heat pumps, electrification, or green energy, they were more likely to engage in discussions about heat pumps. One contractor explained,

> "It's kind of their frame of mind where they're at and why they called. I mean, most of them are specifically calling for insulation, and they don't want to hear a big spiel about other expenses. They just want to focus on the problem at hand…so I'm not necessarily introducing them to whole new other ideas and concepts."

- Contractor offered heat pump services: Four contractors mentioned that they rarely discussed heat pumps or did not delve into the topic in much detail because their companies did not offer heat pump installation services. One contractor stated, "At the moment [I discuss heat pumps] very little [be]cause it's not something that we offer."

Contractors noted that customer reception of information about heat pumps varied due to the factors mentioned above, but a common theme was that many customers often felt overwhelmed by the potential costs associated with heat pumps. One contractor said, "We don't really present that [heat pump information] during the insulation work because I don't want them to be dissuaded or feel like they're overwhelmed by doing heat pumps." Another contractor shared a similar sentiment, saying,

> "One of the fears with heat pumps is that sometimes if you create a project that's too big and nothing gets done. A heat pump itself is typically a very large purchase for a customer. For most people to wrap their head around insulating the whole house and doing the heat pump all at the same time, while from an energy perspective sure it's important and it works, but from a financial perspective, it doesn't."

Although contractors reported that they didn't always discuss heat pumps with customers, the majority of surveyed customers who installed a heat pump after Comfort Home indicated that the program influenced their decision. Of the twenty-five respondents who reported installing a heat pump in their home after receiving their Comfort Home upgrades (out of 128 total survey respondents), all but two (92%) said that Comfort Home was at least slightly influential in their decision to install a heat pump.

Practices for Managing New Electrical Loads

A challenge facing home and consumer transportation decarbonization programs is managing the increased electrical load as homes transition from fossil-fuel powered appliances to all electric equipment. The need for additional electrical loads drives increases costs for consumers who need to replace antiquated electrical wiring, add new circuits, replace their electrical panel, increase electrical service to their homes, or a combination of these.

The frequency of such projects and estimates of costs to consumers vary. As part of the Comfort Home evaluation, we surveyed participating homeowners about panel replacements. Most survey respondents who installed heat pumps after their Comfort Home upgrades reported that additional work was completed as part of the installation process, such as electrical panel

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

upgrades (Flanders, Bates, and Siddiqui 2025). Interviews with participating contractors showed that four of the six contractors who installed heat pumps (rather than only provided weatherization services) said that customers required panel replacements 50-75% of the time. These homes typically had panels that were less than 200 amps, which required upgrading to 200+ amp panels. Such panel replacements can add substantial costs to decarbonization projects. For example, using national data, Rewiring America calculated the cost of electrical panel and service upgrades for a single-family home to be $2,000 to $30,000, depending on the extent of required upstream utility infrastructure (e.g., transformers and poles) that must be replaced to increase a given home's electrical service (Calisch and Wyent 2022).

However, electricians can take steps to avoid these costly panel replacements and additions to electrical service by using PED strategies, also known as panel optimization, low-power electrification, or a Watt Diet (Bates and Steiner 2026). According to the Consortium for Power Efficiency, PED "refers to strategies to limit buildings' electricity use, ensuring that power demands stay within the constraints of buildings' electrical services (i.e., their connections to the electrical grid) and other infrastructure," such as limited physical space in electrical panels (Dunsky Energy and Climate Advisors 2024). Bates and Steiner (2026) summarized three types of technologies that are needed for PED:

1. Appliances that not only use less energy over time (energy efficiency) but also limit in-the-moment power demand (power efficiency),
2. Devices that augment available slots in electrical panels, sometimes called breaker consolidation devices, and
3. Devices adding "smart" control of the electric load in individual circuits or, in the case of smart panels, all circuits in the home (e.g., circuit pausers, circuit sharers, smart circuit splitters, smart circuit breakers, etc.).

Another critical element of PED is the load calculations used by electricians to determine the electrical service required for the home (Walker and Less 2022).

PED practices, though, are relatively rare. For instance, in California, a joint study by Guidehouse and Opinion Dynamics (2024) surveyed 56 electricians about their panel optimization practices. Twenty-four percent of the surveyed electricians reported panel optimization was "often" possible; another 60% said it was possible "sometimes," while 16% reported it was "rarely" possible. The survey also asked electricians how often they took various panel optimization steps, such as adding a subpanel, using smart circuit breakers, or adding circuit pausers. As illuminated by Table 2, subpanels are the only panel optimization option taken "always" or "often" by most electricians, while large percentages of electricians "never" use other options.

Table 2. Surveyed electricians' frequency of panel optimization practices

Optimization Option	n	Always	Often	Sometimes	Rarely	Never	Don't know
Sub-Panel	45	31%	40%	29%	0%	0%	0%
Load-Sharing	45	7%	9%	20%	22%	40%	2%
Smart Circuit Breakers	45	4%	4%	13%	24%	48%	4%
Circuit Pausers	45	2%	4%	9%	18%	58%	9%
Smart Panel	45	0%	4%	18%	24%	51%	2%
Meter Collars	45	0%	2%	2%	18%	67%	11%
Other	45	11%	7%	4%	13%	20%	44%

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

We are currently studying adoption of PED practices in California and anticipate publishing a research study and white paper for the CPUC on the topic by the end of 2026. As part of this research, we completed a web search and literature review (Bates and Steiner 2026). Our web search revealed that even contractors active in CPUC-funded decarbonization initiatives like TECH Clean California do not mention PED or associated terms on their websites. Similarly, only six of the state's utilities, community choice aggregators, and regional energy networks have piloted PED efforts or incorporated at least portions of the PED approach into their programs.

Workforce Preparedness and Training

In this section, we provide an overview of state-level workforce requirements and program credentials in the aforementioned states. We then delve into findings on workforce training needs and contractor training preferences, touching on all three states.

Contractor Licensing and Training

Decarbonization contracting work requires specific knowledge and licenses. California requires state-level licenses for contractors, while neither Illinois nor New York require them—in these states, licenses are issued at the local level. In California, the Contractors State License Board (CSLB), under the Department of Consumer Affairs, protects consumers by licensing and regulating the state's construction industry. CSLB licenses are separated into three classifications: Class A (General Engineering Contractor), Class B (General Building Contractor), and Class C (Specialty Contractor). Depending on the specifics of the HVAC heat pump project, the following licenses may be required to complete the necessary work: a B-General Building Contractor license, a C-20 HVAC license, a C-36 Plumbing license, a D-34 Prefabricated Equipment license, and a C-10 Electrical license.

In 2024, there were 141,388 licensed contractors in California who held at least one of the specialty licenses from the CSLB necessary to replace a gas appliance with a heat pump (Opinion Dynamics, 2025a). This is an increase of 5,163 licensed contractors compared to 2023 data. As we observed in previous years, contractors with Class B licenses outnumbered those with the other licenses. Additionally, licensed contractors with a business address outside of disadvantaged communities (DACs) outnumbered contractors with a business address inside of DACs.[1]

A separate analysis using 2023 data from the Bureau of Labor Statistics (BLS) found that California contractors are not often cross-licensed across the trades. Of the 150,990 electricians, HVAC professionals (heating, air conditioning, and refrigeration mechanics and installers), and plumbers (including pipefitters, and steamfitters), most contractors (92%) were licensed in just one of the three trades (Opinion Dynamics 2024c). Among the 8% of contractors licensed in more than one trade, the most common combination was HVAC and plumbing (35% of those licensed in more than one trade and 3% overall). Seventeen percent of the contractors licensed in more than one trade are licensed as an electrician, HVAC, and plumber, but this represents only 1% of all contractors studied (Opinion Dynamics 2024c).

[1] This webpage explains how California defines disadvantaged communities: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/disadvantaged-communities

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

When HVAC contractors and plumbers are not cross-licensed, they will need to subcontract any non-incidental electrical work to an electrical contractor. However, subcontracting to another firm to perform electrical work is associated with higher heat pump project costs. In California, average project costs for 3-ton heat pump units were higher when sub-contracting electrical work at $16,437 compared to situations when a company could perform electrical work in-house, which averaged $13,904 (Opinion Dynamics 2024a). Therefore, when contractor firms can maintain a mix of contractors with various licenses, it can result in lower project costs to consumers.

As noted above, New York does not have state-level licenses for contractors. However, our Comfort Home evaluation documented training for weatherization jobs and credentials required to become a participating Comfort Home contractor. During interviews with contractors, we learned weatherization work crews received a mix of on-the-job training, certification training, manufacturer training, and company-specific training (Flanders, Bates, and Siddiqui 2025). For example, one contractor said that they provide all new hires with an internal guidebook that is a picture guide showing different types of work offered by the company. Additionally, all contractors employed staff with varying levels of experience and selected team members based on the complexity of each project. For example, over half of interviewed contractors (6 of 11) noted that projects involving window installation or spray foam typically required more experienced staff, while newer team members joined simpler jobs and received on-the-job training during installations. Also, to participate in the Comfort Home program, NYSERDA required contractors to employ at least one full-time staff member with a certification from a list of eight options, including four Building Performance Institute (BPI) certification options. The evaluation team found that most of the participating Comfort Home contractors fulfilled this requirement with BPI certifications, with a small number completing EPA Section 608 Technician Certification or the Air Advice IAQ Specialist Certification.

Training Needs and Preferences

Training of contractors is necessary to develop the incoming workforce to bolster the overall number of contractors as well as ensure the existing contractor workforce continues to evolve their skills. As heat pump technology advances, such as the introduction of 120V heat pump water heaters, and more evidence is shared to support PED and avoid electrical panel upgrades, it is essential that training is attractive to students and contractors. There are a number of organizations and entities offering training to contractors on heat pump technologies and PED. The energy efficiency and decarbonization industry, however, does not commonly evaluate how well contractors apply learnings on the job (Wirtshafter, Dunn, and Schauer 2025).

Opinion Dynamics' 2024 market assessment of HVAC contractors in California found that an increasing number had received heat pump training, most commonly from distributors and manufacturers (Opinion Dynamics 2025a). Over three-quarters of HVAC respondents (75 of 91; 78%) had received heat pump equipment training in the 2024 survey, which represented a 12 percentage point increase since the Baseline Market Assessment conducted in 2021. Of those who had received heat pump equipment training, over two-thirds did so either through a distributor (55 of 75; 73%) or through a manufacturer (45 of 75; 60%) (Figure 2). This was unlike the Baseline Market Assessment, where contractors most commonly received heat pump training while on the job. Even though contractors most commonly received training through a distributor, they preferred training provided by a manufacturer (Figure 3).

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

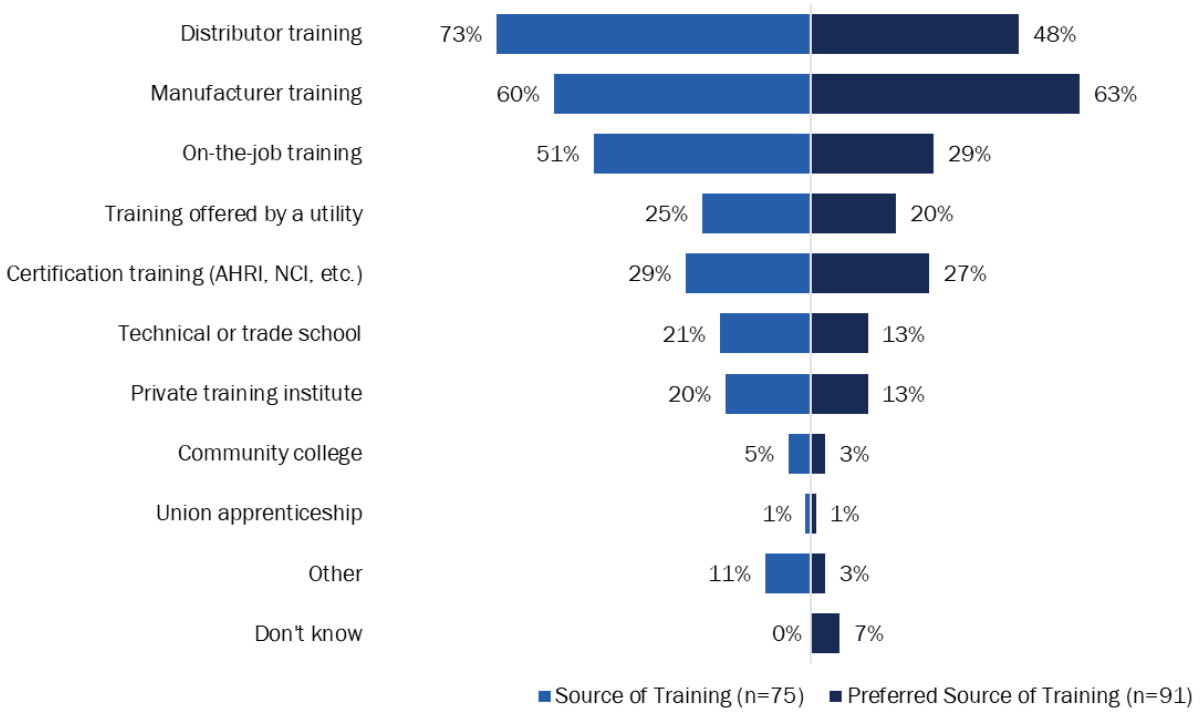

Figure 3. Sources of Heat Pump Training Versus Preferred Sources for Training

California HVAC contractors valued in-person education, with three-quarters of surveyed contractors (68 of 91) preferring either fully in-person training or a hybrid model of online and in-person training (Opinion Dynamics 2025a). A minority of respondents preferred online training (14 of 91; 15%) or said they had no preference about the training mode (9 of 91; 10%).

It can be difficult to motivate contractors to take time away from their jobs to attend trainings. In a survey of both water-heating and HVAC contractors enrolled in TECH Clean California, almost half did not attend any that were offered in 2023 and 2024, despite being aware of the program's optional trainings available at no cost (31 of 69; 46%) (Opinion Dynamics 2025b). These contractors shared that they did not attend a training because they had already attended a similar course (13 of 31), it was not a priority (10 of 31), or that the training sessions were hosted at an inconvenient time for them (5 of 31) (Opinion Dynamics 2025b).

The organization Electrify My Home (EMH), which offers contractor training for proper installation of heat pumps, tested out a cohort training model (Opinion Dynamics 2023). A cohort of 10 contractors who had all taken a three-day introductory course to home electrification met weekly online across 12 weeks. Two EMH instructors led the training while 10 subject matter experts attended as guest speakers. One aspect of the training that set it apart from others was that it facilitated in-depth discussions among a group of peers. To encourage peer sharing, the training was designed with a roundtable format that included frequent open discussions about participants' experiences with heat pump equipment. The training provided a space for contractors to share their best practices, challenges, and work together to brainstorm solutions to problems.

After interviewing a sample of five attendees, Opinion Dynamics (2023) concluded that the training format with instructors, roundtable discussions, and guest speakers was valuable.

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

The combination of these training elements allowed the contractors to learn from experts and from one another. The insights they gained from how others on how to approach project challenges was particularly helpful, and the format led to beneficial relationships that endured beyond the training. Opinion Dynamics (2023) also found that the three-day introductory electrification training required prior to the cohort training was an effective design. The introductory course facilitated conversations in the cohort training by providing a shared vocabulary that led to productive peer discussions. Although the contractors in the cohort training had been successful applying learnings acquired through the training in their work, the high upfront cost and operating costs of heat pumps presented a barrier and made it challenging for contractors to sell heat pumps (Opinion Dynamics 2023).

Regarding training for PED, Bates and Steiner (2026) completed a general web search for PED training, as well as targeted searches of websites that provide electrification training and information: the three primary California electric IOUs, TECH Clean California, TECH Clean California's list of other training providers, and electrification websites The Switch is On, Clean Energy Connection, QuitCarbon, Sealed, Build It Green, and Electrify Now. The search yielded 36 training opportunities that unequivocally included PED-aligned content, including 32 online videos or webinars and three online guides. The remaining training option, from EMH, appeared to be determined upon request by interested participants. Additionally, the Build It Green POWER Group holds a monthly forum for anyone interested in PED.

Based on the review of training session descriptions, most sessions addressed PED as part of whole-home electrification planning and provided a basic overview of key concepts and technologies, such as circuit splitters. A few other sessions focused on avoiding panel upgrades or navigating panel constraints. No sessions appeared to provide in-depth or hands-on practice implementing PED. Interestingly, three trainers have provided 25 of the 36 sessions; these individuals also sometimes offered joint training sessions.

It's important to note that training purveyors also offered other sessions that might include PED content, but course descriptions were too vague to confirm. For instance, trainings on Net Zero homes and Passive House design could address PED topics. Further research is needed to identify any such overlap in training content.

Discussion and Conclusions

Decarbonizing homes requires contractors from multiple trades, including HVAC, plumbing, weatherization, and electrical. However, most California contractors were not cross licensed among trades, necessitating them to have a combination of trades on staff or to sub-contract out work to another firm. Subcontracting to other firms was associated with higher project costs, adding financial burden to homeowners. Even when incentivized to refer customers to other trades, as in NYSERDA's Comfort Home program, most contractors did not carry out such referrals, often due to the cost of the heat pump systems.

Furthermore, contractors showed notable gaps in their knowledge and capabilities. For instance, though HVAC contractors were fairly confident in their ability to size and install HVAC heat pumps in single-family homes, not all used Manual J sizing calculations, which are the standard for properly sizing HVAC heat pumps, and some contractors in Illinois were unaware modern ccHPs can deliver heating when outside temperatures dip below freezing. Electricians in California rarely used most PED options to avoid upsizing a home's electrical panel or service.

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

In conclusion: contractors dealing with home retrofits are mostly organized into single-trade firms whose businesses are not organized to support the huge volume of cross-trade, whole-home electrification projects needed for states like California, Illinois, and New York to meet their decarbonization goals. Gaps in contractor knowledge and skills also hinder states' abilities to meet climate objectives. More effective and appealing training is necessary for contractors to deepen their knowledge and skills *en masse*, which once gained, can contribute to more effective heat pump system sizing and avoidance of unnecessary costs.

There are some promising trends in contractor training that demonstrate progress. Our California market assessments indicate HVAC heat pump training has shifted from less formal, on-the-job training to sponsored trainings from manufacturers and distributors. On-the-job training was still common in 2024 with half of contractors reporting they received it, though, it was not their preferred method. Contractors' top preference for a source of training was manufacturers. Our evaluation of a cohort-based training showed that it was a fruitful model where contractors benefitted from hearing from both expert speakers and learning from their peers' experiences. Alternative training models such as this one may be an effective way to attract contractors to gain additional skills to support decarbonization programs. Our search for PED trainings in California yielded a few dozen online options, but no hands-on or in-depth coverage of PED strategies or technologies. However, given how new PED is to the HVAC industry, we anticipate the resources and trainings on this topic to grow in the near future.

In addition to training on technical skills, policymakers and programs may be wise to consider funding research and training on cross-trade collaboration and alternative business models that foster thoughtful, strategic approaches to whole-home electrification over piecemeal projects that electrify one appliance at a time.

References

Bates, L. and E. Steiner. 2026. *Characterizing the Current State of Power Efficient Design in California*. Publication forthcoming.

Bates, L. 2025. *Ameren Illinois Company Heat Pump Research Study.* Published September 12, 2035. https://www.ilsag.info/wp-content/uploads/AIC-2024-Heat-Pump-Research-Study-2025-09-12.pdf

Calisch, S. and Wyent, C. 2022. *Circuit Breakers: Electrification Won't Break the Grid, It Will Make It Smarter*. Published July 4, 2022. https://www.rewiringamerica.org/research/circuit-breakers/electrification-myths-the-grid.

Dunsky Energy and Climate Advisors. 2024. *Overview of Power Efficient Design Strategies: An Initiative of the Consortium for Power Efficiency*. Published December 2024. https://powerefficiency.ca/wp-content/uploads/2025/03/report_overview-of-power-efficient-design.pdf.

Energy Solutions. 2026. TECH Clean California Program Website. https://techcleanca.com/

Flanders, A. L. Bates, and S. Siddiqui. 2025. *Comfort Home Impact and Process Evaluation.* Published August 2025. https://www.nyserda.ny.gov/-

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

/media/Project/Nyserda/Files/Publications/PPSER/Program-Evaluation/2025-09-Comfort-Home-Impact-and-Process-Evaluation.pdf

Guidehouse and Opinion Dynamics. 2024. *Fuel Substitution Behind the Meter Infrastructure Market Study*. Published May 17, 2024. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/building-decarb/fs-infra-ms_overall-report_20240606.pdf.

Kaltreider, C., A. Parsons, J. Kono, and J. Wanner. 2025. *Not Your Parents' Heat Pump: Training and Tools to Size Heat Pumps for Heating.* In proceedings of the 2024 ACEEE Summer Study on Energy Efficiency in Buildings. Washington, DC: ACEEE. https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/Not%20Your%20Parents%27%20Heat%20Pump%20-%20Training%20and%20Tools%20to%20Size%20Heat%20Pumps%20for%20Heating.pdf

NYSERDA (New York State Energy Research and Development Authority). 2026. Comfort Home Program Website. https://www.nyserda.ny.gov/All-Programs/Comfort-Home-Program

Opinion Dynamics. 2022. *Baseline Market Assessment Report*. Published July 15, 2022. https://opiniondynamics.com/wp-content/uploads/2024/12/TECH_Baseline_Market_Assessment_Final_Report_8AHwAxk.pdf

Opinion Dynamics. 2023. *TECH Cohort Training: In-Depth Interview Findings.* Published March 16, 2023. https://opiniondynamics.com/wp-content/uploads/2025/06/TECH_EMH_Cohort_Training_Evaluation_Memo_Final.pdf

Opinion Dynamics. 2024a. *TECH Clean California: Incremental Cost Study Phase I Findings*. Published February 12, 2024. https://opiniondynamics.com/wp-content/uploads/2025/06/TECH_Cost_Study_-_FINAL_Phase_I_Findings_2.12.24_2.pdf

Opinion Dynamics. 2024b. *TECH Clean California: Time 1 Market Assessment Final Report.* Published February 9, 2024. https://www.calmac.org/publications/TECH_Time_1_Market_Assessment_Final_Report_4.22.24.pdf

Opinion Dynamics. 2024c. *California Residential Fuel Substitution Workforce Readiness Study*. California Public Utilities Commission Group B Contract 17PS5017. Published September 27, 2024. https://www.calmac.org/publications/FuelSubstitutionWorkforceReadiness_Report_9_27_2024_Final.pdf

Opinion Dynamics. 2025a. *TECH Clean California: Time 2 Market Assessment Final Report*. Published May 14, 2025. https://www.calmac.org/publications/TECH_Time_2_Market_Assessment_Final.pdf

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

Opinion Dynamics. 2025b. *Process Evaluation of the TECH Clean California Initiative*. Published May 2, 2025. https://www.calmac.org/publications/TECH_Process_Evaluation_Final_Report.pdf

Opinion Dynamics. 2025c. *TECH Clean California Gas Baseline Incremental Cost Study*. Published September 25, 2025. https://opiniondynamics.com/wp-content/uploads/2026/01/TECH-Incremental-Cost-Study-Final-Report.pdf

State of California. 2026. Governor's Office of Land Use and Climate Innovation. *Carbon Neutrality by 2045*. https://lci.ca.gov/climate/carbon-neutrality/.

The New York State Senate. 2019. *Senate Bill S6599*. https://www.nysenate.gov/legislation/bills/2019/S6599

Walker, I. and B. Less. (2022). *Low-Power Home Electrification: The Key to Avoiding Electric Panel Upgrades*. Published April, 2022. https://homes.lbl.gov/sites/default/files/2023-04/BPA_NHPC23-LowPowerElectrification.pdf

Wirtshafter, B., A. Dunn, and L. 2025. *If Market Transformation is Our Goal, Programs Must Radically Change How We Do Training and Education (T&E)*. International Energy Program Evaluation Conference. Denver, Colorado. https://www.iepec.org/wp-content/uploads/2025/09/Wirtshafter_Robert.pdf

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings