Opinion Dynamics

WE&T AND INSTALLATION IMPROVEMENT EVALUATION

FINAL REPORT

JULY 30, 2024

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I. EXECUTIVE SUMMARY

The California Public Utilities Commission (CPUC) tasked Opinion Dynamics with evaluating the relationship between Investor-Owned Utilities (IOUs) Workforce Education and Training (WE&T) programs and improved installation practices among HVAC professionals who work in residential and small commercial settings. The overarching goal for this study is to assess how training may lead to changes in behavior among the HVAC workforce, thereby leading to increased efficiency of HVAC systems in the buildings they serve. Specifically, the research objectives of the WE&T and Installation Improvement Evaluation were as follows:

- Assess the effectiveness of WE&T programs, specifically among installation professionals;
- Assess the impact of each training workshop/session provided for relevant professions;
- Identify and assess the connection between training and improved installation practices;
- Provide recommendations on how to improve WE&T programs; and
- Collect data to assess whether and to what extent WE&T programs drive energy savings.

To address the research objectives, we conducted four activities. We offer a brief summary of each activity below and elaborate on the purpose and structure of each in Section 3.

Table 1. Description of Evaluation Activities

Evaluation Activities	Description
Instructional Design Assessment	▪ Refined evaluation yardsticks ▪ Evaluated training materials and conducted audits of key installer trainings ▪ Interviewed training instructors
Installer Survey	▪ Surveyed HVAC installers who participated in an HVAC training during 2019 or 2020 calendar years through one of the four IOU energy centers.
Exit Survey Review and Refinement	▪ Reviewed exit surveys IOUs administer to WE&T trainees ▪ Recommended revisions to the exit survey
Behavioral Assessment	▪ Observed trainees fixing an HVAC system once before and once after they completed an IOU-sponsored WE&T HVAC training to evaluate how they apply their learning outside of the training environment.

We have organized the results in this report into two overarching sections focused on the WE&T training environment (Section 4) and work environment of participating HVAC technicians (Section 5). Table 2 provides an overview of each evaluation task that we completed in this study and the relevant sections of this report where we address each task. We describe the two overarching results sections of this report following Table 2.

Table 2. Crosswalk of Evaluation Activities, and Analysis Sections

Evaluation Activities	Training Environment			Work Environment	
	Design & Preparation	Reaction & Engagement	Learning & Knowledge Transfer	Preparedness for Application	Trainee Behavior and Results
Instructional Design Assessment	✓	✓	✓	✓	
Installer Survey		✓	✓	✓	
Exit Survey Review and Refinement	✓				
Behavioral Assessment					✓

- **Training Environment**: Through the evaluation activities presented above, we explored participants' experience with WE&T HVAC trainings, both their satisfaction and knowledge gain. We also examined the design of select HVAC trainings through curriculum review, training audits, and interviews with instructors. Finally, we refined several tools that program administrators and other decision makers can use to assess participant satisfaction, engagement, and curriculum design (Section 4). The virtual trainings included in the instructional design assessment and installer survey were offered during the COVID-19 pandemic, which forced training providers to transition delivery from in-person to virtual formats. We elaborate on this factor in Section 3.5.
- **Work Environment**: We also assessed if and how participants were able to apply the training content to their day-to-day work. Through our audits of select WE&T HVAC trainings and review of training materials we highlighted specific attributes of curriculum design and training delivery that may or may not support participants translating their training experience to their daily work (Section 5.1). Beyond our course audits, we also observed technicians address typical HVAC system failures both before and after participating in a WE&T HVAC training to understand if and how the training content translated into changes in behavior. System failures were specifically selected to provide technicians with an opportunity to demonstrate the objectives of the training they completed (please refer to Table 18 in Section 5.2 for a crosswalk of training objectives and associated observable actions).

1.1 FINDINGS AND RECOMMENDATIONS

We present the key findings and recommendations that resulted from this evaluation below.

- **Finding 1:** While WE&T HVAC trainees generally reported positive experiences and a knowledge increase resulting from their participation, instructors found it difficult to actively engage trainees in a virtual environment. Our Installer Survey of WE&T trainees found that an overwhelming majority of participants in HVAC trainings from 2019 and 2020 felt the trainings met their expectations (95.4% and 91.3%, respectively; see Section 4.2). In addition, most participants reported an increase in level of knowledge across a range of topics relevant to residential and small commercial HVAC installation and maintenance (see Section 4.3), and reported confidence that they would be able to apply what they learned on the job (see Section 5.1). Although self-reported satisfaction and knowledge gain were relatively high among participants, instructors highlighted the challenges of finding ways to actively engage participants in the training content, particularly in virtual or hybrid trainings (see Section 4.2). Further, only one of the four HVAC trainings that our team audited as part of this evaluation included in-class assessments to help instructors understand if and how participants understood the content (see Appendix A.). Relatedly, instructors reported some difficulty understanding how much information from the training that participants retained and whether participants went on to take and ultimately pass certification exams.
    - **Recommendation 1:** We recommend that the four California IOUs draw core questions from the standardized reaction survey that Opinion Dynamics prepared (see Appendix E-III for the instrument) to cover key topics related to participant satisfaction with their training experience. IOUs currently administer exit surveys at the end of trainings. However, topics and survey length differ between IOUs (see Section 4.1). We recommend that IOUs work to administer streamlined surveys that are available to participants online immediately after completing the training. A shorter survey will reduce the burden on respondents and a standardized version will enable decision-makers to understand satisfaction with similar training offerings across the IOUs. We discuss the most critical topics to cover in this type of survey in Section 4.1 and include the complete survey instrument in Appendix E-III.
    - **Recommendation 2:** Training providers should consider incorporating in-training assessments into curricula where possible to ensure that knowledge transfer is occurring among trainees and that the core concepts are understood before moving on to later topics. Training providers should also consider implementing summative assessments or tracking to help instructors understand how to better tailor their

trainings to support outcomes such as higher rates of participants scheduling or passing certification exams post-training.

- **Finding 2:** For the trainings included in this evaluation, Opinion Dynamics identified that both instructor and trainee experiences differed between in-person and virtual trainings, and that the virtual environment posed challenges in terms of participant engagement. The four WE&T trainings we audited included few opportunities for active engagement amongst participants (see Appendix A-II). We also reviewed training materials for twelve WE&T HVAC trainings, both intended to be delivered in-person and virtually, and we found little difference between the materials and training design across delivery modes. Instructors reported preferring in-person delivery over virtual delivery because it allows more opportunities for active participation, gauging engagement and understating, and opportunities, where applicable, for "hands-on" learning. Respondents to the Installer Survey echoed similar sentiments (see Section 4.2). Participants who took the trainings in-person were more likely to be "very satisfied" than virtual/hybrid participants with the training overall , training materials, and the instructor (see Table 3).

Table 3. In-Person and Virtual Training Respondents Very Satisfied with Training Aspects

Training Aspect	In-Person Training Respondents	Virtual/Hybrid Training Respondents
Training Overall	82.3%	69.4%
Training materials	75.4%	63.2%
Instructor	86.2%	73.7%

Recommendation 3: We recommend that training providers consider different strategies to minimize screen fatigue and maximize trainee focus and attention. Virtual trainings can be a convenient option for technicians who do not want to travel to a physical location after working a long day. It can also reduce barriers for technicians who do not have the means to get to the training site. However, training providers should consider that technicians, who already had busy and tiring days, may have trouble focusing in front of a computer screen for several hours at a time. We note that WE&T program administrators may already employ these different types of strategies in their virtual training offerings, and we recommend that IOUs continue to expand these options across their portfolios and work with third-party training providers to encourage adoption of these practices.

One strategy that IOUs and training providers may consider is shortening modules or sessions. We found that virtual trainings involved the same number and duration of sessions as the same training offered in-person. While the number and length of sessions in a training may be appropriate for in-person trainings, virtual trainings could involve more sessions that are shorter in duration thereby reducing screen fatigue. If adjusting the length and frequency of sessions is not possible, training providers should ensure that trainees have the opportunity to take regular breaks during virtual trainings.

IOUs should also explore differentiating activities between in-person and virtual delivery as another strategy that can help maximize trainee focus and attention. For example, lectures may be more appropriate for in-person trainings but may present challenges for sustaining trainee attention in the virtual setting. When exploring virtual training options, WE&T program administrators should consider different technology options, or training designs, that would enable more active participant engagement. One option is to facilitate small group breakout discussions to break up lecture-style presentations. Another option is to explore software that would enable participants to complete activities or mimic repairing or installing HVAC systems.

- **Finding 3:** Technicians who we observed as part of the Behavioral Assessment had somewhat mixed results in terms of how they were able to diagnose and ultimately fix an HVAC system that was not properly functioning. As we detail in Section 5.2, we sabotaged an HVAC system so it presented with faults that a technician could see in their day-to-day jobs. We observed technicians as they diagnosed and attempted to fix the system faults once

before and once after they completed a WE&T training We designed two sets of system faults—one for the pre-training and one for the post-training observations—that provided technicians with an opportunity to demonstrate the objectives of the training they completed. When compared with pre-training observations, technicians demonstrated a better understanding of HVAC systems, a more robust diagnostic process, and more success engaging with the member of our evaluation team completing the observation (i.e., mimicking their customer). As few of the technicians were able to address the system faults included in the observation, a typical residential customer would not have realized the energy savings that could have resulted in successfully addressing these issues were these actual house calls (see Section 5.2). However, their ability to more fluently discuss issues with "their customer" and connect symptoms with root causes of the faults suggest that their participation in the WE&T HVAC training would provide market benefit in their daily work experiences.

- **Recommendation 4:** WE&T trainings should incorporate opportunities for hands-on demonstration of skills the training intends to develop, where appropriate. If hands-on application is not feasible (e.g., in virtual learning environments), we recommend training providers increase opportunities for participants to engage in problem-solving exercises where they are prompted to apply training content. One such example that instructors can consider is employing a case or scenario approach. Instructors could present trainees with a description of a real-world problem and ask participants to discuss appropriate diagnostic methods and potential strategies for addressing the issues presented in the scenario in smaller group settings. Training providers could also consider the use of software to simulate working directly on HVAC systems (see Recommendation 3). Another strategy is to bring HVAC equipment into the training environment to allow instructors to provide demonstrations and trainees the opportunity to practice working on real systems. We note that some of the energy centers may already have training equipment for this purpose and we encourage training administrators to continue and expand this practice to the extent possible.
- **Recommendation 5:** We recommend that WE&T program staff continue to explicitly highlight the customer satisfaction benefits of training to HVAC contractors and other similar employers. Specifically, trained technicians may be more confident in their ability to ask questions of their customer and identify the root causes of the symptoms that customers experience, which may lead to better customer experiences. Additionally, addressing root causes of the issues that customers experience, rather than simply eliminating the symptoms, may lead to more efficient time at individual job sites and fewer callbacks.

- **Finding 4:** Technicians work in a demanding industry that requires them to work long hours in difficult conditions. Both in our efforts to recruit technicians into the behavior assessment portion of this evaluation and post-observation interviews we found that technicians were often over-burdened by their schedules. As such, trainings held in the evenings at the end of a long workday likely do not provide the best opportunities for technicians to retain the complex technical information provided through WE&T trainings.
  - **Recommendation 6:** WE&T program administrators should consider finding additional methods to provide training content to technicians. This may include shorter virtual training content or modules that technicians can do on their own time, reference packets or materials that may be useful to technicians in the field or working with employers to find ways to provide train-the-trainer opportunities or training content during typical work hours. We note that IOUs may be employing some of these strategies to already and we recommend expanding these alternative delivery methods more broadly.

2. INTRODUCTION

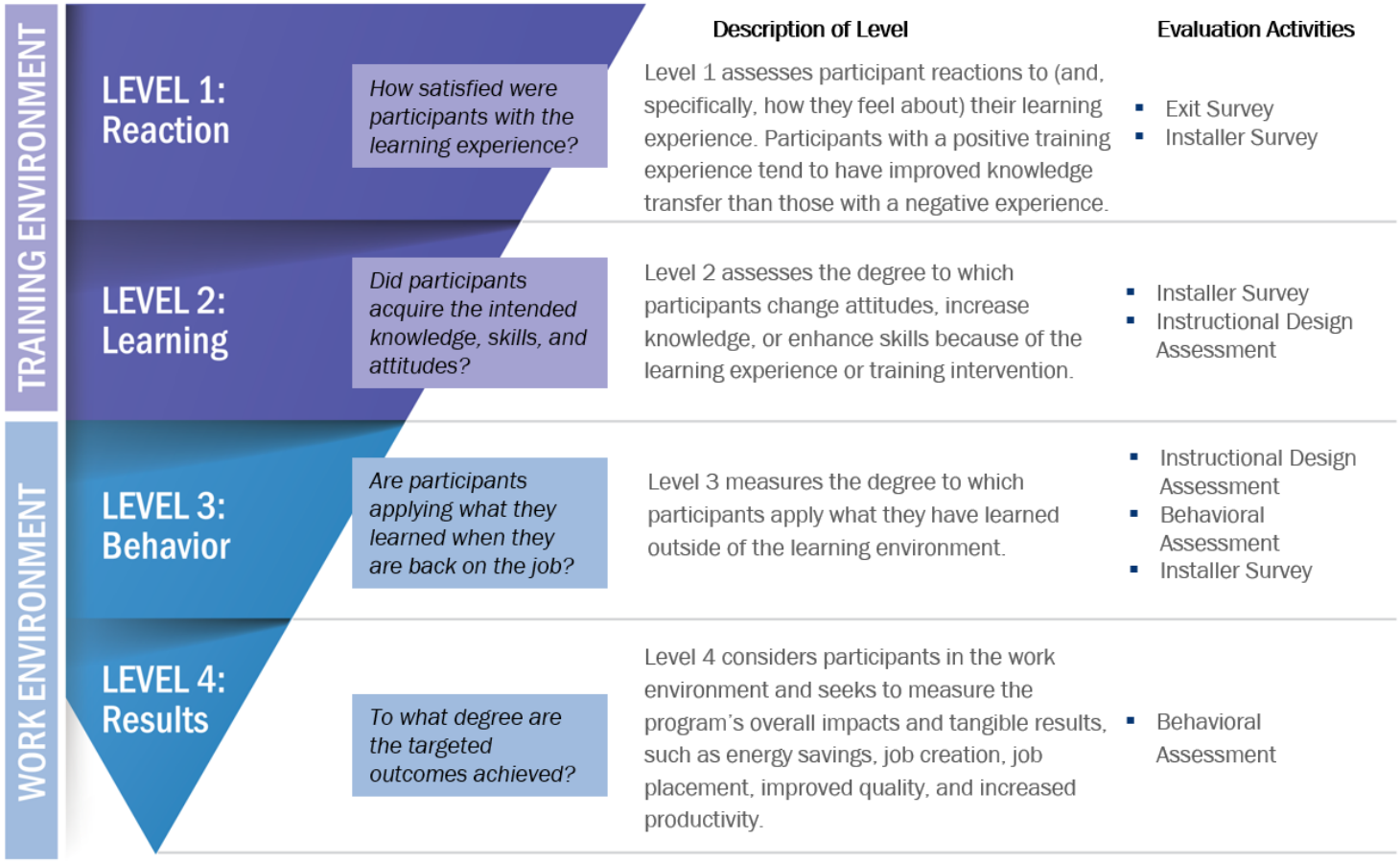
The California Public Utilities Commission (CPUC) tasked Opinion Dynamics with evaluating the causal links relationship between Investor-Owned Utilities (IOUs) Workforce Education and Training (WE&T) programs and improved installation practices among HVAC professionals who work in residential and small commercial settings.

2.1 KIRKPATRICK'S MODEL FOR EVALUATING ADULT LEARNING INTERVENTIONS

The evaluation team leveraged Kirkpatrick's Model for evaluating adult learning interventions as the guiding framework of this evaluation (Figure 1). The model contains four different levels of assessment: (1) Reaction, (2) Learning, (3) Behavior, and (4) Results. When combined, the four levels help evaluators and other stakeholders understand how a training intervention may lead to desired outcomes. We used this model to develop research tasks designed to assess if and how WE&T HVAC training may lead to an increase in knowledge and subsequent changes in installation behaviors among the HVAC workforce in California. In addition to designing tasks aligned with the four levels, several research activities explored topics related to—albeit distinct from—the model. For example, while the Instructional Design Assessment included auditing four trainings to assess Learning (Level 2) and Behavior (Level 3), we also examined the design of these trainings and their ability to engage their target audience given the importance of instructional design practices for learning and behavioral outcomes. We also developed and refined several tools that will aid program administrators and training providers to assess future trainings with regard to the four levels in Kirkpatrick's Model.

We elaborate on the four Model levels in Figure 1, describing each level and the associated evaluation activities from the present study. Please note that the research activities in Figure 1 illustrate how the Model informed our assessment and are not an exhaustive summary.

Figure 1. Kirkpatrick's Model for Evaluating Adult Learning Interventions, Level Descriptions, and Examples of Relevant Research Components



2.2 RESEARCH OBJECTIVES

The overarching goal for this study is to assess how training may lead to changes in behavior among the HVAC workforce, thereby leading to increased efficiency of HVAC systems in the buildings they serve. Specifically, the research objectives of the WE&T and Installation Improvement Evaluation were as follows:

- Assess the effectiveness of WE&T programs, specifically among installation professionals;
- Assess the impact of each training workshop/session provided for relevant professions;
- Identify and assess the connection between training and improved installation practices;
- Provide recommendations on how to improve WE&T programs; and
- Collect data to assess whether and to what extent WE&T programs drive energy savings.

3. METHODS

The section describes the methods Opinion Dynamics used to address the evaluation research objectives listed above. Table 4 provides a high-level overview of each evaluation activity we completed in this study and how they align with one or more relevant levels from Kirkpatrick's Model (described in Section 2.1) and analysis sections in this report. We elaborate on each evaluation activity listed in Table 4 in the following sections.

Table 4. Crosswalk of Kirkpatrick's Model, Evaluation Activities, and Analysis Sections

Evaluation Activity	Relevant Levels from Kirkpatrick's Model	Training Environment			Work Environment	
		Design & Preparation	Reaction & Engagement	Learning & Knowledge Transfer	Preparedness for Application	Trainee Behavior and Results
Instructional Design Assessment	2, 3	✓	✓	✓	✓	
Installer Survey	1, 2, 3		✓	✓	✓	
Exit Survey Review and Refinement	1	✓				
Behavioral Assessment	3, 4					✓

3.1 INSTRUCTIONAL DESIGN ASSESSMENT

Opinion Dynamics performed an Instructional Design Assessment of installer-targeted WE&T learning interventions to address the following key questions:

- Do the WE&T learning interventions meet the needs of installers?
- Are the learning interventions using effective learning strategies for the target audience?
- How can WE&T programs improve offerings for installers?

In addition to answering the questions above, the Instructional Design Assessment aligned with multiple levels of Kirkpatrick's Model (Section 2.1), specifically Level 2 and Level 3. This evaluation activity also collected information on training content design and how trainings support participant application outside the learning environment.

We conducted the following evaluation activities, which provided the foundation for assessing the WE&T learning interventions: (1) refined evaluation yardsticks; (2) evaluated training materials and conducted audits of key installer trainings; and (3) conducted instructor interviews.

EVALUATION YARDSTICKS

Opinion Dynamics leveraged evaluation yardsticks that it developed during a previous process evaluation of California WE&T programs as a core tool in assessing the design of select WE&T trainings.[1] All trainings we evaluated transitioned from in-person to virtual delivery during the evaluation period because of the COVID-19 pandemic. Resultingly, we updated yardsticks based on our review of recent research to ensure that yardsticks applied to online learning before evaluating the instructional design elements. We refined and leveraged three yardsticks for this evaluation, including:

[1] For more information on how evaluation yardsticks and supporting criteria were developed, see the 2010–2012 WE&T Process Evaluation, Volume 1: Centergies (Report ID# PGE0317.01). http://calmac.org/publications/2010-2012_WE&T_Centergies_Process_Eval_Report_volume_I.pdf

- **Support of Behavior Change Yardstick**—provides criteria for assessing whether trainings are designed and delivered in a way that will encourage students to incorporate the training content into how they complete day-to-day tasks.
- **Learning Principles and Best Practices Yardstick**—aims to assess whether training materials, instruction, and content engage students with different learning styles and preferences.
- **Learning Focus Yardstick**—provides criteria to assess how trainings support the range of skills that workers need to manage their daily responsibilities and how training content may help students "upskill" or achieve certain industry certifications.

Each yardstick aims to assess several different dimensions of adult learning interventions (see Figure 2.). As part of this evaluation, we also adjusted the yardsticks to help reinforce the need for WE&T training to draw upon participants' real-world experiences and ensure those tasked with designing and delivering training consider the range of possible learning styles. Specifically, we reviewed recent literature to adjust the yardsticks for applicability to virtual learning environments. We discuss the final yardsticks used for this evaluation in Section 4.1 and provide the full yardsticks in Appendix A.

Figure 2. Evaluation Yardsticks and Dimensions for Assessment

INDIVIDUAL TRAINING AUDITS

Opinion Dynamics conducted audits of four WE&T HVAC trainings in January and February 2021 to assess each training on the range of dimensions outlined in the evaluation yardsticks. Opinion Dynamics worked closely with WE&T program staff to select four trainings focused on HVAC installation and maintenance in residential and small commercial buildings (Table 5).

Table 5. Audited Trainings by IOU Sponsor

IOU Sponsor[2]	Training Name	Third-Party Training Institution	Training Descriptions and Objectives	Length
SCE	Duct System Optimization	National Comfort Institute (NCI)	A four-day training focused on duct system design and equipment sizing to optimize air distribution in residential settings for improved customer comfort and energy efficiency.	16 hours
SoCalGas	Air Distribution Module	Institute of Heating and Air Conditioning Industries (IHACI)	A four-day training designed to develop the comprehensive skill sets required to design, install, and maintain air distribution systems to operate efficiently.	8 hours
SDG&E	HVAC/R New Hire Module	Institute of Heating and Air Conditioning Industries (IHACI)	A four-day training for industry professionals with six to twelve months of experience in the field designed to build understanding of workplace safety, HVAC/R electrical components, appropriate tool selection, and best practices for optimal design, installation, and service for HVAC/R systems.	8 hours
PG&E	Demand Control Ventilation (DCV) and Variable Speed Fans	N/A	A one-day training is targeted for seasoned industry professionals and designed to develop understanding of demand control ventilation and variable speed fan control basics and associated energy savings. The training is currently offered as an online webinar.	2.5 hours

Our staff reviewed the training materials the WE&T program staff provided, such as lesson plans and presentation materials, and attended all sessions of each of the trainings listed in Table 5. While our team initially planned to attend each training in-person, due to the COVID-19 pandemic, all trainings were offered via webinar.

YARDSTICK SCORING

After reviewing materials and attending each session of the four WE&T HVAC trainings, our team used the three evaluation yardsticks to score different training dimensions. Each dimension described in the yardsticks includes multiple criteria our team used to score each dimension. Table 6 summarizes the criteria for each dimension.

Table 6. Evaluation Yardstick Dimensions and Respective Descriptions

Evaluation Yardstick	Dimensions	Assessment Descriptions by Dimension
Support of Behavioral Change	Action Orientation and Support	Does the course set participants up for what comes next—how to look for relevant employment, where to look, and how to assess and analyze options?
	Action Motivation	Does the course provide participants with examples of benefits derived from implementing taught actions and measures?
	Dissemination Support	Does the course foster diverse modes of delivering and engaging with content and learnings?
Adult Learning Principles and Best Practices	Learning orientation, buy-in, engagement	Does the course center on learners and provide opportunities for them to voice their learning goals and ideas?
	Learner success engineering	Does the course allow participants to demonstrate what concepts they know? Are these concepts tied into what is going to be taught?

[2] While these IOUs sponsor the trainings in the table, other IOUs sponsor the same trainings at other points throughout a given calendar year.

Evaluation Yardstick	Dimensions	Assessment Descriptions by Dimension
	Practice, application, interactivity	Does the course provide activities for participants to demonstrate what they've learned and confirm comprehension and understanding?
	Lesson plan and content decisions	Does the course follow a set of learning objectives in its content and design?
	Learning facilitation and feedback	Does the course instructor periodically pause learning to check in with participants?
	Assessments	Does the course implement assessments that align with its key learning objectives?
Learning Focus	Workforce Enablement	Does the course address "real-world" (e.g., on the job) responsibilities and opportunities?

Table 7 provides an example of our assessment of each criterion related to the Action Motivation Dimension included in the Support for Behavior Change Yardstick (Appendix A-I). Evaluators scored each criterion by assigning a one when the specified conditions were met, a zero where they were not, and a not applicable (N/A) where criteria may not be applicable based on the training material. When scoring, evaluators did not count criteria deemed not applicable for a specific training toward the total number of possible points for that training. We then scored each training across the dimensions specified in the three yardsticks (see Appendix A. for full yardstick scoring).

Table 7. Scoring Example: Action Motivation Dimension of Support for Behavior Change Yardstick

II: Action Motivation	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
1. Includes examples of "typical" benefits realized through actions or measures addressed by training	1	1	1	1
2. Includes detailed case study of actual implementations and benefits derived	1	1	1	1
3. Provides guidance on "selling" recommendations to decision-makers in the organization when appropriate	1	1	1	N/A
4. Includes references to relevant incentive and rebate programs	N/A	N/A	N/A	1
Total Points Scored / Total Possible Points	**3 of 3**	**3 of 3**	**3 of 3**	**3 of 3**
Score	**100%**	**100%**	**100%**	**100%**

For four separate criteria, rather than providing a binary score, we used different scales to express our impression of the learning level of trainings, how targeted the content was to specific job responsibilities, and how directly training content supported specific industry certifications. For these criteria, we provide scoring information as footnotes to the appropriate tables included in Appendix A.

INSTRUCTOR INTERVIEWS

After auditing the four WE&T trainings shown in Table 5, we conducted in-depth interviews with the training instructors (see interview guide in Appendix E-IV). Our team completed three interviews with instructors representing all four trainings (one team of instructors taught two trainings). The objectives of these interviews were to:

- Understand the instructors' prior training in and experience with adult learning principles and practices;
- Learn about the process for developing training materials, how the instructors tailored materials to participants' needs, and how they delivered these materials to the participants; and

- Gather feedback from instructors on training successes and challenges to garner measures of improvement for potential future program changes.

3.2 INSTALLER SURVEY

Opinion Dynamics surveyed HVAC installers who participated in relevant WE&T trainings administered through one of the four IOU energy centers. We designed the survey to align with Level 1 and Level 2 of Kirkpatrick's Model, although it also included some questions related to Level 3 (see Section 2.1). Specifically, the goals of the survey were to gather information on participant satisfaction with the training they received and to understand what participants learned and how they may apply that learning to their daily responsibilities. We include the full survey instrument in Appendix E-I.

The sample frame for this survey included technicians or other trade professionals who participated in an HVAC training during the 2019 or 2020 calendar years and install or repair HVAC systems in small commercial or residential buildings. We received data from IOUs containing contact information for all those enrolled in HVAC-related WE&T training during 2019 and 2020.[3] Our team reviewed the data and performed basic data-cleaning steps. Specifically, we combined duplicate records, removed records without valid contact information, and resolved any other erroneous records.

We emailed survey invitations to 9,000 individuals. Of the emails sent, 1,468 returned undeliverable; 7,686 individuals never responded to our initial email or subsequent reminders. We screened respondents based on completing a WE&T HVAC training during 2019 or 2020 and current residential or small commercial HVAC industry employment. After screening out those outside of our population of interest, 375 individuals completed the survey. Among those, 136 completed in-person training, 224 completed virtual training, and 15 completed training that combined virtual and in-person instruction. Those who completed the survey received a $50 gift card as compensation for their time.

3.3 EXIT SURVEY INSTRUMENT REVIEW AND REFINEMENT

In addition to the Installer Survey, Opinion Dynamics reviewed and recommended revisions to the exit surveys IOUs administer to participants upon completing WE&T training to gauge individuals' reactions to training interventions and enhance resources for assessing participants' reactions to WE&T training. We analyzed the existing exit surveys to identify topics covered and how those topics correspond to a Level 1 assessment in Kirkpatrick's Model (see Section 2.1). After reviewing the topics, we created a revised exit survey instrument that included questions critical to a Level 1 assessment, provided in Appendix E.

3.4 BEHAVIORAL ASSESSMENT

To assess Levels 3 and 4 of Kirkpatrick's Model, Opinion Dynamics evaluated how technicians in an IOU-sponsored WE&T HVAC applied their learning outside the training environment through direct observation. We present the findings from observing four technicians in a simulated service call in Section 5, and also developed case studies with detailed narratives from those observations and included each in Appendix C.

We recruited HVAC technicians who attended one WE&T HVAC training and observed them addressing pre-determined system faults on HVAC equipment in a lab setting once before and once after they completed the training. In the following subsections, we describe our process for selecting the WE&T HVAC training that served as the focus for our

[3] Note that SoCalGas provided data for those who attended HVAC training in 2019 but did not provide data for those who attended training in 2020.

observations and recruiting trainees to participate, the design of the observation scenario, and our data collection analysis procedures.

TRAINING SELECTION

The evaluation team reviewed IOU-sponsored IHACI trainings to identify a preliminary list of trainings relevant to our study. We only considered IHACI trainings as they are frequently offered and delivered in a standardized manner across all IOUs. We screened IHACI trainings based on the relevance of learning objectives to this study, reviewing training materials to identify trainings that included Quality Installation topics and best practices for troubleshooting and servicing heating and cooling equipment.[4] Given the seasonality of the HVAC profession and WE&T enrollment patterns, we considered trainings scheduled for the late spring and early summer.[5] Based on these criteria, we identified four trainings as potentially suitable options for our study, shown in Table 8.

Table 8. Preliminary List of IOU-Sponsored IHACI HVAC Trainings

Training	IOU Sponsor	Duration of Training*	Training Start Date	Training End Date	Number of Enrollees
IHACI System Performance Module	SCE	12 hours	5/10/2023	5/18/2023	13
IHACI System Diagnostics Module	SDG&E	12 hours	5/8/2023	5/16/2023	15
IHACI AC/HP Refrigeration Module	SCE	12 hours	6/6/2023	6/14/2023	16
IHACI System Performance Module	SDG&E	12 hours	6/19/2023	6/27/2023	11

*Note: All trainings shown in the table were structured as four three-hour sessions. The start and end dates in the table above refer to the dates of the first and final sessions, respectively. All training sessions were on weekdays from 6:30 p.m. to 9:30 p.m.

Next, we examined each training listed in Table 8 to determine the best option for technician recruitment based on several criteria. We requested and examined enrollment data for each training; we considered the number of participants enrolled in each training and the availability of participant contact information because these factors would support our recruiting efforts. As we planned to conduct observations in a lab setting, we also examined the proximity and availability of HVAC lab facilities. Specifically, we researched the proximity of HVAC labs that (1) were within a one-hour drive of the training facility, (2) could schedule observations in May and June, and (3) had the required heating and cooling equipment for the tasks we planned to observe. Considering these criteria, Opinion Dynamics prioritized outreach and recruitment of enrollees of the IHACI AC/HP Refrigeration Module offered through SCE's Energy Education Center in Tulare between June 6 and June 14, 2023.

TECHNICIAN RECRUITMENT

Our evaluation team conducted two rounds of email outreach and two rounds of phone outreach to recruit study participants. We successfully recruited five technicians, with four technicians participating in both rounds and one technician who withdrew from the study.[6] Our criteria for participants to qualify for this study included the following:

[4] Quality Installation refers to a standard set of minimum criteria for the proper installation of HVAC systems in residential and commercial applications.

[5] The evaluation team learned this was the optimal timing for the assessment from an initial attempt to complete this evaluation activity that was unsuccessful because of recruiting challenges. We discuss our initial attempt and the lessons learned, including the seasonality of the HVAC profession and WE&T training enrollment patterns in detail in Section 3.5.

[6] One technician dropped out of the study before the first round of observations occurred.

- Employment as a full-time HVAC technician or installer;
- Ability to travel to an HVAC lab facility in Fresno, California;
- Enrollment in and completion of the four sessions of the IHACI AC/HP Refrigeration module; [7]
- Availability to complete a pre-training observation between May 24 and June 5 and a post-training observation between June 19 and June 23.

OBSERVATION DESIGN

The evaluation team designed each session to last between 75 and 90 minutes. Each observation consisted of an introduction (5–10 mins), work time (60 minutes), follow-up for observation, and an interview (15–20 mins), all conducted by the same member of our evaluation team. We used the same HVAC equipment in pre- and- post-training observations: a three-ton split system heat pump that was permanently installed and ducted into the HVAC lab facility. We prepared two service scenarios and presented technicians with one service scenario in the pre-training observation and the other in the post-training observation. The scenarios involved common faults for HVAC systems to simulate situations technicians experience in the field and provided technicians with opportunities to demonstrate the training's learning objectives. Table 9 below details each scenario's faults and how the faults correspond to relevant training objectives. We also developed energy and demand savings estimates that we would expect to result from successfully addressing these system failures and included those estimates in Section 5, with detailed calculations included in Appendix D.

Table 9. Training Learning Objectives and Corresponding Observation Scenario Faults

Relevant Training Learning Objectives	Scenario 1 Faults			Scenario 2 Faults		
	Low Refrigerant Level	Thermostat with Loose Wiring	Obstructed Airflow	High Refrigerant Level	Incorrect Thermostat Setting	Obstructed Condenser Coils
1. Understand the fundamentals of refrigerant flow conditions	✓			✓		
2. Understand how the AC and HP refrigeration system operates	✓	✓		✓	✓	
3. Understand how the components operate together in the refrigeration cycle	✓	✓		✓	✓	✓
4. Understand how and when to measure subcooling and superheating of the system	✓			✓		
5. Be able to perform simple refrigeration commissioning	✓	✓	✓	✓	✓	✓
6. Be able to perform common refrigeration preventive maintenance	✓			✓		
7. Be able to determine when a refrigeration system is operating correctly		✓	✓		✓	✓
8. Be able to track reported symptoms to the actual root causes of the problems	✓	✓	✓	✓	✓	✓

[7] Technicians provided the proof of completing the training that IHACI provides at the conclusion of the module.

OBSERVATION POINTS

The evaluation team developed an observation guide organized around six points to facilitate data collection. The observation points describe actions that reflect training objectives and HVAC industry best practices and are presented below in Figure 3.

Figure 3. Observation Points of Behavioral Assessment

The evaluation team member who conducted the observations documented technician actions pertaining to each observation point. We collected quantitative data, such as the number of diagnostic methods a technician used, as well as qualitative data, such as characterizing how easily a technician selected the appropriate diagnostic tool and noting comments that the technician made that demonstrated their thought process.

The evaluation team constructed a rubric to assess technician performance on each observation point with the goal of evaluating the effectiveness of the IHACI AC/HP Refrigeration Module, which we provide in Appendix B. We developed a five-point Likert scale for each observation point, including criteria and examples of technician actions associated with each score. After synthesizing notes and observations, the evaluation team assigned scores based on this five-point scale (1-5) that represent the degree to which technicians met the criteria for each observation point. The pre- and-post-training observation rubrics used the same scale for both rounds of observations with examples of technician actions specific to the service scenario.

SEMI-STRUCTURED INTERVIEWS

Following each observation, we conducted a semi-structured interview with the technician. We asked questions on topics such as the technician's professional background, previous training experience, the experience troubleshooting the HVAC system in the observation, and how they applied what they learned in the recent training while attempting to address the different faults. We provide the interview guide in Appendix E.

3.5 STUDY LIMITATIONS

We highlight two specific factors that presented limitations to this study below—the COVID-19 pandemic and recruitment challenges associated with the Behavioral Assessment.

COVID-19 PANDEMIC

The evaluation team originally planned to observe each WE&T training in person for the Instructional Design Assessment to assess the various dimensions against relevant criteria defined in the evaluation yardsticks. Some of the dimensions included in the yardsticks, such as Dissemination Support in the Support of Behavioral Change Yardstick, included criteria as to whether the training offered hands-on activities for learners to demonstrate their knowledge and application of learned skills to instructors, as well as additional in-person training demonstrations to enhance visual learning and application. However, due to the COVID-19 pandemic, all Energy Center trainings had to be transitioned from in-person to online; thus, these in-person criteria were no longer applicable to our audit of the trainings. While the yardsticks were still an extremely useful and effective tool to audit the trainings, during the refinement process of the evaluation yardsticks, the evaluation team had to exclude several criteria that no longer applied in a virtual environment and added other criteria specific to virtual learning (Section 4.1).

Additionally, the COVID-19 pandemic forced the WE&T program administrators to transition training delivery, in some cases, abruptly to virtual formats. The virtual trainings included in our instructional design assessment and installer survey represent those offered during and immediately following the pandemic. We note that virtual training delivery may have evolved since that period, and, in some cases, WE&T program administrators may have already incorporated some of the practices recommended in this report.

RECRUITMENT CHALLENGES

The original design of the Behavioral Assessment involved conducting ride-alongs with technicians in which a member of our team would accompany HVAC professionals as they installed HVAC systems in residential and small commercial sites before and after participating in a WE&T training. We attempted to recruit technicians enrolled in relevant IOU-sponsored IHACI HVAC trainings in the late summer of 2022. We planned to schedule the pre- and- post-training ride-alongs in the summer and fall of 2022, respectively. After these recruiting efforts garnered no interest from technicians, we sought input regarding our enrollment challenges from key stakeholders such as IOU Energy Center staff, training instructors, the Executive Vice President of IHACI, and HVAC distributors who knew about the trainings.

Based on the feedback we received, we concluded that recruiting difficulties for the ride-alongs were, in general, attributable to several factors, including the timing of the study coinciding with HVAC professionals' busiest season, buy-in from technicians' employers, and concern for disruption of their customers' experience. Consequently, we redesigned elements of this research task to support technician participation, including conducting observations in a lab setting where work schedules, employer buy-in, and customer experience would not be mitigating factors.

While these changes enabled observing technicians' application of skills outside of the learning environment, facilitating lab-based observations had several impacts on the evaluation. Notably, the lab environment was not conducive to observing the installation of HVAC equipment. As a result, we shifted the observation scenarios to focus on system maintenance and troubleshooting. Given that we could not observe Quality Installation practices, we were also limited in the amount of savings data we could collect; that is, the types of tasks involved in the redesigned scenarios were associated with marginal savings impacts compared to the savings associated with Quality Installation.

4. TRAINING ENVIRONMENT

We have separated the remainder of this report into two overarching sections: one that provides our assessments of the WE&T HVAC training environment and another that discusses how those trainings support technicians in their work environment. This section focuses on our evaluation of the training environment, specifically, our assessment of curriculum design for four select HVAC trainings, participant satisfaction with HVAC trainings, and participants' self-reported knowledge gain. Additionally, we provide several refined tools that stakeholders can use to evaluate the effectiveness of future WE&T training (i.e., refined evaluation yardsticks and participant exit surveys). As described in Section 3, this discussion encompasses analyses related to Levels 1 (Reaction) and 2 (Learning) of Kirkpatrick's Model.

4.1 TOOLS FOR ASSESSMENT

As part of this evaluation, Opinion Dynamics developed and refined materials to assist training providers, WE&T program administrators, and other stakeholders in continuously assessing training design and effectiveness. Importantly, decision-makers can use these tools to assess whether WE&T trainings draw upon best practices for delivering adult training programs and gauge participants' initial reactions to and satisfaction with their training experiences. In addition, we also spoke with instructors to learn their perspectives on course design and their role in creating course material for the designated target audience.

YARDSTICKS

Opinion Dynamics developed three evaluation yardsticks as part of our previous process evaluation of California WE&T programs.[8] These yardsticks are organized into different dimensions that include different criteria evaluators can use to assess whether training draws upon several core best practices in adult learning theory, as shown below in Figure 4. Examples of criteria reflected in the yardsticks include whether the training focuses on the learner rather than the instructor and the presence of problem-solving activities to engage learners. We used these yardsticks to assess different aspects of four select WE&T HVAC trainings that are listed in Table 5 above.

[8] Opinion Dynamics Corporation. "2010–2012 Workforce, Education, and Training Process Evaluation Volume I: Centergies." CALMAC, December 2012. http://calmac.org/publications/2010-2012_WE&T_Centergies_Process_Eval_Report_volume_I.pdf

Figure 4. Evaluation Yardsticks and Dimensions for Assessment

As part of this evaluation, we refined the evaluation yardsticks. Revisions included editing criteria language to focus on applicability to participants' work environment and adding two criteria. We describe the updates that we made to the criteria below and provide the full evaluation yardsticks in in Appendix A.

First, we added context to two criteria included under the Learner Orientation, Buy-In, and Engagement Dimension of the Adult Learning Principles and Practices Yardstick to make both more active by adding the underlined language below. Further, both edits highlight the need to focus training content on the learner and reinforce core concepts by relating to learners' experiences. Similarly, we added two criteria to the Practice, Application, and Interactivity Dimension of the Learning Focus Yardstick to reinforce the need to support a variety of learning styles through practical activities and the use of varying group sizes.

Table 10. Updated Evaluation Yardstick Criteria

Evaluation Yardsticks	Dimensions	Criteria
Adult Learning Principles and Best Practices	Learning Orientation, Buy-In, Engagement	▪ **Criterion #2:** The usefulness of the learning in the participants' lives is emphasized and demonstrated <u>using real-world examples.</u> ▪ **Criterion #9:** The class builds on the learner's prior learning or experience and <u>leverages this experience to drive home key content.</u>
Learning Focus Yardstick	Practice, Application, and Interactivity	▪ **Criterion #11:** Activities reinforce key material, concepts, or skills. ▪ **Criterion #12:** Training employs a variety of large-group, small-group, and individual experiences.

Finally, we identified two dimensions specified in the previous evaluation that were irrelevant to the four trainings included in this Instructional Design Assessment and this study.[9] As such, we removed the following:

- **General Impressions of Adult Learning (Adult Learning Principals and Practices Yardstick).** As stated in the 2010–2012 WE&T evaluation, this dimension is not score-based. It is useful when comparing the evaluation team's general observations with parallel assessments provided by Energy Center staff. This study did not include a comparison with data collected from energy center staff; therefore, we excluded this dimension.

[9] Opinion Dynamics Corporation. "2010–2012 Workforce, Education, and Training Process Evaluation Volume I: Centergies." CALMAC, December 2012. http://calmac.org/publications/2010-2012_WE&T_Centergies_Process_Eval_Report_volume_I.pdf

- **Integrated Demand Side Management Dimension (Learning Focus Yardstick).** In the 2010–2012 WE&T evaluation, Opinion Dynamics included the criteria under the Integrated Demand Side Management (IDSM) Dimension to assess whether training content directly related to IDSM topics (e.g., energy efficiency, demand response, or distributed generation). Opinion Dynamics selected trainings for study specifically due to their focus on an energy efficiency topic (i.e., HVAC system efficiency in residential and commercial buildings). Given that all of the trainings included in this study focused on IDSM topics, we deemed it unnecessary to provide an assessment on this dimension

WE&T REACTION SURVEY

According to the principles of adult learning theory, individuals who exhibit positive responses to training programs are more likely to effectively retain and apply the knowledge and skills acquired during such programs. A consistent and quality assessment of participant reactions is a critical first step to evaluating a training's effectiveness.

As part of this evaluation, Opinion Dynamics developed a short set of questions to gauge the satisfaction of training participants immediately after they complete a WE&T training (i.e., addressing Level 1 of Kirkpatrick's model) to be used by all four IOUs. We reviewed the current versions of each IOU's exit survey to catalog topics covered in each survey and identify if any topics critical to assessing participants' reactions were missing. We include the full exit survey instrument in Appendix E. Table 11 lists all the topics covered in IOUs' WE&T reaction surveys at the time of our review in 2020. Topics one through nine are most critical for assessing participants' reactions to and satisfaction with different training components. In a previous evaluation of the WE&T Program, Opinion Dynamics recommended that IOUs cover consistent question topics (i.e., a standard survey design).[10] While IOUs have taken steps to achieve greater consistency in these surveys, there are some minor differences in the topics these surveys cover. Several topics that IOUs address in their exit survey are not relevant to evaluating trainees' reactions to the learning environment in Level 1 of Kirkpatrick's Model; however, these topics may be important for IOUs.

Table 11. Current Exit Survey Topics by IOU

Question Topics	PG&E	SCE	SDG&E	SoCalGas
1. Overall training quality	✓	✓	✓	✓
2. Instructor's abilities	✓	✓	✓	✓
3. Quality/usefulness of training materials	✓	✓	✓	✓
4. Appropriate level of instruction/interaction	✓	✓	✓	✓
5. How will the participant directly apply skills learned from training	✓	✓	✓	✓
6. How often will the participant apply skills learned from training	✓	✓	✓	✓
7. Appropriate length of training				✓
8. Does the participant recommend the training	✓			✓
9. What is the participant's goal for attending training	✓	✓	✓	✓
10. How the participant heard about the training	✓	✓	✓	✓
11. Participant's preference for future training offerings	✓			✓
12. Does the participant plan to participate in the rebate program		✓	✓	

[10] Opinion Dynamics Corporation. "2013-2014 Statewide Workforce, Education, and Training Program: Program Theory and Logic Model Update; Centergies Data Needs; and Critical WE&T Data Needs." CALMAC, June 2014. www.calmac.org/publications/2013-2014_WET_PTLM_and_Critical_Data_Gap_Assessment.pdf

Question Topics	PG&E	SCE	SDG&E	SoCalGas
13. Did training help the participant to participate in the program		✓	✓	✓
14. Will the participant share information with others				✓

4.2 PARTICIPANT ENGAGEMENT AND SATISFACTION

Creating learning environments that successfully engage participants is critical to delivering effective trainings. Our Instructional Design Assessment examined how well the designs for four specific WE&T trainings (see Section 3.1) understood and tailored training content to their target audiences. We also measured participants' satisfaction with their training experience, one measure of engagement, through a survey with those who took part in HVAC training during the 2019 and 2020 calendar years (see Section 3.2).

TARGET AUDIENCE

Designing and delivering effective training begins when training providers understand their target audience and incorporate materials that are accessible and applicable to the populations they aim to serve. This may mean considering their audiences' range of learning and engagement styles when designing and delivering instruction. To assess these elements, our Instructional Design Assessment of four WE&T trainings (see Table 5) involved auditing those trainings and completing interviews with each instructor (see Section 3.1).

From talking with instructors, we gathered that they had a clear sense of the target audiences for their specific trainings and developed content with their target audience in mind. When asked about the target audience for their trainings during in-depth interviews, instructors identified a specific subset of professionals who work in the HVAC installation and maintenance industry. Though some trainings also target company owners or supervisory staff, in most cases, instructors reported that they develop and deliver content aimed at the professionals in the field conducting HVAC installation, service, or maintenance work. In addition to those working directly for HVAC installation and maintenance companies, instructors reported that some training content might be suitable for Home Energy Rating System (HERS) raters, municipal code officials, and homeowners. Table 12 describes the primary target audience for each training according to instructors, training materials, and WE&T program staff.

> *"The guy, the girl that are in the trenches, not in the office, not an engineer, but they're on the roof. They're in a mechanical room working with their hands on aged HVAC and refrigeration equipment. That's our target audience."*

Table 12. Target Audiences for Audited WE&T Trainings

IOU Sponsor	Training Name	Description of Target Audience
SCE	NCI—Duct System Optimization (NCI DSO)	Residential HVAC technicians and installers, service managers, and company owners
SCE	IHACI—Air Distribution Module (IHACI AD)	Residential and commercial HVAC service technicians who have some "hands-on" experience in the field
SDG&E	IHACI—HVAC/R New Hire Module (IHACI NH)	Early career HVAC technicians, typically recently hired or working towards employment in HVAC service and installation
PG&E	PG&E—DCV and Variable Speed Fans (PG&E DCV)	HVAC service technicians, building operations and maintenance professionals, and individuals new to, or hoping to enter the building operations/maintenance industry

TRAINING DESIGN

Appropriate training materials and curriculum design facilitate engagement and, therefore, feelings of satisfaction among participants. When asked about the curriculum design process, instructors across all four trainings reported that they work closely with WE&T program staff and their respective training partners (e.g., NCI or IHACI) where applicable to continuously update and tailor the presentation and materials to improve upon the learners' experiences. One instructor described the training presentation as a "working document" as there is "always room for improvement." Instructors and training institutions improve their training by addressing errors or typos in materials, updating the curriculum to reflect technological changes, and integrating participant feedback. All instructors interviewed for this study have substantial experience in the HVAC field and are heavily involved in enhancing the training curriculum.

While program staff at all four IOU sponsors are involved in curriculum development, their involvement in materials development varies from training to training. In some cases, WE&T program staff provide feedback on training presentation slides and content or have a team of subject matter experts dedicated to curriculum development. In other cases, WE&T staff contracts with third-party training partners such as IHACI to design and deliver training. Instructors we interviewed for this evaluation reported satisfaction with the processes for periodically updating the curriculum design and training materials, along with the support provided by WE&T program teams.

Along with auditing the four training courses, we reviewed associated materials, including lesson plans, training slides, and other materials provided to participants. Lesson plans and other materials for all four trainings demonstrated organizing principles and exhibited measurable learning objectives. The objectives for three of the four trainings focused on building participants' understanding and comprehension of key topics, while the objectives for one training focused on skill development. In general, we found that materials included appropriate material for the time allotted. One common improvement area was the number and type of training methods; three of four audited trainings did not meet the criteria for exhibiting a variety of training methods. Instructors delivered all four trainings largely through a lecture style with limited opportunities for activities, breakout groups, or other varied training methods that might help engage audiences with a broad range of learning styles. Table 13 provides yardstick scoring for the related dimension based on our audits. We provide complete yardstick scoring in Appendix A.

Table 13. Adult Learning Principals and Practices Yardstick Scoring

Lesson Plan and Content Decisions Dimension	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
1. There are learning objectives	1	1	1	1
2. The learning objectives are specific, observable, and measurable	1	1	1	1
3. The materials indicate the desired learning levels	1	0.5	1	1
4. Their design reflects a variety of training methods	1	0	0	0
5. There is a clear focus on key content; interesting but unimportant content is kept to a minimum	1	0	1	1
6. There is an organizing principle	1	1	1	1
7. There is an appropriate amount of content for the time period	1	1	1	1
Total Points Scored / Total Possible Points	7 of 7	4.5 of 7	6 of 7	6 of 7
Score	100%	64%	86%	86%

Instructional materials across the four trainings audited through this evaluation reflected limited activities to support trainee engagement. All four audited trainings performed poorly on the Learner Orientation, Buy-In, and Engagement Dimension of the Adult Learning Principals and Practices Evaluation Yardstick (see Appendix A.) with scores ranging from 33% to 56%. The criteria within this dimension focused on activities that could engage learners and encourage them to share ideas, indicate their learning goals, and discover important information on their own, most of which were

unmet by these trainings. Importantly, only one of the four trainings included an activity to help participants see the value of the training, and none included an activity to help participants indicate learning goals or engage different learning styles.

PARTICIPANT ENGAGEMENT

Overall, we found that engaging participants was challenging across all four trainings. Instructors tried to engage trainees but struggled to elicit student participation in the virtual setting. Instructors across all four trainings employed different strategies to engage students. However, students often seemed reticent to participate. Some students used chat functions through the virtual meeting platforms, and several joined the conversation by asking questions or verbally sharing their experiences. Notably, these instructors attempted to engage with students by asking questions and encouraging participation when asking periodic review questions at different points during their instruction. That said, without specific activities designed to engage students in the virtual environment, instructors often could not achieve levels of student participation expected for similar in-person training.

> *"I think the downfall of the webinars is...the networking. These guys don't get to meet new people anymore. They don't get to go out and sit with a room of 85 different people that they don't know."*

Instructor interviews corroborated the challenges to student engagement in the virtual learning environment. Instructors representing all four trainings unanimously reported they prefer in-person delivery because participants have fewer distractions and more opportunities for participation. With in-person delivery, participants can have more dynamic conversations with instructors and each other, including professional networking. Two instructors indicated a desire to include more videos and images in the training presentation slides to improve their virtual technical demonstrations, including exploded views of HVAC systems. In particular, the PG&E DCV training faced challenges translating the training curriculum to a webinar format. When in-person, students taking this training benefit from hands-on activities and demonstrations using actual equipment they would work on in the field—that is, instructors demonstrate how to apply the concepts they are learning on a full-sized packaged HVAC unit. While creating a similar interactive experience for virtual trainings is likely possible, it would require substantial investments in software and effort to update training materials.

> *"One challenge we've had is our ability to generate metrics on knowledge improvements and exam pass rates, things like that. It has slowed down a little bit because the students aren't taking them right at the end of the class. The webinar ends and then they have an extended period of time to go in and take that exam, so our reporting is delayed."*

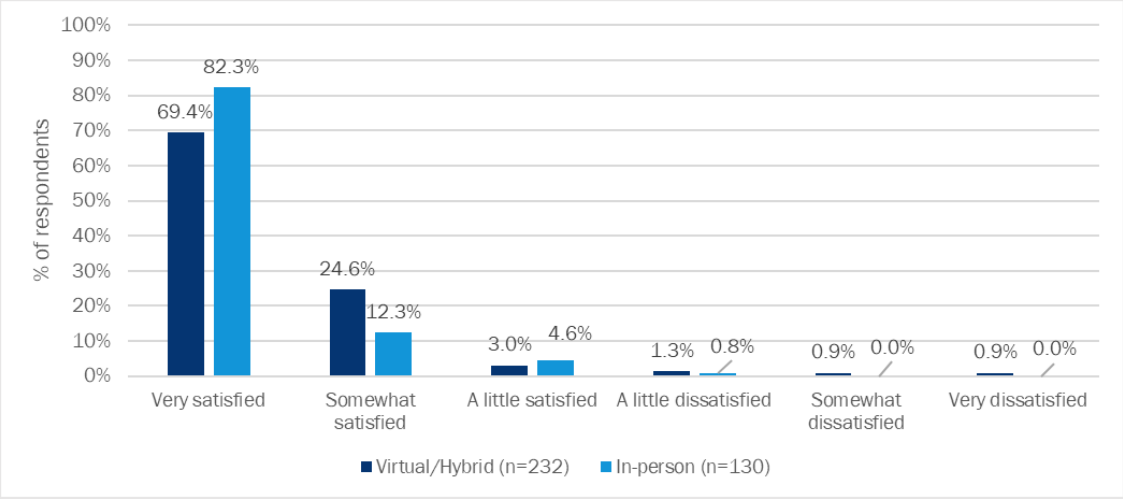
Instructors also noted challenges to understanding trainee experiences in the virtual environment. Our interviews with instructors explored challenges and opportunities for understanding and improving learner reactions to the trainings. Instructors noted that collecting data on participant experiences, knowledge gain, or other details was also challenging in a virtual environment. For example, instructors reported that some of these challenges might relate to the fact that training attendees were given a longer period to complete feedback surveys (e.g., satisfaction assessments immediately following training completion), compared to in-person trainings requiring attendees to complete these assessments before leaving. However, during our training audits, our team also observed instances where training staff did not use software that would allow for real-time data collection and results sharing. For example, during some trainings, trainers asked participants to answer multiple-choice questions to reinforce key concepts when completing a specific module. Instructors often displayed questions and answer choices in these scenarios on a PowerPoint slide, and, as such, there was no mechanism to gather feedback from participants in real time. Students were encouraged to either offer responses through the chat function of the meeting software or on their own. Our team observed that it was not always clear that trainees were participating in these situations, which proved challenging for instructors as they were unaware of students' engagement levels. Further, as the sudden shift to online learning during the pandemic left instructors

without a mechanism to obtain real-time feedback from students, instructors were also unable to assess how students were receiving the training material and where remedial work may be required.

PARTICIPANT SATISFACTION

To understand trainee satisfaction with training experiences, we surveyed individuals who participated in HVAC training during the 2019 and 2020 calendar years (see Section 3.2). For in-person and virtual delivery, trainees report high satisfaction with their most recent training experience. Most respondents indicated they were "very satisfied" or "somewhat satisfied," with 94% of virtual/hybrid participants and 94.6% of in-person respondents reporting such satisfaction (Figure 5). Though both groups reported high levels of satisfaction, a larger portion of respondents who completed in-person training (82.3%) were "very satisfied" when compared with those providing similar ratings from the virtual/hybrid group (69.4%).[11] Few respondents across either delivery group reported dissatisfaction with their training experience.

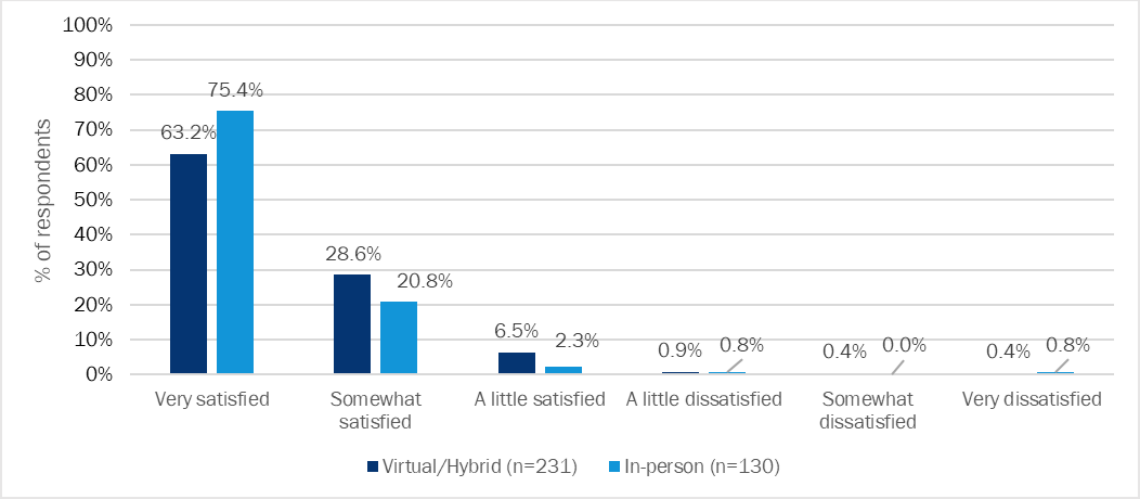
Figure 5. Overall Satisfaction with WE&T Training



Additionally, trainees reported high satisfaction with their instructors (Figure 6). In both delivery groups, more than ninety percent of respondents indicated they were somewhat or very satisfied with their instructor. Mirroring the trend with overall satisfaction, a larger share of respondents that most recently attended an in-person training (75.4%) reported the highest level of satisfaction. In comparison, a smaller share of virtual/hybrid respondents reported the same level of satisfaction (63.2%).

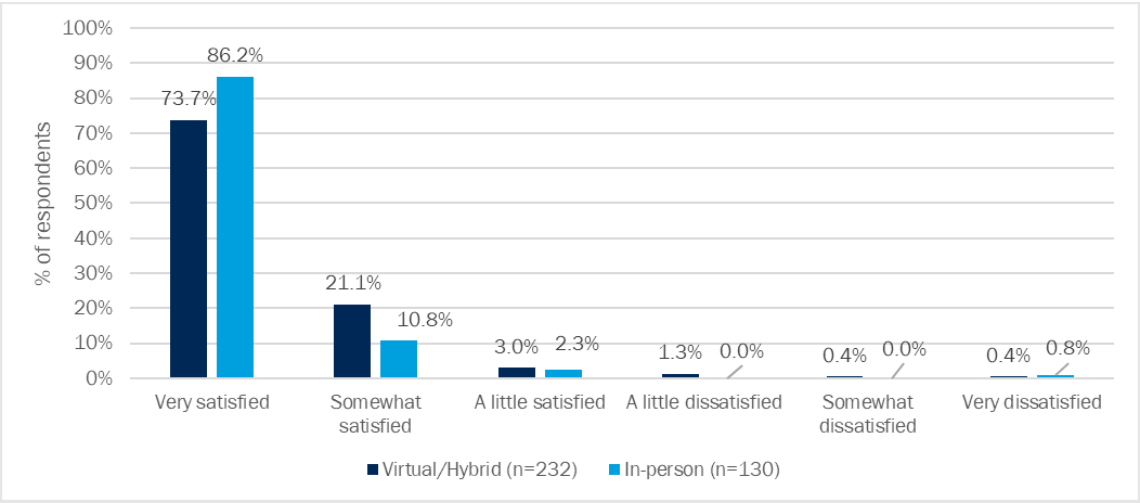
[11] The virtual trainings included in the installer survey were offered during the COVID-19 pandemic, which forced training providers to transition delivery from in-person to virtual formats. Please see Section 3.5 for additional details regarding the impacts of the pandemic on this evaluation.

Figure 6. Satisfaction with the Instructor



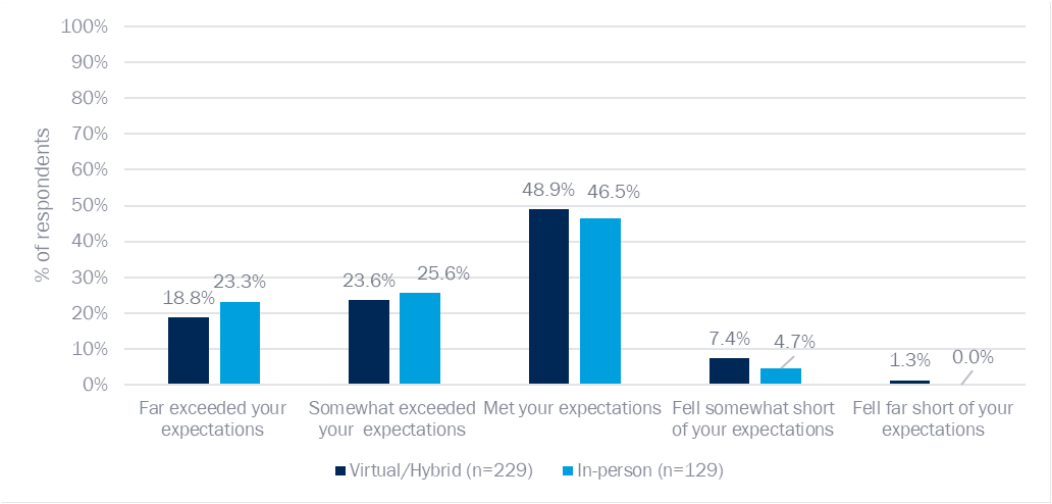
Most respondents across all delivery groups also reported being either very or somewhat satisfied with the training materials (see Figure 7). However, a larger share of respondents in both groups reported being "very satisfied" with the materials (73.7% and 86.2% of in-person and virtual/hybrid respondents, respectively) when compared with instructor satisfaction levels.

Figure 7. Satisfaction with Training Materials



Finally, nearly half of respondents in both delivery groups reported that their WE&T training experience met their expectations (Figure 8). Additionally, many respondents indicated that their most recent WE&T training experience exceeded their expectations, with roughly 49% of in-person respondents and 42% of virtual/hybrid respondents reporting that their experience either somewhat or far exceeded their expectations. A small share reported that experience fell short of expectations; however, the portion of virtual/hybrid respondents (8.7%) reporting dissatisfaction was nearly double that of dissatisfied in-person respondents (4.7%).

Figure 8. Based on What You Expected to Learn, Did the Training Meet Your Expectations



We also asked respondents to describe improvements they would recommend for the training they completed. We analyzed the open-ended responses and recoded participants' recommendations to identify the three most common types of improvements that trainees suggested. Of the 128 respondents who answered this question, 38 had completed an in-person training and 90 completed a virtual/hybrid training. Overall, the most frequently desired improvement was to increase the number of hands-on activities (29%, n=38). This was also the most common recommendation among respondents who completed in-person trainings (45%, n=17) and those who attended virtual/hybrid trainings (23%, n=21). The desire to go deeper into topics was the second most common overall (20%, n=25) and among in-person training respondents (21%, n=8), while this was the third most frequently cited recommendation among survey-takers who completed virtual/hybrid trainings (19%, n=17). Notably, the second most frequently cited recommendation among virtual/hybrid trainees we surveyed was to deliver the content as an in-person training (22%, n=20).

4.3 LEARNING AND KNOWLEDGE TRANSFER

In addition to gauging participant engagement and satisfaction, we assessed participant-reported learning and how training designs enabled that learning. In the remainder of this subsection, we provide an assessment of training delivery from the Instructional Design Assessment (Section 3.1) and self-reported learning results from a survey of participants in HVAC training from 2019 and 2020 (Section 3.2).

TRAINING DELIVERY AND LEARNING

Based on results from the instruction design assessment, all four of the trainings performed well in terms of instructor facilitation, but performance varied in terms of participant activities. To understand instructional delivery, the evaluation team focused on two key dimensions of the evaluation yardsticks: Learner Facilitation and Feedback and Learner Success Engineering (Appendix A.). Learner Facilitation and Feedback is comprised of criteria regarding the instructor's facilitation of the lesson. For example, criteria address how instructors validate learner responses and transitions between different topics. Overall, the trainings performed well on this dimension based on the scores determined during the course audits, which range from 75% to 100%, and two trainings demonstrated all criteria.

The Learner Success Engineering Dimension includes criteria that address the types of participant activities involved in the learning intervention and how those activities support learners in accessing content and achieving learning objectives. For example, criteria describe activities enabling trainees to indicate experience with training topics and connect to participant background knowledge. The criteria also consider the number of new concepts introduced and

how a lesson ensures students understand a concept before introducing additional details or complexity. Scores in this dimension varied from 50% to 100%. Notably, one training did not include participant activities; meanwhile, only one included activities for participants to demonstrate background knowledge and expertise. Full results for all four trainings are listed in Table 14.

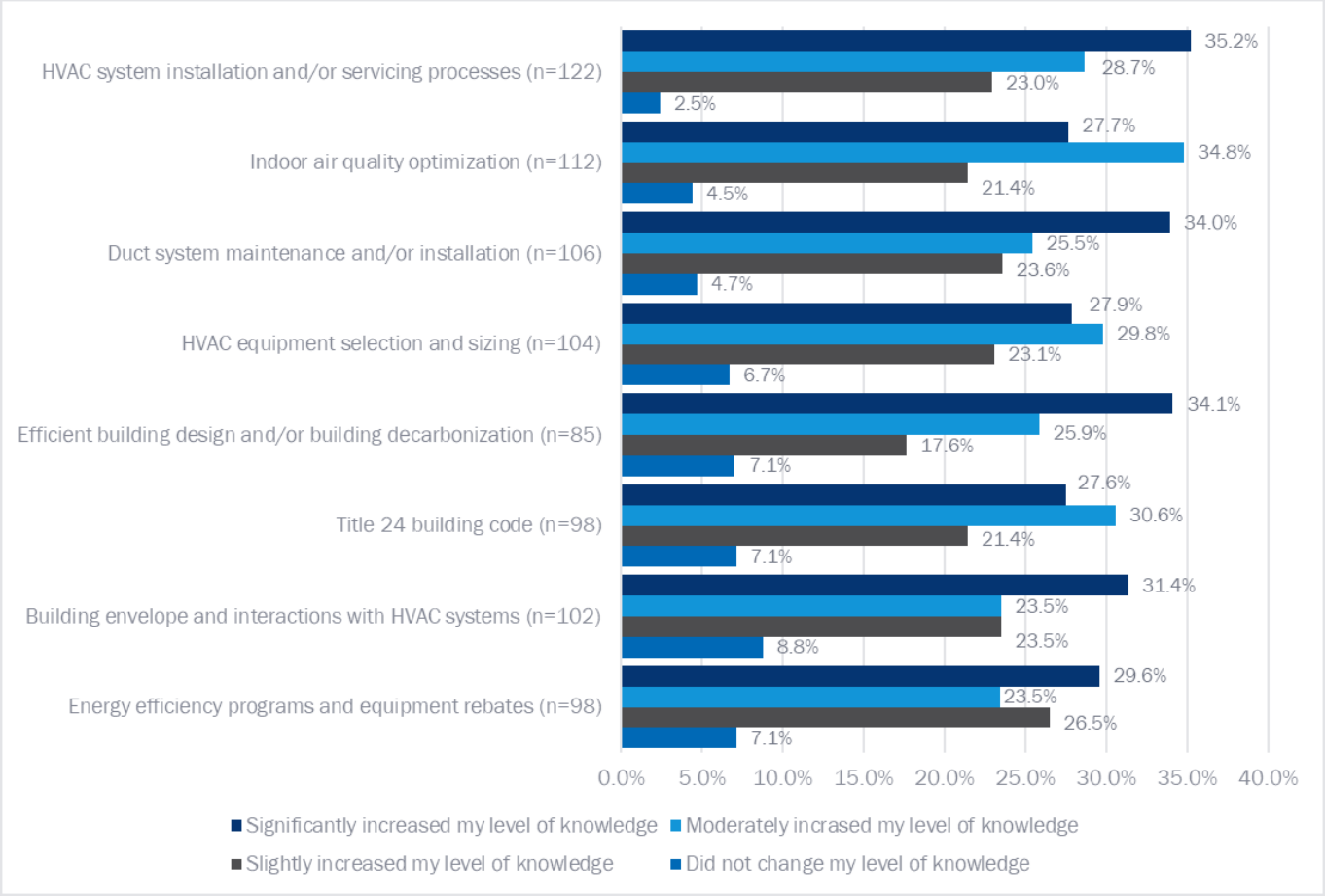
Table 14. Evaluation Yardstick Scores for Learner Success Engineering and Facilitation and Feedback

Learning Principles and Practices Yardstick	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
Learner Success Engineering				
1. There are learning objectives	1	1	1	1
2. The learning objectives are specific, observable, and measurable	1	1	1	1
3. The materials indicate the desired learning levels	1	0.5	1	1
4. Their design reflects a variety of training methods	1	0	0	0
5. There is a clear focus on key content; interesting but unimportant content is kept to a minimum	1	0	1	1
6. There is an organizing principle	1	1	1	1
7. There is an appropriate amount of content for the time period	na	na	na	na
Total Points Scored / Total Possible Points	**6 of 6**	**3 of 6**	**5 of 6**	**4 of 6**
Score	**100%**	**50%**	**83%**	**67%**
Learner Facilitation and Feedback				
1. Instructor validates learners' involvement and responses	1	1	1	1
2. Instructor makes transitional statements between sections	1	1	1	1
3. Instructor ensures that all learners can see and hear	1	1	1	1
4. Instructor provides breaks every 50 minutes or so	1	0	0	1
5. Instructor provides guidance and feedback when participants are asked to practice or demonstrate skills or knowledge	na	na	na	na
6. Instructor's feedback encompasses both positive and corrective feedback as appropriate	na	na	na	na
7. Instructor provides corrective guidance as appropriate	na	na	na	na
Total Points Scored / Total Possible Points	**4 of 4**	**3 of 4**	**3 of 4**	**4 of 4**
Score	**100%**	**75%**	**75%**	**100%**

PERCEPTION OF KNOWLEDGE GAINED

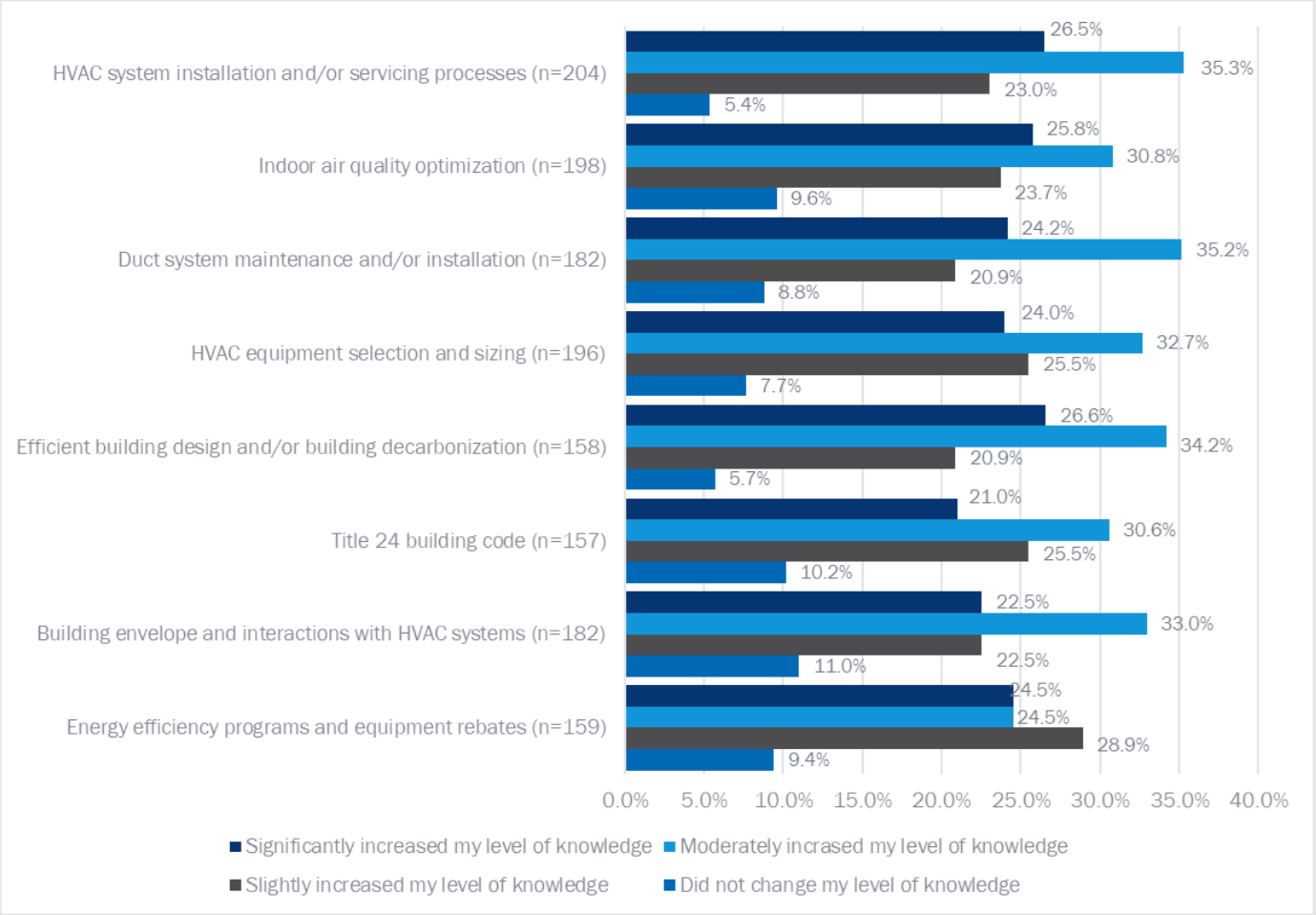
As displayed in Figure 9, more than half of survey respondents whose most recent WE&T training was in-person reported at least a moderate knowledge increase across a range of topics because of their training. In-person respondents reported high levels of knowledge gain for five of eight different HVAC-related topics. Over 35% reported that their training significantly increased their knowledge of HVAC system installation and/or servicing processes, and 34% reported that their most recent training increased their knowledge of duct system maintenance and efficient building design. A smaller share of in-person respondents (ranging from 2.5% to 8.8%) reported that their most recent training did not change their knowledge of each of the topics presented in the figure below.

Figure 9. Self-Reported Knowledge Gain by Topic (In-Person Training Delivery)



While more than half of virtual and hybrid respondents also indicated at least moderate knowledge gain from their most recent WE&T training, they reported a somewhat lower knowledge gain than in-person respondents. Figure 10 displays responses from virtual or hybrid participants and indicates the degree to which they felt their knowledge increased across various topics because of their most recent training. Over 26% of virtual or hybrid respondents indicated that their most recent training significantly increased their knowledge of HVAC system installation and servicing processes, and almost 27% of respondents indicated the same about efficient building design and building decarbonization topics. Compared to in-person respondents, a larger share of virtual or hybrid respondents across most topic areas reported that their training moderately increased their level of knowledge. The percentage of respondents who reported no change in their level of knowledge was also larger for virtual or hybrid respondents, with percentages ranging from 5.4% to 11%.

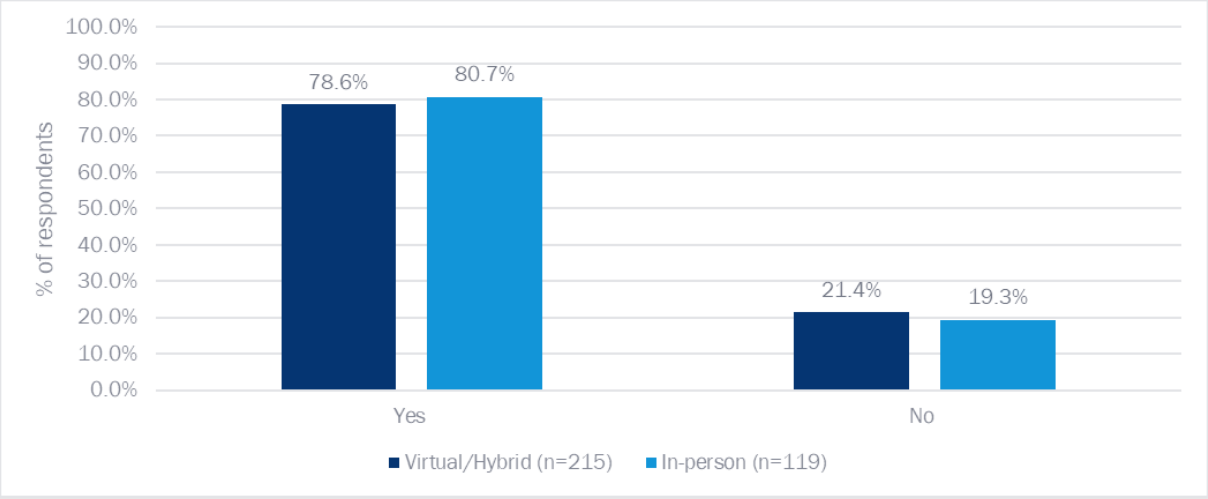
Figure 10. Self-Reported Knowledge Gain by Topic (Virtual/Hybrid Training Delivery)



Across both in-person and virtual/hybrid groups, the share of respondents who did not report any knowledge gain was the lowest for "the HVAC system installation and/or servicing processes" topic. Conversely, that share of respondents across both groups was highest for the "building envelope and interaction with HVAC systems" topic. Two-and-a-half percent of in-person respondents and 5.4% of virtual or hybrid respondents reported no knowledge gain regarding HVAC system installation or servicing processes. However, the topic of building envelope and interaction with HVAC systems had the largest share of respondents reporting no change in their knowledge level (8.8% of in-person respondents and 11% of virtual or hybrid respondents).

Most respondents across all training delivery modalities indicated that they could train others they work with on the topics covered during their most recent WE&T training. As illustrated in Figure 11, over 80% of in-person respondents and over 78% of virtual or hybrid respondents reported that they could use the knowledge they gained during their training to train others.

Figure 11. Using Knowledge to Train Others



5. WORK ENVIRONMENT

This section examines the extent to which WE&T trainees apply their learning from the training environment to the work environment and the degree to which curriculum design supports that application. We provide findings from the Instructional Design Assessment (Section 3.1) concerning how training content supports the development of knowledge and skills applicable to HVAC technicians' day-to-day responsibilities and results of our observations of and interviews with technicians who participated in the Behavioral Assessment of this evaluation (Section 3.4). As described in Section 3, this discussion encompasses analyses related to Level 3 (Behavior) of Kirkpatrick's Model.

5.1 TRAINING DESIGN: APPLICATION

Trainings we audited as part of the Instructional Design Assessment explained real-world connections consistently but provided limited opportunities for demonstrating the application. We used the evaluation yardsticks defined in Section 3.1 to score each training along the yardsticks' respective dimensions. For the two key dimensions that focus on the applicability of content, the four trainings we audited performed well, scoring at least 80% (Table 15).

Every training earned a score of 100% for the Action Motivation Dimension, meeting all associated criteria, which included (1) providing examples of common benefits realized through certain actions or measures addressed through work and (2) providing guidance on how to convey recommendations or ideas to decisionmakers in their organization. Trainings also did well on the Workforce Enablement Dimension, adequately meeting criteria such as (1) providing content and concepts encountered on the job, including examples of real-world, on-the-job opportunities, and (2) providing support to obtain or work towards a certification outside of the classroom.

Table 15. Dimensions for Explaining Applicability of Content

Evaluation Yardsticks and Dimensions	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
Action Motivation (Support for Behavioral Change Yardstick)				
1. Includes examples of "typical" benefits realized through actions or measures addressed by course	1	1	1	1
2. Includes detailed case study of actual implementations and benefits derived	1	1	1	1
3. Provides guidance on "selling" recommendations to decision makers in the organization, when appropriate	1	1	1	na
4. Includes references to relevant incentive and rebate programs	na	na	na	1
Total Points Scored / Total Possible Points	**3 of 3**	**3 of 3**	**3 of 3**	**3 of 3**
Score	**100%**	**100%**	**100%**	**100%**
Workforce Enablement (Learning Focus Yardstick)				
1. The course is targeted to specific job/role responsibilities*	1	1	1	1
2. The course clearly relates content and concepts to on-the-job responsibilities	1	1	1	1
3. The course includes examples that reflect "real-world" on-the-job opportunities	1	1	1	1
4. The course provides direct support for certification or has a clear relationship to certification (if applicable) +	0.5	0.5	0.5	0.5
5. Addresses the Apply (level 3) skill development level or higher++	1	0.5	1	1
Total Points Scored / Total Possible Points	**4.5 of 5**	**4 of 5**	**4.5 of 5**	**4.5 of 5**
Score	**90%**	**80%**	**90%**	**90%**

However, trainings scored lower on the key dimensions that focus on opportunities for application in and outside of the classroom (Table 16). On the Action Orientation and Support Dimension, scores ranged from 20% to 60%, with no training providing resources to trainees to support their assessment and analysis of situations on the job; only two of the four trainings provided resources to support action in the field. Performance varied on the Practice, Application, and Interactivity Dimension, with most scores ranging from 0% to 63% and one training scoring 90%.

Table 16. Dimensions for Practice and Support Applying Content

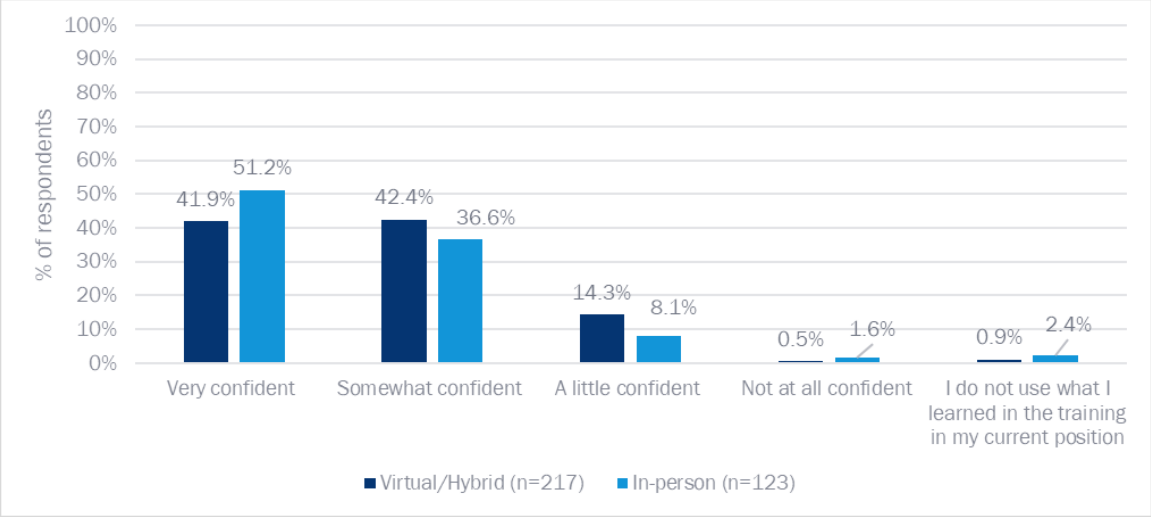
Evaluation Yardsticks and Dimensions	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
Action Orientation and Support (Support for Behavioral Change Yardstick)				
1. Includes specific calls to action / next steps	1	1	1	1
2. Supports development of individualized action plan	0	0	0	0
3. Includes job aids / worksheets to assist in assessing / analyzing options	0	0	0	0
4. Includes job aids / checklists to assist in taking action	1	1	0	0
5. Includes information on where/how to get assistance in taking action	1	1	1	0
Total Points Scored / Total Possible Points	**3 of 5**	**3 of 5**	**2 of 5**	**1 of 5**
Score	**60%**	**60%**	**40%**	**20%**
Practice, Application, and Interactivity (Learning Principles and Practices Yardstick)				
1. There are problem-solving activities that actively engage the learners	1	0	0	0
2. There are opportunities for participants to immediately apply their new learning in the classroom	1	na	0	0
3. Materials include a participant workbook for hands on activities to check learning and comprehension	1	1	0	0
4. Learners are actively engaged in discovering answers	na	1	na	na
5. The design includes checks for comprehension before leaving a key topic area	1	0	0	0
6. There are opportunities for learners to practice what they've learned as they learn it	1	na	0	0
7. The activities reflect the learning objectives, including an appropriate mix of terminal performance and enabling objectives	1	1	1	0
8. Activities are included after each new concept or skill area is addressed	1	1	0	0
9. Activities are parallel to - but different from - assessment items focusing on the same objectives	na	na	na	na
10. Activities employ a variety of approaches appropriate to relevant objectives and participants "real world" requirements	1	1	0	0
11. Activities reinforce key material, concepts, or skills	1	na	1	0
12. Course employs a variety of large group, small group, and individual experiences	0	0	0	0
Total Points Scored / Total Possible Points	**9 of 10**	**5 of 8**	**2 of 10**	**0 of 10**
Score	**90%**	**63%**	**20%**	**0%**

Most WE&T training participants self-reported high confidence in applying what they learned to their jobs. We also asked participants to indicate their confidence level in applying knowledge and skills from their most recent WE&T training to their work. As

Figure 12 below illustrates, over half of respondents who completed in-person training (51.2%) indicated that they were very confident in their ability to apply what they learned in their daily work, and over a third of respondents indicated they were somewhat confident (36.6%). Though most virtual or hybrid respondents reported that they were either

somewhat or very confident in their ability to apply their newly acquired knowledge and skills on the job, a smaller share indicated they were very confident (41.9%) compared to in-person respondents.

Figure 12. Post-Training Confidence in Applying Skills Needed on the Job



5.2 TRAINEE BEHAVIOR AND RESULTS

In the remainder of this section, we present findings from the Behavioral Assessment detailing how participants we observed were able to apply the concepts they learned from a select WE&T training in a simulated work environment (Section 3.4). We recruited HVAC technicians who attended the IHACI AC/HP Refrigeration Module in June 2023. The training was comprised of four three-hour sessions conducted in the evening hours over a two-week period. We observed study participants addressing pre-determined system faults on HVAC equipment in a lab setting before the training intervention and after completing said training. Prior to the start of the observation, we simulated a service call by having a member of our evaluation team explain the symptoms resulting from the pre-determined faults. System faults included refrigerant levels that were either too high or too low, issues related to thermostat installation, and either obstructed air flow or condenser coils (see Table 9 in Section 3.4). We highlight the differences in technician performance before and after the training along the elements listed below:

- **Demonstration of training objectives:** the extent to which technicians demonstrated the knowledge and skills associated with the learning objectives of the IHACI AC/HP Refrigeration Module.
- **Task completion:** the number and types of tasks technicians completed in their pre-training and post-training observations.
- **Technicians' processes:** how technicians approached the simulated service call before and after training.

Additionally, we provide context related to the foundational skills and experiences of the technicians we observed as part of this study. We also summarized the energy and demand savings associated with the types of system faults that we designed in the Behavioral Assessment.

TECHNICIAN BACKGROUND

The technicians who participated in this study had mostly novice HVAC work experience (e.g., maintenance and installation) and familiarity with heat pump systems. While they ranged in their training background, all four had previously taken IHACI courses in the last few years. Table 17 provides a summary of each technician's self-reported background and experience.

Table 17. Technician Background and Experience

Technician	Years of Experience	Experience in the Field (Novice, Moderate, Skilled)	Heat Pump Experience	Past Participation in HVAC Training(s)
1	1	**Novice Experience:** Maintenance of gas furnaces and air-conditioning systems	Limited	▪ IHACI trainings ▪ NCI trainings
2	6	**Moderate Experience:** Some prior maintenance and service of HVAC equipment, but mostly works on installations	Limited	▪ IHACI trainings ▪ NCI trainings
3	1	**Novice Experience:** Installation of HVAC equipment	None	▪ IHACI trainings
4	1	**Novice Experience:** Maintenance and service of HVAC equipment and minimal experience with installations	None	▪ IHACI trainings ▪ 10-month HVAC program at technical college

DEMONSTRATION OF TRAINING OBJECTIVES

We recruited technicians to participate in this study who enrolled and planned to participate in all sessions of the IHACI AC/HP Refrigeration Module offered through SCE's Energy Education Center in Tulare between June 6 and June 14, 2023. In designing our observation guide and rubric (see Appendix B.), we reviewed the training materials (i.e., lesson plans and training presentation) to identify the relevant training objectives. We observed technicians' actions and analyzed their responses to questions in the post-observation interviews to identify if and how they demonstrated an understanding of the different training objectives.

Table 18 presents the training objectives relevant to the observation scenarios and whether technicians demonstrated the knowledge and skills described in the objectives. The table also includes actions the evaluation team observed to help illustrate how technicians applied what they learned in accordance with the training objectives. The table also lists the number of objectives each technician demonstrated and the difference in the number of objectives between the two rounds of observations. As Table 18 illustrates, three technicians demonstrated improvement with the relevant training objectives.

Table 18. Training Objectives Reflected in Technician Knowledge and Skills

Training Objective	*Example of Observed Actions*	Technician 1		Technician 2		Technician 3		Technician 4	
		Pre-Training	Post-Training	Pre-Training	Post-Training	Pre-Training	Post-Training	Pre-Training	Post-Training
1. Understand the fundamentals of refrigerant flow conditions	*Placing a hand on the refrigerant line and explaining that it was hotter than it should be if the unit were operating in cooling mode.*	--	✓	--	✓	--	--	--	--

Training Objective	*Example of Observed Actions*	Technician 1		Technician 2		Technician 3		Technician 4	
		Pre-Training	Post-Training	Pre-Training	Post-Training	Pre-Training	Post-Training	Pre-Training	Post-Training
2. Understand how the AC and HP refrigeration system operates	*Checking the temperature of the compressor and the condenser and suggesting that the thermostat was set to heating instead of cooling.*	--	✓	--	✓	--	--	--	✓
3. Understand how the components operate together in the refrigeration cycle	*Stating the reversing valve is not energized, which causes the system to operate as if it is in heating mode.*	--	✓	--	✓	--	--	--	✓
4. Understand how and when to measure subcooling and superheating of the system	*Starting the system inspection by calculating the subcooling and superheating because the system was turning on but not blowing cold air when set to cooling mode.*	--	✓	--	✓	--	--	--	--
5. Be able to perform common refrigeration preventive maintenance	*Conducting a physical inspection of components such as ducts, air filters, and condenser coils.*	--	✓	✓	✓	✓	--	--	✓
6. Be able to determine when a refrigeration system is operating correctly	*Comparing subcooling and superheating values to normal operating ranges for the specific unit.*	--	✓	--	✓	--	--	--	✓
7. Be able to track reported symptoms to the actual root causes of the problems	*Identifying that the thermostat was set to the wrong mode, causing the system to operate as a heat pump rather than an air conditioner.*	--	✓	✓	✓	✓	--	--	✓
Total # of Objectives Demonstrated:		0	7	2	7	2	0	0	5
Difference in # of Objectives Demonstrated:		+7		+5		-2		+5	

Note: The checkmarks denote where technicians demonstrated actions related to the training objectives whereas dashes indicate technicians did not.

During the interviews that followed the post-training observation, each technician described connections between topics covered in the training and the tasks involved in the observation.[12] Three of the technicians described that the training covered subcooling, superheat, and airflow topics, all of which related to the system faults presented in the observation. One technician also stated that the training taught them to physically check and interpret the air temperature from the condenser, which they used in the second round of observation.

We also asked Technician #3 to comment on the difficulty they experienced demonstrating training objectives #5 and #7 in the post-training observation after being able to demonstrate those objectives during the pre-training session. Regarding training objective #5, they recognized that they forgot to perform common refrigeration preventative maintenance and stated that they thought this was attributable to feeling more nervous before the post-training observation than they felt before the pre-training observation. The technician's difficulty demonstrating objective #7

[12] See Appendix E. for the full post-observation interview guide.

was seemingly due to the specific tasks involved in second observation. Specifically, they spent the majority of the observation struggling to troubleshoot the incorrect thermostat settings. The explained in the interview that this is not something they typically think to inspect during their typical work in the field.

DIFFERENCES IN TASK COMPLETION

For the purposes of these observations, we use the term "task" to refer to either checking, diagnosing, or fixing a specific system fault. "Checking" refers to the methods technicians employ to examine system faults, such as taking measurements using diagnostic tools or conducting physical inspection of system components. "Diagnosing" refers to interpreting the information gathered to identify the root cause of the symptoms the system presents. "Fixing" is the corrective action to address the root cause of the system fault, resulting in the system performing in normal operating ranges. Specific examples for each scenario are included in the Observation Rubric in Appendix B.

We observed that a larger number of technicians were able to check, diagnose, or fix at least one of the faults after the training when compared to their pre-training observations. Table 19 summarizes how many and which technicians successfully checked, diagnosed, or fixed at least one system fault in both pre- and post-training observations. The icons correspond with each of the four technicians who participated in this study. technicians succeeded in checking, diagnosing, and fixing at least one system fault. Only Technician #2 successfully checked, diagnosed, and fixed at least one of the system faults both observations.

Table 19. Number of Technicians Who Successfully Completed At Least One Task

Type of Task Completed	Pre-Training Observation	Post-Training Observation
Technicians who successfully checked at least 1 fault	2 3	2 3 4
Technicians who successfully diagnosed at least 1 fault	2 3	1 2 4
Technicians who successfully fixed at least 1 fault	2 3	1 2 4

We also scored task completion related to each fault for all participating technicians for both pre- and post-training observations. The scores reflect whether the technician successfully completed (1.0), partially completed (0.5), or did not attempt (0.0) to check, diagnose, or fix each system fault.

Three of four technicians partially or successfully checked more system faults in the post-training observation than in the pre-training observation. Table 20 summarizes the system faults that technicians partially or successfully checked in each observation. Technicians #1, #2, and #4 partially or successfully completed more tasks related to checking system faults in their post-training observation than pre-training. Technician #2 successfully checked two faults in the first observation (thermostat wiring and airflow obstructions). In the second observation, they successfully checked two faults (thermostat settings and refrigerant charge) and partially checked a third fault (condenser coil obstruction). Technician #4 demonstrated the most improvement in checking system faults, partially checking one fault (refrigerant charge) in round one and successfully checking two system faults (refrigerant charge and thermostat settings) in round two.

Table 20. System Faults **Checked** by Technician and Observation Round

	Pre-Training				Post-Training				Difference Between Pre- and Post-Training
	Low Refrigerant Charge	Detached Thermostat Wires	Airflow Obstruction	Total	High Refrigerant Charge	Incorrect Thermostat Settings	Condenser Coil Obstruction	Total	
Technician #1	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	+0.5
Technician #2	0.0	1.0	1.0	2.0	1.0	1.0	0.5	2.5	+0.5
Technician #3	0.0	1.0	1.0	2.0	1.0	0.0	0.0	1.0	-1.0
Technician #4	0.5	0.0	0.0	0.5	1.0	1.0	0.0	2.0	+1.5

All four technicians improved in checking refrigerant-related faults between pre- and post-training. As illustrated in Table 20, Technician #4 was the only individual to check for refrigerant charge issues, at least partially in the pre-training observation. Conversely, three technicians checked the refrigerant charge successfully in the second round of observation (Technicians #2, 3, and #4). Technician #1 partially checked for the refrigerant charge issue in the post-training observation after having not completed the same task before the training.

Two of four technicians partially or successfully diagnosed and fixed more system faults in the post-training observation than in the pre-training observation, as shown in Table 21 and Table 22. Technicians #1 and #4 partially or successfully diagnosed and fixed more system faults in post-training than in pre-training observations. After being unable to diagnose or fix any system faults in round one, Technician #1 succeeded in diagnosing and fixing the condenser coil obstruction in the post-training observation. Technician #4 partially diagnosed one system fault in the pre-training observation (low refrigerant charge) and then successfully diagnosed one system fault in the second round (thermostat setting). Similarly, they did not partially or successfully fix any system faults in the first observation but succeeded in fixing one fault (thermostat setting) in the second observation. Technician #2 diagnosed and fixed fewer faults in the post-training observation than in the pre-training observation. Technician #3 checked and fixed fewer system faults and had no difference in the number of faults diagnosed from pre- to post-training.

Table 21. System Faults **Diagnosed** by Technician and Observation Round

	Pre-Training				Post-Training				Difference Between Pre- and Post-Training
	Low Refrigerant Charge	Detached Thermostat Wires	Airflow Obstruction	Total	High Refrigerant Charge	Incorrect Thermostat Settings	Condenser Coil Obstruction	Total	
Technician #1	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	+1.0
Technician #2	0.0	1.0	1.0	2.0	0.0	1.0	0.5	1.5	-0.5
Technician #3	0.0	0.0	1.0	1.0	1.0	0.0	0.0	1.0	0.0
Technician #4	0.5	0.0	0.0	0.5	0.0	1.0	0.0	1.0	+0.5

Table 22. System Faults **Fixed** by Technician and Observation Round

	Pre-Training				Post-Training				Difference Between Pre- and Post-Training
	Low Refrigerant Charge	Detached Thermostat Wires	Airflow Obstruction	Total	High Refrigerant Charge	Incorrect Thermostat Settings	Condenser Coil Obstruction	Total	
Technician #1	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	+1.0

	Pre-Training				Post-Training				Difference Between Pre- and Post-Training
	Low Refrigerant Charge	Detached Thermostat Wires	Airflow Obstruction	Total	High Refrigerant Charge	Incorrect Thermostat Settings	Condenser Coil Obstruction	Total	
Technician #2	0.0	1.0	1.0	2.0	0.0	1.0	0.5	1.5	-0.5
Technician #3	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0	-2.0
Technician #4	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	+1.0

Technicians demonstrated limited improvement in diagnosing—and no improvement in fixing—refrigerant-related faults. As illustrated in Table 21 above, Technician #3 was the only technician to improve in diagnosing refrigerant faults; they did not diagnose the refrigerant issue in the first observation but diagnosed the refrigerant issue in the second observation. Technician #4 performed worse in diagnosing refrigerant faults, partially diagnosing the refrigerant issue in round one and failing to diagnose the refrigerant issue in round two. Neither Technicians #1 nor #2 partially or successfully diagnosed the refrigerant fault in either round of observation. None of the technicians partially or successfully fixed the refrigerant fault in either round of observation.

DIFFERENCES IN TECHNICIANS' PROCESSES

The evaluation team also assessed each technician's approach to the simulated service call by using rubric to characterize the degree to which they demonstrated the behaviors and/or completed the actions described in each of the six observation points. As described in Section 3.4, the observation points reflect training objectives and HVAC industry best practices related to examining, diagnosing, and fixing HVAC systems. We assigned scores for each observation point using a five-point Likert scale (1–5). A score of 1 was associated with a technician who was unable or did not attempt the actions described in an observation point. When a technician demonstrated few, some, most, or all of an observation point, we assigned a score of 2, 3, 4, or 5, respectively. Table 23 describes the five-point Likert scale and provides an example of the criteria from Observation Point #1. We provide the full rubric, including criteria and examples of actions that demonstrate criteria for each observation point, in Appendix B.

Table 23. Description of Likert Scale and Example Criteria for Observation Point Scoring

	1	2	3	4	5
Scale Description	The technician does not attempt to accomplish the goals/ actions described in the observation point.	The technician attempts but accomplishes/ completes few to none of the goals/ actions described in the observation point.	The technician successfully accomplishes/ completes some of the goals/ actions described in the observation point.	The technician successfully accomplishes/ completes most of the goals/ actions described in the observation point.	The technician successfully accomplishes / completes all of the goals/ actions described in the observation point.

	1	2	3	4	5
Example Criteria: Observation Point #1	The technician does not attempt to obtain additional information about the system failure that may not have been included in the customer narrative.	The technician obtains little to no additional necessary information about the system failure that may not have been included in the customer narrative but does attempt to confirm their understanding of the situation with the customer.	The technician obtains some of the necessary information about the system failure including information that may not have been included in the customer narrative by asking pertinent questions of the customer.	The technician obtains most necessary information about the system failure including information that may not have been included in the customer narrative by asking pertinent questions of the customer.	The technician obtains all necessary information about the system failure including information that may not have been included in the customer narrative by asking pertinent questions of the customer.

Three of the four technicians improved on multiple observation points. Table 24 displays each observation point and each technician's scores from the pre- and post-training observations. Technician #1 improved on observation points one, four, and five. Technician #2 improved on all observation points. Technician #4 improved on observation points one, two, three, five, and six. Technician #3 maintained the same score on observation points one through three but earned lower scores on observation points four through six.

Table 24. Scores on Observation Points by Technician and Round of Observation

Observation Points	Technician #1		Technician #2		Technician #3		Technician #4	
	Pre-Training Score	Post-Training Score	Pre-Training Score	Post-Training Score	Pre-Training Score	Post-Training Score	Pre-Training Score	Post-Training Score
1. Asks customer pertinent questions for deeper understanding of symptoms.	1	2	1	2	2	2	1	2
2. Gathers diagnostic information to identify the issue using diagnostic tools.	2	2	2	4	3	3	2	3
3. Uses calculations, comparison, and other additional techniques to identify root cause of the issues.	2	2	2	3	2	2	2	3
4. Reports diagnostics, root causes, and corrective actions to the customer.	1	2	2	3	2	1	2	2
5. Takes proper corrective action to fix the system as authorized and directed by the customer	1	2	2	3	2	1	2	3
6. Re-evaluates the system to verify that the solution has eliminated all the symptom(s) and root cause(s).	1	1	2	3	2	1	2	3

Three of the four technicians improved the number and quality of questions they asked the "customer." Technicians #1, #2, and #4 improved concerning observation point one, which addresses the questions that technicians ask to learn more about the system (Table 24). After none of these technicians asked any questions in the first observation, all three individuals asked at least one question at the beginning and throughout the second observation to help diagnose the different system failures. Each technician's questions established important clarification about the symptoms the unit presented and helped inform their process. For example, three of the four technicians asked to confirm if the system was not blowing any air or not blowing cold air. In the post-observation interview, technicians explained that this distinction helped them identify how to start diagnosing the issues.

Two of the four technicians increased the number of methods they used to inspect and reevaluate the system. As presented in Table 24, Technicians #2 and #4 improved concerning observation points two and three, which deal with gathering and interpreting diagnostic information, and observation point six, which addresses reevaluating the system after attempting to fix an issue. The evaluation team noted that both technicians used multiple methods to take or confirm measurements to discern the root causes of system faults. For example, both technicians used physical inspection (e.g., holding a hand over the condenser to see if the air was warm or cold) and calculated measurements (e.g., subcooling and superheat). One technician also used two different diagnostic tools to check that the measure they initially collected was correct. Additionally, we noted that all technicians demonstrated increased comfort selecting and using appropriate diagnostic tools from pre- to post-training, even among the technicians who did not improve their scores on observations points two and three.

PERFORMANCE AND TECHNICIAN BACKGROUND

We analyzed the technicians' performance relative to their professional backgrounds to identify potential relationships between technician characteristics and their ability to apply what they learned in the training. The two technicians who demonstrated the most improvement were newer to the field and had previously completed multiple trainings from different providers. Table 25 summarizes the number and type of improvements each technician exhibited between pre- and post-training observations. Technicians #1 and #4 demonstrated the most improvements (seven of nine and eight of nine, respectively) and had several common characteristics. Notably, both technicians reported having just over a year of experience as HVAC professionals and previously completing HVAC training from multiple sources. Technician #1 stated that they completed training from IHACI and NCI. Technician #4, who demonstrated the most improvement of the four technicians, completed a 10-month training program through a technical college before entering the profession.

Table 25. Number of Improvements Each Technician Exhibited from Pre-Training to Post-Training

Type of Improvement	Technician #1	Technician #2	Technician #3	Technician #4
1. Checked more faults partially or successfully	✓	✓	✓	✓
2. Diagnosed more faults partially or successfully	✓	X	X	✓
3. Fixed more faults partially or successfully	✓	X	X	✓
4. Improved multiple observation point scores	✓	✓	X	✓
5. Asked more questions	✓	✓	X	✓
6. Improved use of tools	✓	✓	X	✓
7. Increased number of diagnostic techniques	X	✓	X	✓
8. Increased deemed savings earned	X	X	X	X
9. Demonstrated more learning objectives	✓	✓	X	✓
Total	**7/9**	**6/9**	**1/9**	**8/9**

Meanwhile, Technician #2 demonstrated the third most improvement (six of nine). Like Technicians #1 and #4, Technician #2 previously completed multiple trainings from different sources, including the NCI and IHACI. However,

Technician #2 is unique in that they have the most professional experience out of the four individuals (six years). It is also important to note that Technician #2 had less room for improvement than the other technicians, performing the best in tasks partially or successfully completed in both rounds of observations (Table 24).

Technician #3 demonstrated the least improvement (one of nine). Like Technicians #1 and #4, Technician #3 reported having approximately a year of professional experience. However, unlike the others, Technician #3 stated they had no experience with maintenance and no experience with heat pumps. They were also unique from the other technicians in that, although they had taken multiple previous trainings, all prior training was through IHACI.

ASSOCIATED DEEMED SAVINGS

We also calculated the potential energy and demand savings associated with successfully addressing each of the system faults in an average residential setting. We developed energy and demand savings values based on deemed parameters included in the California eTRM.

Table 26 displays the savings values associated with correcting scenario faults and we provide the detailed calculations and assumptions in Appendix D. Considering the technicians' limitations in returning the system to normal operating ranges (see Table 22), little-to-no savings were earned in either round of observation. In the first round, two technicians successfully fixed the closed dampers and dirty air filters in the pre-training observation, while none of the technicians fixed the refrigerant charge issue. No technician successfully completed the required actions to earn deemed savings values during the post-training observations.

Table 26. Scenario Faults and Associated Savings

Scenario and Fault	Energy Savings	Demand Savings
Scenario 1: Airflow obstruction (1) – closed dampers	20.91 kWh	0.02 kW
Scenario 1: Airflow obstruction (2) – dirty air filter	8.47 kWh	0.00 kW
Scenario 1: Refrigerant adjustment	177.30 kWh	0.15 kW
Scenario 2: Refrigerant adjustment	1.52 kWh	0.01 kW
Scenario 2: Condenser coil obstruction	41.70 kWh	0.03 kW

6. FINDINGS AND RECOMMENDATIONS

This section includes the findings and recommendations resulting from this evaluation.

- **Finding 1:** While WE&T HVAC trainees generally reported positive experiences and a knowledge increase resulting from their participation, instructors found it difficult to actively engage trainees in a virtual environment. Our Installer Survey of WE&T trainees found that an overwhelming majority of participants in HVAC trainings from 2019 and 2020 felt the trainings met their expectations (95.4% and 91.3%, respectively; see Section 4.2). In addition, most participants reported an increase in level of knowledge across a range of topics relevant to residential and small commercial HVAC installation and maintenance (see Section 4.3), and reported confidence that they would be able to apply what they learned on the job (see Section 5.1). Although self-reported satisfaction and knowledge gain were relatively high among participants, instructors highlighted the challenges of finding ways to actively engage participants in the training content, particularly in virtual or hybrid trainings (see Section 4.2). Further, only one of the four HVAC trainings that our team audited as part of this evaluation included in-class assessments to help instructors understand if and how participants understood the content (see Appendix A.). Relatedly, instructors reported some difficulty understanding how much information from the training that participants retained and whether participants went on to take and ultimately pass certification exams.
    - **Recommendation 1:** We recommend that the four California IOUs draw core questions from the standardized reaction survey that Opinion Dynamics prepared (see Appendix E-III for the instrument) to cover key topics related to participant satisfaction with their training experience. IOUs currently administer exit surveys at the end of trainings. However, topics and survey length differ between IOUs (see Section 4.1). We recommend that IOUs work to administer streamlined surveys that are available to participants online immediately after completing the training. A shorter survey will reduce the burden on respondents and a standardized version will enable decision-makers to understand satisfaction with similar training offerings across the IOUs. We discuss the most critical topics to cover in this type of survey in Section 4.1 and include the complete survey instrument in Appendix E-III.
    - **Recommendation 2:** Training providers should consider incorporating in-training assessments into curricula where possible to ensure that knowledge transfer is occurring among trainees and that the core concepts are understood before moving on to later topics. Training providers should also consider implementing summative assessments or tracking to help instructors understand how to better tailor their trainings to support outcomes such as higher rates of participants scheduling or passing certification exams post-training.
- **Finding 2:** For the trainings included in this evaluation, Opinion Dynamics identified that both instructor and trainee experiences differed between in-person and virtual trainings, and that the virtual environment posed challenges in terms of participant engagement. The four WE&T trainings we audited included few opportunities for active engagement amongst participants (see Appendix A-II). We also reviewed training materials for twelve WE&T HVAC trainings, both intended to be delivered in-person and virtually, and we found little difference between the materials and training design across delivery modes. Instructors reported preferring in-person delivery over virtual delivery because it allows more opportunities for active participation, gauging engagement and understating, and opportunities, where applicable, for “hands-on” learning. Respondents to the Installer Survey echoed similar sentiments (see Section 4.2). Participants who took the trainings in-person were more likely to be “very satisfied” than virtual/hybrid participants with the training overall , training materials, and the instructor (see Table 3).

Table 27. In-Person and Virtual Training Respondents Very Satisfied with Training Aspects

Training Aspect	In-Person Training Respondents	Virtual/Hybrid Training Respondents
Training Overall	82.3%	69.4%
Training materials	75.4%	63.2%
Instructor	86.2%	73.7%

Recommendation 3: We recommend that training providers consider different strategies to minimize screen fatigue and maximize trainee focus and attention. Virtual trainings can be a convenient option for technicians who do not want to travel to a physical location after working a long day. It can also reduce barriers for technicians who do not have the means to get to the training site. However, training providers should consider that technicians, who already had busy and tiring days, may have trouble focusing in front of a computer screen for several hours at a time. We note that WE&T program administrators may already employ these different types of strategies in their virtual training offerings, and we recommend that IOUs continue to expand these options across their peortfolios and work with third-party training providers to encourage adoption of these practices.

One strategy that IOUs and training providers may consider is shortening modules or sessions. We found that virtual trainings involved the same number and duration of sessions as the same training offered in-person. While the number and length of sessions in a training may be appropriate for in-person trainings, virtual trainings could involve more sessions that are shorter in duration thereby reducing screen fatigue. If adjusting the length and frequency of sessions is not possible, training providers should ensure that trainees have the opportunity to take regular breaks during virtual trainings.

IOUs should also explore differentiating activities between in-person and virtual delivery as another strategy that can help maximize trainee focus and attention. For example, lectures may be more appropriate for in-person trainings but may present challenges for sustaining trainee attention in the virtual setting. When exploring virtual training options, WE&T program administrators should consider different technology options, or training designs, that would enable more active participant engagement. One option is to facilitate small group breakout discussions to break up lecture-style presentations. Another option is to explore software that would enable participants to complete activities or mimic repairing or installing HVAC systems.

- **Finding 3:** Technicians who we observed as part of the Behavioral Assessment had somewhat mixed results in terms of how they were able to diagnose and ultimately fix an HVAC system that was not properly functioning. As we detail in Section 5.2, we sabotaged an HVAC system so it presented with faults that a technician could see in their day-to-day jobs. We observed technicians as they diagnosed and attempted to fix the system faults once before and once after they completed a WE&T training We designed two sets of system faults—one for the pre-training and one for the post-training observations—that provided technicians with an opportunity to demonstrate the objectives of the training they completed. When compared with pre-training observations, technicians demonstrated a better understanding of HVAC systems, a more robust diagnostic process, and more success engaging with the member of our evaluation team completing the observation (i.e., mimicking their customer). As few of the technicians were able to address the system faults included in the observation, a typical residential customer would not have realized the energy savings that could have resulted in successfully addressing these issues were these actual house calls (see Section 5.2). However, their ability to more fluently discuss issues with "their customer" and connect symptoms with root causes of the faults suggest that their participation in the WE&T HVAC training would provide market benefit in their daily work experiences.
    - **Recommendation 4:** WE&T trainings should incorporate opportunities for hands-on demonstration of skills the training intends to develop, where appropriate. If hands-on application is not feasible (e.g., in virtual learning environments), we recommend training providers increase opportunities for participants to engage

in problem-solving exercises where they are prompted to apply training content. One such example that instructors can consider is employing a case or scenario approach. Instructors could present trainees with a description of a real-world problem and ask participants to discuss appropriate diagnostic methods and potential strategies for addressing the issues presented in the scenario in smaller group settings. Training providers could also consider the use of software to simulate working directly on HVAC systems (see Recommendation 3). Another strategy is to bring HVAC equipment into the training environment to allow instructors to provide demonstrations and trainees the opportunity to practice working on real systems. We note that some of the energy centers may already have training equipment for this purpose and we encourage training administrators to continue and expand this practice to the extent possible.

  - **Recommendation 5:** We recommend that WE&T program staff continue to explicitly highlight the customer satisfaction benefits of training to HVAC contractors and other similar employers. Specifically, trained technicians may be more confident in their ability to ask questions of their customer and identify the root causes of the symptoms that customers experience, which may lead to better customer experiences. Additionally, addressing root causes of the issues that customers experience, rather than simply eliminating the symptoms, may lead to more efficient time at individual job sites and fewer callbacks.

- **Finding 4:** Technicians work in a demanding industry that requires them to work long hours in difficult conditions. Both in our efforts to recruit technicians into the behavior assessment portion of this evaluation and post-observation interviews we found that technicians were often over-burdened by their schedules. As such, trainings held in the evenings at the end of a long workday likely do not provide the best opportunities for technicians to retain the complex technical information provided through WE&T trainings.

  - **Recommendation 6:** WE&T program administrators should consider finding additional methods to provide training content to technicians. This may include shorter virtual training content or modules that technicians can do on their own time, reference packets or materials that may be useful to technicians in the field or working with employers to find ways to provide train-the-trainer opportunities or training content during typical work hours. We note that IOUs may be employing some of these strategies to already and we recommend expanding these alternative delivery methods more broadly.

APPENDIX A. EVALUATION YARDSTICKS

Appendix A-I, Appendix A-II, and Appendix A-III include the three full evaluation yardsticks that Opinion Dynamics used when auditing the four trainings listed in Table 5. These yardsticks were originally developed as part of a process evaluation of California WE&T programs. Opinion Dynamics made minor revisions as part of this evaluation (see Section 4.1 for changes).

The yardsticks provided below include the scores that Opinion Dynamics assigned to each training. Evaluators scored each criterion by assigning a one when the specified conditions were met, a zero where they were not, and a not applicable (N/A) where criteria may not be applicable based on the training material. When scoring, evaluators did not count criteria deemed not applicable for a specific training toward the total number of possible points for that training. We then scored each training across the dimensions specified in the three yardsticks.

APPENDIX A-I. SUPPORT FOR BEHAVIORAL CHANGE YARDSTICK

Table 28. Support for Behavioral Change Yardstick Scores

Support of Behavior Change	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
I: Action Orientation and Support				
1. Includes specific calls to action / next steps	1	1	1	1
2. Supports development of individualized action plan	0	0	0	0
3. Includes job aids / worksheets to assist in assessing / analyzing options	0	0	0	0
4. Includes job aids / checklists to assist in taking action	1	1	0	0
5. Includes information on where/how to get assistance in taking action	1	1	1	0
Total Points Scored / Total Possible Points	**3 of 5**	**3 of 5**	**2 of 5**	**1 of 5**
Score	**60%**	**60%**	**40%**	**20%**
II: Action Motivation				
1. Includes examples of "typical" benefits realized through actions or measures addressed by course	1	1	1	1
2. Includes detailed case study of actual implementations and benefits derived	1	1	1	1
3. Provides guidance on "selling" recommendations to decision makers in the organization, when appropriate	1	1	1	na
4. Includes references to relevant incentive and rebate programs	na	na	na	1
Total Points Scored / Total Possible Points	**3 of 3**	**3 of 3**	**3 of 3**	**3 of 3**
Score	**100%**	**100%**	**100%**	**100%**
III: Dissemination Support				
1. Includes units of instruction appropriate to in-house training by supervisors or others to support development of their organization's workforce	na	na	na	na
2. Provides preparation guidelines and delivery suggestions for the in-house units of instruction	na	na	na	na
3. Supports a variety of delivery formats such as one-to-one, short small group sessions, and longer more formal sessions	0	0	0	0
4. Specifies one or more learning objectives for each in-house unit of instruction	na	na	na	na
5. Provides materials to support in-house delivery of specific teaching points that directly support the targeted objectives	na	na	na	na
6. Includes in-house "go-do" activities that directly support the targeted objectives	na	na	na	na

Support of Behavior Change	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
7. Provides appropriate evaluation, coaching and feedback guidelines for each "go do" activity associated with an in-house unit of instruction	na	na	na	na
Total Points Scored / Total Possible Points	**0 of 1**	**0 of 1**	**0 of 1**	**0 of 1**
Score	**0%**	**0%**	**0%**	**0%**

APPENDIX A-II. ADULT LEARNING PRINCIPLES AND PRACTICE YARDSTICKS

Table 29. Adult Learning Principles and Practice Yardstick Scores

Adult Learning Principles and Practices	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
I: Learner Orientation, Buy-In, and Engagement				
1. There is an initial activity that helps participants see the value of the training	1	0	0	0
2. The usefulness of the learning in the participants' lives is emphasized and demonstrated through use of real-world examples	1	1	1	1
3. The instructor creates a safe and respectful learning environment	1	1	1	1
4. There is an activity that enables participates to indicate their learning goals, and/or participants are given choices to select activities or content that is relevant to their interests and needs	0	0	0	0
5. There are activities that enable the learners to discover important information on their own	0	0	0	0
6. There are activities that enable the participants to contribute ideas	1	1	0	0
7. An in-class mini needs assessment conducted	0	0	0	0
8. The focus is on learner rather than presenter	na	na	na	na
9. The class builds on learner's prior learning or experience and leverages this experience to drive home key content	1	na	1	1
10. The class meets needs of different learning styles	0	0	0	0
Total Points Scored / Total Possible Points	**5 of 9**	**3 of 8**	**3 of 9**	**3 of 9**
Score	**56%**	**38%**	**33%**	**33%**
II: Learner Success Engineering				
1. There are participant activities	1	1	1	0
2. There are activities that enable participants to indicate and/or demonstrate their level of experience and expertise	1	0	0	0
3. Good examples and stories are provided that connect new learning to the participants' prior learning and experience	1	1	1	1
4. A maximum of 5 familiar and meaningful concepts and a maximum of 3 unfamiliar concepts are taught at one time	1	0	1	1
5. Rules are taught first; exceptions are not introduced until it is clear that the rules are understood	1	0	1	1
6. Transitional statements are made that show how different sections of the training related to each other	1	1	1	1
7. A variety of instructional methods are used to ensure that visual, aural, and kinesthetic learners' needs are addressed	na	na	na	na
Total Points Scored / Total Possible Points	**6 of 6**	**3 of 6**	**5 of 6**	**4 of 6**
Score	**100%**	**50%**	**83%**	**67%**
III: Practice, Application, and Interactivity				
1. There are problem-solving activities that actively engage the learners	1	0	0	0

Adult Learning Principles and Practices	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
2. There are opportunities for participants to immediately apply their new learning in the classroom	1	na	0	0
3. Materials include a participant workbook for hands on activities to check learning and comprehension	1	1	0	0
4. Learners are actively engaged in discovering answers	na	1	na	na
5. The design includes checks for comprehension before leaving a key topic area	1	0	0	0
6. There are opportunities for learners to practice what they've learned as they learn it	1	na	0	0
7. The activities reflect the learning objectives, including an appropriate mix of terminal performance and enabling objectives	1	1	1	0
8. Activities are included after each new concept or skill area is addressed	1	1	0	0
9. Activities are parallel to - but different from - assessment items focusing on the same objectives	na	na	na	na
10. Activities employ a variety of approaches appropriate to relevant objectives and participants "real world" requirements	1	1	0	0
11. Activities reinforce key material, concepts, or skills	1	na	1	0
12. Course employs a variety of large group, small group, and individual experiences	0	0	0	0
Total Points Scored / Total Possible Points	**9 of 10**	**5 of 8**	**2 of 10**	**0 of 10**
Score	**90%**	**63%**	**20%**	**0%**
IV: Lesson Plan and Content Decisions				
1. There are learning objectives	1	1	1	1
2. The learning objectives are specific, observable, and measurable	1	1	1	1
3. The materials indicate the desired learning levels*	1	0.5	1	1
4. Their design reflects a variety of training methods	1	0	0	0
5. There is a clear focus on key content; interesting but unimportant content kept to a minimum	1	0	1	1
6. There is an organizing principle	1	1	1	1
7. There is an appropriate amount of content for the time period	1	1	1	1
Total Points Scored / Total Possible Points	**7 of 7**	**4.5 of 7**	**6 of 7**	**6 of 7**
Score	**100%**	**64%**	**86%**	**86%**
V: Leaner Facilitation and Feedback				
1. Instructor validates learners' involvement and responses	1	1	1	1
2. Instructor makes transitional statements between sections	1	1	1	1
3. Instructor ensures that all learners can see and hear	1	1	1	1
4. Instructor provides breaks every 50 minutes or so	1	0	0	1
5. Instructor provides guidance and feedback when participants are asked to practice or demonstrate skills or knowledge	na	na	na	na
6. Instructor's feedback encompasses both positive and corrective feedback as appropriate	na	na	na	na
7. Instructor provides corrective guidance as appropriate	na	na	na	na
Total Points Scored / Total Possible Points	**4 of 4**	**3 of 4**	**3 of 4**	**4 of 4**
Score	**100%**	**75%**	**75%**	**100%**
VI: Assessments				
1. There are assessments	0	1	0	0

Adult Learning Principles and Practices	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
2. Assessments measure successful completion based on "curriculum teaching" rather than "item teaching"	na	0	na	na
3. Assessments include items that sample the full range of learning objectives, including terminal performance and enabling objectives	na	1	na	na
4. Assessments reflect the learning level inherent in the objectives addressed by the items	na	1	na	na
5. Assessments distinguish between those who can meet the course objectives and those who do not	na	0	na	na
Total Points Scored / Total Possible Points	**0 of 1**	**3 of 5**	**0 of 1**	**0 of 1**
Score	**0%**	**60%**	**0%**	**0%**
VII: Additional Data Points				
1. Includes agenda for each session on what material will be covered	1	1	1	1
Total Points Scored / Total Possible Points	**1 of 1**	**1 of 1**	**1 of 1**	**1 of 1**
Score	**100%**	**100%**	**100%**	**100%**

* 3.0 = Evaluate—i.e., making judgments based on criteria and standards through checking and critiquing; 2.50 = Create—i.e., putting elements together into a coherent whole; reorganize elements into a new structure by generating, planning, or producing; 2.00 = Analyze—i.e., determining how parts relate to one another and to an overall structure or purpose by differentiating, organizing, etc.; 1.50 = Apply—i.e., carrying out or using a procedure through executing, or implementing; 1.00 = Understand—i.e., constructing meaningful messages by interpreting, exemplifying, classifying, summarizing, explaining, etc.; 0.50 = Remember—i.e., retrieving, recognizing, and recalling relevant knowledge from long-term memory.

APPENDIX A-III. LEARNING FOCUS YARDSTICK

Table 30. Learning Focus Yardstick Scores

Learning Focus	NCI DSO	IHACI NH	IHACI AD	PG&E DCV
I: Workforce Enablement				
1. The course is targeted to specific job/role responsibilities*	1	1	1	1
2. The course clearly relates content and concepts to on-the-job responsibilities	1	1	1	1
3. The course includes examples that reflect "real-world" on-the-job opportunities	1	1	1	1
4. The course provides direct support for certification or has a clear relationship to certification (if applicable) +	0.5	0.5	0.5	0.5
5. Addresses the Apply (level 3) skill development level or higher++	1	0.5	1	1
Total Points Scored / Total Possible Points	**4.5 of 5**	**4 of 5**	**4.5 of 5**	**4.5 of 5**
Score	**90%**	**80%**	**90%**	**90%**
II: Additional data points				
1. The course addresses technologies that achieve permanent load shift to off-peak periods	0	na	0	0
2. The course addresses "soft skills"	1	1	1	0
3. The course provides opportunities for remedial instruction in soft skills	0	na	0	0
4. The course provides opportunities for remedial instruction in technical skills	0	na	0	0
Total Points Scored / Total Possible Points	**1 of 4**	**1 of 1**	**1 of 4**	**0 of 4**
Score	**25%**	**100%**	**25%**	**0%**

* 1.0 = High—i.e., most of the course is specifically focused on how to perform tasks or make decisions that are typically associated with on-the-job responsibilities of a given role(s); 0.5 = Moderate—i.e., about half of the course is specifically focused on how to perform tasks or make

decisions that are typically associated with on-the-job responsibilities of a given role(s); 0.0 = Low—i.e., little or none of the course is focused on how to perform tasks or make decisions associated with on-the-job responsibilities; however the content is dire.

+ 1.0 = Direct support—i.e., is a requirement for a certification program or is recommended by the certifying agency or its designates as preparation for certification; 0.5 = Clear relationship—i.e., clearly and specifically addresses knowledge or skills required to obtain certification, but is not specifically required or recommended by the certifying agency; also includes courses that provide continuing education credits; 0.0 = Not directly related—i.e., does not directly address knowledge or skills that an individual must demonstrate in order to become certified; may or may not address knowledge or skills typically held by individuals with certification.

++ Same scale as IV.4 in the Adult Learning Principals and Practices Yardstick describing course learning levels.

APPENDIX B. BEHAVIORAL ASSESSMENT OBSERVATION RUBRIC

This appendix includes the Scenario 1 and Scenario 2 rubrics used to assess the degree to which technicians demonstrated each of the six observation points detailed in Section 5.2 of this report.

APPENDIX B-I. SCENARIO I

Table 31. Scenario 1 Rubric: Observation Points #1 Through #6

Scenario 1 Rubric: Observation Points #1 - #6			
Observation Point #1: Asks customer pertinent questions for deeper understanding of symptoms			
Score	**Criteria**	**Examples**	**Notes**
5	The technician obtains all necessary information about the system failure including information that may not have been included in the customer narrative by asking pertinent questions of the customer.	▪ The technician asks multiple questions and follow-up questions to obtain additional details about the symptoms that the customer is experiencing as well as information about the history of the unit. Examples of quality questions include: ▪ What are the symptoms you are experiencing? ▪ How was the system operating prior to the reported symptoms? ▪ When did the symptoms start? Or how long has this been happening? Have the symptoms gotten worse over time? ▪ Does the system have a history of problems/ breakdowns? ▪ How frequently have you maintained or repaired this system? When was the last time you [insert common maintenance here]? ▪ Have there been any previous attempts to fix the symptoms you are experiencing? ▪ The technician not only asks questions prior to beginning their work but also throughout the service call as new information arises or they think of additional information that would be helpful to their diagnosis.	
4	The technician obtains most necessary information about the system failure including information that may not have been included in the customer narrative by asking pertinent questions of the customer.	▪ The technician asks questions to understand the symptoms that the customer is presenting but asks few questions about the history of the system or previous attempts to fix the symptoms. Examples of questions that the technician may ask include: ▪ What are the symptoms you are experiencing? ▪ When did the symptoms start? Or how long has this been happening? ▪ When was the last time you got the system tuned-up?	
3	The technician obtains some of the necessary information about the system failure including information that may not have been included in the customer narrative by asking pertinent questions of the customer.	▪ The technician asks several questions to learn more about the symptoms that the customer is experiencing but does not ask about the system's maintenance history or previous system failures. Examples of questions that the technician may ask include: ▪ What are the symptoms you are experiencing? ▪ When did the symptoms start? Or how long has this been happening?	
2	The technician obtains little to no additional necessary information about the system failure that may not have been included in the customer narrative but does attempt to confirm their understanding of the situation with the customer.	▪ The technician does not ask questions to obtain additional details about the symptoms or the system's history but does check their understanding of what the customer communicated in the customer narrative. Examples include: ▪ "It sounds like you are experiencing [insert detail from customer narrative]. Is that right?" ▪ Restating or rephrasing information that the customer shared in the customer narrative.	
1	The technician does not attempt to obtain additional information about the system failure that may not have been included in the customer narrative.	▪ The technician begins working on the unit after the customer narrative without asking any questions or confirming their understanding with the customer.	

Scenario 1 Rubric: Observation Points #1 - #6			
Observation Point #2: Gathers diagnostic information to identify the issue through the use of diagnostic tools			
Score	**Criteria**	**Examples**	**Notes**
5	The technician gathers all key diagnostic information using diagnostic tools.	▪ The technician successfully gathers all key diagnostic information listed below, evidenced either by their actions during the service call (e.g., parts of the machine they visibly inspect), measures they take via the diagnostic tools, or their responses to follow-up questions during the post-observation interview. ▪ System model number ▪ Capacity, efficiency, refrigerant type, and operating limits of the equipment ▪ Physical inspection of the system for visible problems ▪ Ductwork, supply register, and return grille type and condition ▪ Thermostat type and if it is receiving power ▪ The quality/ cleanness of air filters, indoor evaporator coil, and an outdoor condensing coil ▪ The inner electrical components condition in terms of wear, dirt, and grime. ▪ Outside air temperature ▪ Subcooling/ Superheat temperature ▪ Supply and return air wet bulb and dry bulb temperature ▪ Refrigerant suction and liquid line pressure and temperature ▪ Compressor/condenser motor running amps ▪ Airflow (CFM) in return and supply duct	
4	The technician gathers most key diagnostic information using diagnostic tools.	▪ The technician successfully gathers most key diagnostic information listed above, evidenced either by their actions during the service call, the measures they take via the Bluetooth diagnostic tools, or their responses to follow-up questions during the post-observation interview. ▪ If the technician experiences issues collecting diagnostic information (e.g., misuses the diagnostic tool and gets a bad reading), they adeptly and quickly identify and correct the mistake and ultimately collect the information that they need to diagnose the system failure.	
3	The technician gathers some key diagnostic information using diagnostic tools.	▪ The technician successfully gathers most key diagnostic information listed above, evidenced either by their actions during the service call, the measures they take via the Bluetooth diagnostic tools, or their responses to follow-up questions during the post-observation interview. ▪ The technician may experience minor issues collecting diagnostic information but they are still able to proceed with diagnosing the system failure. Issues in their process could include: ▪ The technician misuses the diagnostic tools but, after repeated attempts, corrects the mistake, and collects the information that they need. ▪ The technician misuses the diagnostic tools, but the error does not prevent them from diagnosing the system failure.	
2	The technician gathers little diagnostic information using diagnostic tools.	▪ The technician attempts to gather key diagnostic information, but there are critical issues with their use of diagnostic tools that prevent the diagnostic information from being useful. For example, the technician does not know how to deploy or incorrectly deploys some of the diagnostic tools. ▪ The technician attempts to gather diagnostic information but does not collect the most necessary diagnostic information (listed below). ▪ Outside air temperature ▪ Supply and return air wet bulb and dry bulb temperature ▪ Refrigerant suction and liquid line pressure and temperature	
1	The technician does not gather diagnostic information.	▪ The technician does not attempt to collect diagnostic information. ▪ The technician is unable to use the diagnostic tools to collect key information.	

Scenario 1 Rubric: Observation Points #1 - #6			
Observation Point #3: Uses calculations, comparison, and other additional techniques to identify root cause of the issues			
Score	**Criteria**	**Examples**	**Notes**
5	The technician successfully uses calculations, comparisons, and other additional techniques to identify root cause of the issues.	▪ The technician analyzes, evaluates, and identifies all data that is outside the normal operating range of a properly operating HVAC system and uses the "cause and effect" method to identify the root causes of all problems with the unit (refrigerant charge and thermostat problem). The key data are: ▪ High discharge temp ▪ Low subcooling in the condenser ▪ High superheat ▪ Low temperature/pressure in the condenser and evaporator ▪ Thermostat that is none working or not functioning correctly ▪ Unbalanced/limited airflow	
4	The technician mostly successfully uses calculations, comparisons, and other additional techniques to identify root cause of the issues.	▪ The technician identifies most data that is outside the normal operating range of a properly operating HVAC system and correctly identifies the root causes of all problems with the unit (refrigerant charge and thermostat problem). Key data are listed above.	
3	The technician somewhat successfully uses calculations, comparisons, and other additional techniques to identify root cause of the issues.	▪ The technician identifies some of the key data that is outside the normal operating range of a properly operating HVAC system. While the technician may not identify all the key data, they are still able to determine the root cause of one of the system failure points (either the refrigerant charge or thermostat problem). Key data are listed above.	
2	The technician attempts to use calculations, comparisons, and other additional techniques to identify root cause of the issues.	▪ The technician attempts but is not able to identify most of the key data that are outside of the normal operating range for a properly operating HVAC system. The technician is unable to identify the root cause of any system failures (neither refrigerant issue nor thermostat issue). Key data are listed above.	
1	The technician does not use calculations, comparisons, and other additional techniques to identify root cause of the issues.	▪ The technician does not attempt to identify any key data that are outside of the normal operating range for a properly operating system.	
Observation Point #4: Reports diagnostics, root causes, and corrective actions to the customer			
Score	**Criteria**	**Examples**	**Notes**
5	The technician reports all the diagnostics, root causes, and corrective actions to the customer.	▪ The technician clearly communicates all diagnostic information and root cause(s) of the system failure to the customer; the information that the technician provides is exhaustive, and details are explained in a manner that is accessible to the customer. The technician lists all corrective actions available to the customer and provides a detailed explanation as to how each option will address the root cause(s) of the system failure. The technician recommends corrective action if asked. The list of potential corrective actions are as follows: ▪ Corrective actions for the refrigerant charge issue: ▪ Add refrigerant, or ▪ Replace the entire system (depending on the age of the system) ▪ Corrective actions for the refrigerant charge issue: ▪ Fix the issue with the existing thermostat (e.g., reconnect loose wire), or ▪ Replace the old thermostat with a new thermostat (depending on the severity of the issue) ▪ Corrective actions for the airflow adjustment: ▪ Open the dampers and/or remove any blockages from the return/supply ducts	
4	The technician reports most of the diagnostics, root causes, and corrective actions to the customer.	▪ The technician communicates most of the diagnostic information and root causes of the system failure to the customer, but the technician excludes some of the relevant details or communicates in a manner that is confusing	

Scenario 1 Rubric: Observation Points #1 - #6			
		for the customer. The technician states most of the corrective actions available to the customer and describes the corrective actions in some detail. The technician recommends corrective action if asked. The available corrective actions are listed above.	
3	The technician reports some of the diagnostics, root causes, and corrective actions to the customer.	▪ The technician communicates the root causes of the system failure to the customer but does not provide all the diagnostic information in their explanation. The technician tells the customer the available corrective actions but does not describe corrective actions in detail. The available corrective actions are listed above.	
2	The technician attempts to report diagnostics, root causes, and corrective actions to the customer.	▪ The technician provides limited or incorrect information to the customer regarding the diagnostics, root causes of the problems, or available corrective actions.	
1	The technician does not report diagnostics, root causes, and corrective actions to the customer.	▪ The technician does not attempt to explain diagnostics, root causes, or available corrective actions to the customer. ▪ Due to an error in a previous step of the service call, the technician is unable to explain diagnostics, root causes, or available corrective actions to the customer.	
Observation Point #5: Takes proper corrective action to fix the system as authorized and directed by the customer			
Score	**Criteria**	**Examples**	**Notes**
5	The technician successfully takes proper corrective action to fix the system as authorized and directed by the customer.	▪ The technician fixes the issues with the refrigerant charge and the thermostat through the corrective actions listed below. The technician completes corrective actions efficiently and without errors. ▪ Steps involved in fixing the refrigerant charge issue: ▪ Connects the charging or supply hose from the manifold to the refrigerant container. ▪ Adds the required amount of refrigerant. ▪ Steps involved in fixing the thermostat issue: Note that the thermostat issue may require one or more of the corrective actions listed below depending on the nature of the issue arranged by the evaluation team. ▪ Uses a wire stripper to remove the corroded section of wiring, reveals a new section or wire, and reinstalls the wire. ▪ Tightens loose screws if needed. ▪ Fixes circuit breaker if needed. ▪ Corrective action for the airflow issue will include opening dampers and/or removing blockages from the return/supply ducts	
4	The technician mostly successfully takes proper corrective action to fix the system as authorized and directed by the customer.	▪ The technician fixes the issues with the refrigerant charge and the thermostat through the corrective actions listed below. The technician may make minor errors while taking the corrective actions but identifies and addresses errors quickly and effectively. Steps involved to fix the refrigerant charge and thermostat issue are listed above.	
3	The technician somewhat successfully takes proper corrective action to fix the system as authorized and directed by the customer.	▪ The technician successfully takes corrective action to fix the refrigerant charge issue but is unable to fix the thermostat issue. Steps involved to fix the refrigerant charge issue are listed above. ▪ The technician successfully takes corrective action to fix the thermostat issue but is unable to fix the refrigerant charge issue. Steps involved to fix the thermostat issue are listed above.	
2	The technician attempts to take corrective action(s) to fix the system as authorized and directed by the customer but is unable to complete the corrective action(s) successfully.	▪ The technician attempts but is unable to complete corrective action to fix both the refrigerant charge issue and the thermostat issue. ▪ During the post-observation interview, the technician is able to articulate some of the steps involved in the appropriate corrective action but was unable to complete the corrective action during the actual observation.	
1	The technician does not take proper corrective action to fix the system.	▪ The technician does not attempt corrective action. ▪ Due to an error in a previous step in the service call, the technician is unable to take corrective action.	

Scenario 1 Rubric: Observation Points #1 - #6			
Observation Point #6: Re-evaluates the system to verify that the solution has eliminated all the symptom(s) and root cause(s)			
Score	**Criteria**	**Examples**	**Notes**

5	The technician successfully reevaluates the system to verify that the solution has eliminated all symptoms and root causes.	▪ The technician attempts and successfully completes all of the following:
		  ▪ Measures and records all revised relevant operating data and information from the system:
		  ▪ Subcooling/ Superheat temperature
		  ▪ Supply and return air wet bulb and dry bulb temperature
		  ▪ Refrigerant suction and liquid line pressure and temperature
		  ▪ Compressor/condenser motor running amps
		  ▪ Airflow (CFM) in return and supply duct
		  ▪ Compares, analyzes, and evaluates the revised data and information to verify that the symptoms and root causes have been eliminated.
		  ▪ Before leaving the job site, clearly communicates with the customer about corrective actions and makes sure the customer has no additional questions.	

4	The technician mostly successfully reevaluates the system to verify that the solution has eliminated all symptoms and root causes.	▪ The technician attempts all, and successfully completes most, of the following:
		  ▪ Measures and records all revised relevant operating data and information from the system. The relevant operating data are listed above.
		  ▪ Compares, analyzes, and evaluates the revised data and information to verify that the symptoms and root causes have been eliminated.
		▪ Before leaving the job site, clearly communicates with the customer about corrective actions and makes sure the customer has no additional questions.	

3	The technician somewhat successfully reevaluates the system to verify that the solution has eliminated all symptoms and root causes.	▪ The technician attempts most, and successfully completes some, of the following:
		  ▪ Measures and records all revised relevant operating data and information from the system. The relevant operating data are listed above.
		  ▪ Compares, analyzes, and evaluates the revised data and information to verify that the symptoms and root causes have been eliminated.
		▪ Before leaving the job site, clearly communicates with the customer about corrective actions and makes sure the customer has no additional questions.	

2	The technician attempts but does not successfully reevaluate the system to verify that the solution has eliminated all symptoms and root causes.	▪ The technician attempts some/most of, but is unsuccessful in completing, the following:
		  ▪ Measures and records all revised relevant operating data and information from the system. The relevant operating data are listed above.
		  ▪ Compares, analyzes, and evaluates the revised data and information to verify that the symptoms and root causes have been eliminated.
		  ▪ Before leaving the job site, clearly communicates with the customer about corrective actions and makes sure the customer has no additional questions.	

1	The technician does not reevaluate the system to verify that the solution has eliminated all symptoms and root causes.	▪ The technician does not attempt to reevaluate the system. ▪ Due to an error in a previous step in the service call, the technician is unable to reevaluate the system.	

APPENDIX B-II. SCENARIO 2

Table 32. Scenario 2 Rubric: Observation Points #1 Through #6

Scenario 2 Rubric: Observation Points #1 - #6			
Observation Point #1: Asks customer pertinent questions for deeper understanding of symptoms			
Score	**Criteria**	**Examples**	**Notes**
5	The technician obtains all necessary information about the system failure including information that may not have been included in the customer narrative by asking pertinent questions of the customer.	▪ The technician asks multiple questions and follow-up questions to obtain additional details about the symptoms that the customer is experiencing as well as information about the history of the unit. Examples of quality questions include: ▪ What are the symptoms you are experiencing? ▪ How was the system operating prior to the reported symptoms? ▪ When did the symptoms start? Or how long has this been happening? Have the symptoms gotten worse over time? ▪ Does the system have a history of problems/ breakdowns? ▪ How frequently have you maintained or repaired this system? When was the last time you [insert common maintenance here]? ▪ Have there been any previous attempts to fix the symptoms you are experiencing? ▪ The technician not only asks questions prior to beginning their work but also throughout the service call as new information arises or they think of additional information that would be helpful to their diagnosis.	
4	The technician obtains most necessary information about the system failure including information that may not have been included in the customer narrative by asking pertinent questions of the customer.	▪ The technician asks questions to understand the symptoms that the customer is presenting but asks few questions about the history of the system or previous attempts to fix the symptoms. Examples of questions that the technician may ask include: ▪ What are the symptoms you are experiencing? ▪ When did the symptoms start? Or how long has this been happening? ▪ When was the last time you got the system tuned-up?	
3	The technician obtains some of the necessary information about the system failure including information that may not have been included in the customer narrative by asking pertinent questions of the customer.	▪ The technician asks several questions to learn more about the symptoms that the customer is experiencing but does not ask about the system's maintenance history or previous system failures. Examples of questions that the technician may ask include: ▪ What are the symptoms you are experiencing? ▪ When did the symptoms start? Or how long has this been happening?	
2	The technician obtains little to no additional necessary information about the system failure that may not have been included in the customer narrative but does attempt to confirm their understanding of the situation with the customer.	▪ The technician does not ask questions to obtain additional details about the symptoms or the system's history but does check their understanding of what the customer communicated in the customer narrative. Examples include: ▪ "It sounds like you are experiencing [insert detail from customer narrative]. Is that right?" ▪ Restating or rephrasing information that the customer shared in the customer narrative.	
1	The technician does not attempt to obtain additional information about the system failure that may not have been included in the customer narrative.	▪ The technician begins working on the unit after the customer narrative without asking any questions or confirming their understanding with the customer.	

Scenario 2 Rubric: Observation Points #1 - #6			
Observation Point #2: Gathers diagnostic information to identify the issue through the use of diagnostic tools			
Score	**Criteria**	**Examples**	**Notes**
5	The technician gathers all key diagnostic information using diagnostic tools.	▪ The technician successfully gathers all key diagnostic information listed below, evidenced either by their actions during the service call (e.g., parts of the machine they visibly inspect), measures they take via the diagnostic tools, or their responses to follow-up questions during the post-observation interview. ▪ System model number ▪ Capacity, efficiency, refrigerant type, and operating limits of the equipment ▪ Physical inspection of the system for visible problems ▪ Ductwork, supply register, and return grille type and condition ▪ Thermostat type and if it is receiving power ▪ The quality/ cleanness of air filters, indoor evaporator coil, and an outdoor condensing coil ▪ The inner electrical components condition in terms of wear, dirt, and grime. ▪ Outside air temperature ▪ Subcooling/ Superheat temperature ▪ Supply and return air wet bulb and dry bulb temperature ▪ Refrigerant suction and liquid line pressure and temperature ▪ Compressor/condenser motor running amps ▪ Airflow (CFM) in return and supply duct	
4	The technician gathers most key diagnostic information using diagnostic tools.	▪ The technician successfully gathers most key diagnostic information listed above, evidenced either by their actions during the service call, the measures they take via the Bluetooth diagnostic tools, or their responses to follow-up questions during the post-observation interview. ▪ If the technician experiences issues collecting diagnostic information (e.g., misuses the diagnostic tool and gets a bad reading), they adeptly and quickly identify and correct the mistake and ultimately collect the information that they need to diagnose the system failure.	
3	The technician gathers some key diagnostic information using diagnostic tools.	▪ The technician successfully gathers most key diagnostic information listed above, evidenced either by their actions during the service call, the measures they take via the Bluetooth diagnostic tools, or their responses to follow-up questions during the post-observation interview. ▪ The technician may experience minor issues collecting diagnostic information but they are still able to proceed with diagnosing the system failure. Issues in their process could include: ▪ The technician misuses the diagnostic tools but, after repeated attempts, corrects the mistake, and collects the information that they need. ▪ The technician misuses the diagnostic tools, but the error does not prevent them from diagnosing the system failure.	
2	The technician gathers little diagnostic information using diagnostic tools.	▪ The technician attempts to gather key diagnostic information, but there are critical issues with their use of diagnostic tools that prevent the diagnostic information from being useful. For example, the technician does not know how to deploy or incorrectly deploys some of the diagnostic tools. ▪ The technician attempts to gather diagnostic information but does not collect the most necessary diagnostic information (listed below). ▪ Outside air temperature ▪ Supply and return air wet bulb and dry bulb temperature ▪ Refrigerant suction and liquid line pressure and temperature	
1	The technician does not gather diagnostic information.	▪ The technician does not attempt to collect diagnostic information. ▪ The technician is unable to use the diagnostic tools to collect key information.	

Scenario 2 Rubric: Observation Points #1 - #6			
Observation Point #3: Uses calculations, comparison, and other additional techniques to identify root cause of the issues			
Score	**Criteria**	**Examples**	**Notes**
5	The technician successfully uses calculations, comparisons, and other additional techniques to identify root cause of the issues.	▪ The technician analyzes, evaluates, and identifies all data that is outside the normal operating range of a properly operating HVAC system and uses the "cause and effect" method to identify the root causes of all problems with the unit (refrigerant charge, condenser coil problem, thermostat programming issue). The key data are: ▪ High discharge temp ▪ High subcooling in the condenser ▪ Low superheat ▪ High temperature/pressure in the condenser and evaporator ▪ Obstructed condenser coils ▪ Thermostat not programmed correctly for HP	
4	The technician mostly successfully uses calculations, comparisons, and other additional techniques to identify root cause of the issues.	▪ The technician identifies most data that is outside the normal operating range of a properly operating HVAC system and correctly identifies the root causes of all problems with the unit (refrigerant charge and thermostat problem). Key data are listed above.	
3	The technician somewhat successfully uses calculations, comparisons, and other additional techniques to identify root cause of the issues.	▪ The technician identifies some of the key data that is outside the normal operating range of a properly operating HVAC system. While the technician may not identify all the key data, they are still able to determine the root cause of one of the system failure points (either the refrigerant charge or thermostat problem). Key data are listed above.	
2	The technician attempts to use calculations, comparisons, and other additional techniques to identify root cause of the issues.	▪ The technician attempts but is not able to identify most of the key data that are outside of the normal operating range for a properly operating HVAC system. The technician is unable to identify the root cause of any system failures (neither refrigerant issue nor thermostat issue). Key data are listed above.	
1	The technician does not use calculations, comparisons, and other additional techniques to identify root cause of the issues.	▪ The technician does not attempt to identify any key data that are outside of the normal operating range for a properly operating system.	
Observation Point #4: Reports diagnostics, root causes, and corrective actions to the customer			
Score	**Criteria**	**Examples**	**Notes**
5	The technician reports all the diagnostics, root causes, and corrective actions to the customer.	▪ The technician clearly communicates all diagnostic information and root cause(s) of the system failure to the customer; the information that the technician provides is exhaustive, and details are explained in a manner that is accessible to the customer. The technician lists all corrective actions available to the customer and provides a detailed explanation as to how each option will address the root cause(s) of the system failure. The technician recommends corrective action if asked. The list of potential corrective actions are as follows: ▪ Corrective actions for the refrigerant charge issue: ▪ Remove refrigerant, or ▪ Replace the entire system (depending on the age of the system) ▪ Corrective actions for the thermostat issue: ▪ Reprogram the thermostat to run in heat pump mode ▪ Corrective actions for the condenser issue: ▪ Remove the blockage	
4	The technician reports most of the diagnostics, root causes, and corrective actions to the customer.	▪ The technician communicates most of the diagnostic information and root causes of the system failure to the customer, but the technician excludes some of the relevant details or communicates in a manner that is confusing for the customer. The technician states most of the corrective actions available to the customer and describes the corrective actions in some detail. The technician recommends corrective action if asked. The available corrective actions are listed above.	

Scenario 2 Rubric: Observation Points #1 - #6			
3	The technician reports some of the diagnostics, root causes, and corrective actions to the customer.	▪ The technician communicates the root causes of the system failure to the customer but does not provide all the diagnostic information in their explanation. The technician tells the customer the available corrective actions but does not describe corrective actions in detail. The available corrective actions are listed above.	
2	The technician attempts to report diagnostics, root causes, and corrective actions to the customer.	▪ The technician provides limited or incorrect information to the customer regarding the diagnostics, root causes of the problems, or available corrective actions.	
1	The technician does not report diagnostics, root causes, and corrective actions to the customer.	▪ The technician does not attempt to explain diagnostics, root causes, or available corrective actions to the customer. ▪ Due to an error in a previous step of the service call, the technician is unable to explain diagnostics, root causes, or available corrective actions to the customer.	
Observation Point #5: Takes proper corrective action to fix the system as authorized and directed by the customer			
Score	**Criteria**	**Examples**	**Notes**
5	The technician successfully takes proper corrective action to fix the system as authorized and directed by the customer.	▪ The technician fixes the issues with the refrigerant charge and the thermostat through the corrective actions listed below. The technician completes corrective actions efficiently and without errors. ▪ Steps involved in fixing the refrigerant charge issue: ▪ Connects the charging or supply hose from the manifold to the refrigerant container. ▪ Adds the required amount of refrigerant. ▪ Steps involved in fixing the condenser coils: ▪ Open the system to access the coils and remove the blockage ▪ Steps involved in fixing the thermostat issue: ▪ Reprograms the thermostat to operate in heat pump mode.	
4	The technician mostly successfully takes proper corrective action to fix the system as authorized and directed by the customer.	▪ The technician fixes the issues with the refrigerant charge and the thermostat through the corrective actions listed below. The technician may make minor errors while taking the corrective actions but identifies and addresses errors quickly and effectively. Steps involved to fix the refrigerant charge and thermostat issue are listed above.	
3	The technician somewhat successfully takes proper corrective action to fix the system as authorized and directed by the customer.	▪ The technician successfully takes corrective action to fix the refrigerant charge issue but is unable to fix the thermostat issue. Steps involved to fix the refrigerant charge issue are listed above. ▪ The technician successfully takes corrective action to fix the thermostat issue but is unable to fix the refrigerant charge issue. Steps involved to fix the thermostat issue are listed above.	
2	The technician attempts to take corrective action(s) to fix the system as authorized and directed by the customer but is unable to complete the corrective action(s) successfully.	▪ The technician attempts but is unable to complete corrective action to fix both the refrigerant charge issue and the thermostat issue. ▪ During the post-observation interview, the technician is able to articulate some of the steps involved in the appropriate corrective action but was unable to complete the corrective action during the actual observation.	
1	The technician does not take proper corrective action to fix the system.	▪ The technician does not attempt corrective action. ▪ Due to an error in a previous step in the service call, the technician is unable to take corrective action.	
Observation Point #6: Re-evaluates the system to verify that the solution has eliminated all the symptom(s) and root cause(s)			
Score	**Criteria**	**Examples**	**Notes**
5	The technician successfully reevaluates the system to verify that the solution has eliminated all symptoms and root causes.	▪ The technician attempts and successfully completes all of the following: ▪ Measures and records all revised relevant operating data and information from the system: ▪ Subcooling/ Superheat temperature ▪ Supply and return air wet bulb and dry bulb temperature ▪ Refrigerant suction and liquid line pressure and temperature	

Scenario 2 Rubric: Observation Points #1 - #6			
		▪ Compressor/condenser motor running amps ▪ Visually inspects the thermostat settings to confirm that it is operating in the right setting. ▪ Compares, analyzes, and evaluates the revised data and information to verify that the symptoms and root causes have been eliminated. ▪ Before leaving the job site, clearly communicates with the customer about corrective actions and makes sure the customer has no additional questions.	
4	The technician mostly successfully reevaluates the system to verify that the solution has eliminated all symptoms and root causes.	▪ The technician attempts all, and successfully completes most, of the following: ▪ Measures and records all revised relevant operating data and information from the system. The relevant operating data are listed above. ▪ Compares, analyzes, and evaluates the revised data and information to verify that the symptoms and root causes have been eliminated. ▪ Before leaving the job site, clearly communicates with the customer about corrective actions and makes sure the customer has no additional questions.	
3	The technician somewhat successfully reevaluates the system to verify that the solution has eliminated all symptoms and root causes.	▪ The technician attempts most, and successfully completes some, of the following: ▪ Measures and records all revised relevant operating data and information from the system. The relevant operating data are listed above. ▪ Compares, analyzes, and evaluates the revised data and information to verify that the symptoms and root causes have been eliminated. ▪ Before leaving the job site, clearly communicates with the customer about corrective actions and makes sure the customer has no additional questions.	
2	The technician attempts but does not successfully reevaluate the system to verify that the solution has eliminated all symptoms and root causes.	▪ The technician attempts some/most of, but is unsuccessful in completing, the following: ▪ Measures and records all revised relevant operating data and information from the system. The relevant operating data are listed above. ▪ Compares, analyzes, and evaluates the revised data and information to verify that the symptoms and root causes have been eliminated. ▪ Before leaving the job site, clearly communicates with the customer about corrective actions and makes sure the customer has no additional questions.	
1	The technician does not reevaluate the system to verify that the solution has eliminated all symptoms and root causes.	▪ The technician does not attempt to reevaluate the system. ▪ Due to an error in a previous step in the service call, the technician is unable to reevaluate the system.	

APPENDIX C. CASE STUDIES

This appendix contains four case studies Opinion Dynamics developed to summarize each technician's performance and behavioral changes who participated in the lab study detailed in Section 3.4 of this report.

APPENDIX C-I. CASE STUDY #1

Technician #1 is an HVAC professional with one year of experience focusing on system maintenance for gas furnaces and air-conditioning systems. They have limited experience with heat pump systems or Bluetooth-enabled diagnostic tools. Their professional background is summarized in the graphic on the right.

There were several differences between Technician #1's actions pre- and- post-training. These differences improved the technician's scores on three observation points (

Technician Background

Question Topics Corresponding to a Level 1 Assessment	Question in Revised Instrument

). Importantly, there are several connections between their actions and training objectives. The differences and their relationship to training objectives are explored below.

Behavioral Difference 1: Exhibiting a greater understanding of heat pump systems; attempting to identify root causes.

In the post-training observation, the technician demonstrated an increased understanding of heat pumps, evidenced by (1) the question they asked following the customer narrative, (2) how they reported their measures and hypothesized root causes to the "customer" throughout the observation, and (3) their responses to questions in the post-observation interview.

Before starting to work on the system, the technician asked whether or not the system was blowing cold air or any air at all. The question illustrates the technician's thought process and connections to two training objectives. In the post-observation interview, they described that not blowing cold air signaled an issue with the reversing valve. Asking a question to confirm a detail is evidence that they were attempting to track reported symptoms to the root causes of the problem, which is an objective of the training. Furthermore, the thought process behind the question reflects that the technician was thinking about the components of a refrigeration cycle and how they operate together, another learning objective. This represents an important behavioral improvement as they did not ask any questions in the pre-training observation.

Table 33. Pre-Training and Post-Training Observation Points

Observation Points	Pre-Training Score	Post-Training Score
1. Asks customer pertinent questions for deeper understanding of symptoms.	1	2
2. Gathers diagnostic information to identify the issue using diagnostic tools.	2	2
3. Uses calculations, comparison, and other additional techniques to identify root cause of the issues.	2	2
4. Reports diagnostics, root causes, and corrective actions to the customer.	1	2
5. Takes proper corrective action to fix the system as authorized and directed by the customer	1	2
6. Re-evaluates the system to verify that the solution has eliminated all the symptom(s) and root cause(s).	1	1

The technician articulated potential explanations for the system fault throughout the observation and post-observation interview. In addition to hypothesizing an issue with the reversing valve, they suggested a restricted refrigerant line caused the symptoms the unit presented. Although incorrect, these theories are plausible and reflect knowledge about how the unit functions, reflecting two training objectives: (1) understanding the fundamentals of refrigerant flow conditions and (2) understanding how AC/HP refrigeration systems operate. The technician did not make similar comments in the pre-training observations. Moreover, the technician explicitly stated in the exit interview that they thought the problem was the reversing valve because it was a topic covered in the training.

Behavioral Difference 2: Increased comfort using diagnostic tools to examine system components and compare measures to operating ranges.

The technician was more comfortable using diagnostic tools in the second observation compared to the first observation. They used diagnostic tools to measure the subcooling and superheat of the system, which demonstrated the learning objective related to when and how to measure subcooling and superheat. The technician also correctly explained that the system presented high subcooling, which is related to the learning objective about determining when refrigeration systems are operating correctly.

Behavioral Difference 3: Not collecting important diagnostic information.

The technician took key diagnostic steps in the pre-training observation but did not take them in the second observation, including measuring the amperage of the compressor and examining the cleanliness of the condenser coils. Failure to take these steps—inspecting the condenser in particular—contributed to the technician's inability to identify the root causes of the system faults.

Detailed Narrative

Low Refrigerant Level

- Checked
- Diagnosed
- Fixed

Disconnected Thermostat Wires

- Checked
- Diagnosed
- Fixed

Airflow Obstructions

- Checked
- Diagnosed
- Fixed

Pre-Training Observation

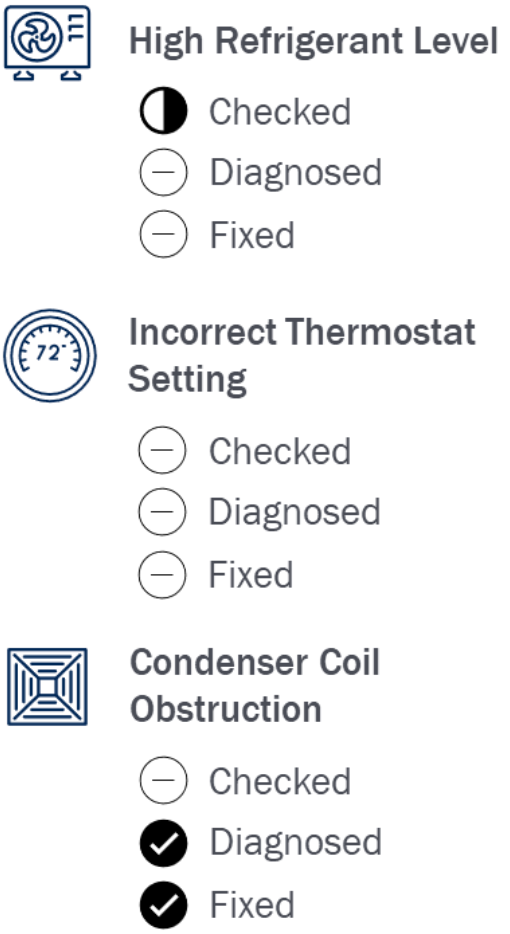
Technician #1 began inspecting the HVAC system without asking follow-up questions about the system history or symptoms. The technician checked and confirmed the compressor was receiving power using a multimeter. They visually inspected the air filter, saw it was dirty, and changed the filter. They did not visually inspect the condenser coils or the dampers and ductwork. The technician also did not identify the system model information, capacity, efficiency, refrigerant type, and normal operating range of the unit. In addition, the technician did not inspect the thermostat and whether it was receiving power. With limited diagnostic information, the technician was unable to identify the root causes of the system faults.

We prompted the technician to inspect the thermostat, refrigerant charge, and ductwork to create additional opportunities to observe the technician's process and abilities. When prompted to inspect the thermostat, the technician did not know how to check if the thermostat was receiving power or fix the wiring issue in the thermostat. After being directed to examine the ducts, the technician was unable to tell if the dampers were closed or how to open them. Similarly, the technician explained that they did not know how to take refrigerant side measurements. A member of our team assisted so the observation could continue, but the technician was unable to interpret the measurements. After informing the technician that the system was low on refrigerant charge, the technician attempted to add refrigerant but did not know how to measure the amount they were adding and could not get the subcooling and superheating values within the correct operating range.

Post-Training Observation

At the start of the second observation, Technician #1 asked our team a follow-up question to the customer narrative to confirm whether or not the system was blowing cold air or any air at all. As they started inspecting the system, they initially wanted to measure static pressure but changed their mind and took refrigerant side measurements. Unlike the first observation, the technician selected and attached the appropriate tool without needing assistance and collected measures, including the dry bulb temperature. They did not know that the temperature needed to be entered into the app to generate a subcooling and superheat measure. We intervened to enter the temperature into the app so the technician could interpret the subcooling and superheating at a later step in the process. The technician also visually inspected the air filters, noting that the filters were clean. The technician inspected the blower fan and, seeing that the fan was running, concluded the system was getting power; they also held a hand over the compressor and noted it was blowing cold air.

The technician did not attempt to collect air-side measurements, inspect the thermostat, or visually check the condenser coil. They also did not use the multimeter to check if the system was receiving power. However, the technician explained in the exit interview that they did not use the multimeter because they concluded that the system was receiving power since the blower was running. Crucially, the technician did not measure the charge of the refrigerant line.



The technician attempted to interpret the information they collected but was unable to identify the root causes of the system failure. They explained that high subcooling and the compressor blowing cold air could indicate an issue with the reversing valve but did not know that the thermostat settings controlling the reversing valve caused the fault. The technician also mentioned that a restriction on the refrigerant line could cause high subcooling. While this is a plausible hypothesis, the unit did not have any restrictions on the refrigerant line. Ultimately, the technician was unable to diagnose the incorrect thermostat settings, overcharged refrigerant, or obstruction on the condenser coils.

We provided information regarding the diagnosis to observe the technician taking corrective action. When informed to check the thermostat settings, the technician read through the system manual. They hypothesized that the problem was caused by the system being set to stage 1 instead of stage 2, and they changed the thermostat setting to operate in stage 2. However, this was not the appropriate corrective action, and it did not solve the problem. Our team prompted the technician to check the condenser coils, at which point the technician noticed the obstruction and removed the blockage. They neglected to turn off the system before opening the unit to clean the condenser coils, which is an important first step in the interests of safety.

APPENDIX C-II. CASE STUDY #2

Technician #2 is an HVAC professional with six years of experience in the field, prior experience with Bluetooth-enabled diagnostic tools, and prior completion of HVAC trainings.

The technician demonstrated behavioral differences between the pre-training and post-training observations. The technician's scores on all six observation points improved from pre-training to post-training (Table 34). Key differences in the technician's approach and connections between their actions and the training's objectives are described below.

Technician Background

6 years of Professional HVAC Experience

Experience with Bluetooth Diagnostic Tools

Prior Completion of HVAC Trainings

Behavioral Difference 1: Asking more questions of the "customer."

While the technician did not ask any questions before attempting to diagnose the system in the pre-training observation, they asked one question prior to diagnosing the system and continued asking questions about the system throughout the observation in the post-training observation. Questions included if the space was not getting cold air, if the blower fan had variable speed, and if the system had auxiliary heating. These questions were relevant to identifying the root causes of system faults and were related to three training objectives: (1) understanding how the AC and HP refrigeration system operates, (2) determining when a refrigeration system is operating correctly, and (3) tracking reported symptoms to the actual root causes of the problems.

Behavioral Difference 2: Greater ease of collecting refrigerant-side measures.

Although Technician #2 was unable to identify and fix the refrigerant charge issue in either observation, they demonstrated improvement from pre-training to post-training in using diagnostic tools to collect measures that would help them understand the issues with the refrigerant level. This difference in behavior is related to three training objectives: (1) understanding fundamentals of refrigerant flow conditions; (2) understanding how the components operate together in the refrigeration cycle; and (3) understanding how and when to measure subcooling and superheat of the system.

Table 34 Pre-Training and Post-Training Observation Points

Observation Points	Pre-Training Score	Post-Training Score
1. Asks customer pertinent questions for deeper understanding of symptoms.	1	2
2. Gathers diagnostic information to identify the issue using diagnostic tools.	2	4
3. Uses calculations, comparison, and other additional techniques to identify root cause of the issues.	2	3
4. Reports diagnostics, root causes, and corrective actions to the customer.	2	3
5. Takes proper corrective action to fix the system as authorized and directed by the customer	2	3
6. Re-evaluates the system to verify that the solution has eliminated all the symptom(s) and root cause(s).	2	3

Behavioral Difference 3: A more thorough diagnostic process.

Technician #2's diagnostic process was more thorough in the post-training observation than in the pre-training observation. They used multiple techniques to identify the thermostat setting issue, including the use of diagnostic tools, comparing measurements to normal operating ranges, and physically inspecting refrigerant lines and the discharge temperature from the compressor. By switching the thermostat to heat mode and collecting and comparing key measures, Technician #2's troubleshooting process revealed their understanding of how heat pump systems operate and how the thermostat controls the reversing valve. These actions are associated with the following training objectives: (1) understanding how the AC and HP refrigeration system operates; (2) understanding high pressure and low pressure components and how

they function; (3) understanding how the components operate together in the refrigeration cycle; and (4) tracking reported symptoms to the actual root causes of the problems.

Behavioral Difference 4: Demonstrating metacognition.

During the interview that followed the post-training observation, the technician discussed their thought process, mistakes, and connections to the training. They described where their process erred and how they were thinking about the system faults. Moreover, the technician articulated where they could have used content from the training to diagnose and fix the system fault but that they have yet to commit the training to memory and be able to apply it to their work. Although it does not relate to a specific objective, this behavioral change offers insight into how the technician thinks about applying training content to their day-to-day work. Their comments suggest that the training is relevant and valuable to their day-to-day work but not immediately applicable to their skill set.

Detailed Narrative

Pre-Training Observation

Technician #2 began inspecting the HVAC system without asking follow-up questions about the system history or current symptoms. They used the multimeter to check if the compressor and thermostat were getting power and confirmed quickly and correctly the thermostat was not receiving voltage. The technician proceeded to fix the wiring issue in the thermostat. Next, they took air-side measurements, collecting the supply and return air temperatures. After seeing the high delta T (difference between supply and return temperature), the technician correctly diagnosed that there were remaining issues. They inspected the air filter, saw the filters were dirty, and replaced them.

Having corrected the issues with the thermostat and air filter, the technician stated that the system was fixed (even though the delta T was still not in the acceptable range). However, Technician #2 neglected several system faults. Because they did not measure static pressure in the ducts, the technician did not identify that the dampers were closed and could not completely resolve the airflow issues. In addition, Technician #2 did not collect any refrigerant side measurements, such as the temperature and pressure in the refrigerant suction line and liquid line—these measurements would help identify if the subcooling/superheat is outside the operating ranges because of a low/high refrigerant level. As a result, they did not identify the system's low refrigerant level.

We prompted the technician to inspect the refrigerant lines to create additional opportunities to observe the technician's process. Technician #2 collected the refrigerant side measurements and noted that the subcooling and superheat were outside normal operating ranges. The technician explained they did not know how to diagnose the system fault, but they guessed the refrigerant level was low because of the subcooling and superheat readings. The technician then attempted to add refrigerant. Technician #2 thought they were adding a charge, but the refrigerant tank was not open. After repeated attempts and asking numerous questions, they started adding refrigerant. The technician did not measure how much refrigerant they were adding and could not get the subcooling and superheating within the correct operating range.

Post-Training Observation

At the start of the second observation, Technician #2 asked a follow-up question about the customer narrative, asking us to confirm the system was not blowing cold air when in cooling mode. Technician #2 began their diagnostic process by collecting refrigerant side measurements. They used diagnostic tools to note the pressure and temperature of the liquid and suction lines. They also placed their hands on the lines to physically inspect the temperature and noted correctly that the temperature was higher than it should be.

High Refrigerant Level

- Checked
- Diagnosed
- Fixed

Incorrect Thermostat Setting

- Checked
- Diagnosed
- Fixed

Condenser Coil Obstruction

- Checked
- Diagnosed
- Fixed

Continuing to diagnose the scope of the system failure, they attached air side tools to collect the supply and return air temperature, inspected the thermostat settings, and checked the discharge temperature of the air from the compressor. The technician noticed that although the thermostat was set for cooling, the compressor was blowing cool air, which is associated with the unit being programmed for heating. Technician #2 restarted the system, changed the thermostat to heating mode, and rechecked airside measurements. They explained the system measurements were close to normal operating ranges when the thermostat was set to heating. Still, the measurements were significantly outside of normal operating ranges when the thermostat was set to cooling. Based on this information, they inferred the thermostat was the cause of the system failure.

To test their supposition, Technician #2 started inspecting the wiring connections in the thermostat. After confirming the wiring was not the problem, they read the thermostat manual to examine the system settings. As they read the manual, Technician #2 asked us questions about the system, such as whether the blower fan had variable speed and if there was auxiliary heating from the system. Having asked additional questions about the system and examined the manual, they identified the setting in the thermostat that was the source of the error, made the change, and restarted the system.

Technician #2 attempted, but was unable, to identify and fix the remaining system faults (e.g., high refrigerant charge and dirty condenser coils) for the remainder of the observation. Because they did not collect the electrical measurement of the compressor, they did not have enough information to realize the refrigerant level was overcharged. Technician #2 explained in the interview that they realized their mistake: if they had checked the amperage of the fan, they would have noticed the system was drawing too much power, which is a symptom of overcharged refrigerant. They also explained that they did not check the amperage of the compressor because they saw that the system was on and, therefore, receiving power. They also did not physically inspect the condenser coils and resultantly did not identify the obstruction on the coils.

APPENDIX C-III. CASE STUDY #3

Technician #3 has about a year of experience in the HVAC industry and experience with Bluetooth-enabled diagnostic tools. They mentioned that they take as many free classes as their schedule allows and have taken several IHACI courses covering topics such as ductwork and air distribution.

In general, Technician #3 struggled with the tasks in both rounds of observations. Below, we describe two differences in the technician's performance. We also summarize areas where the technician demonstrated no difference before and after the training and how these lack of differences relates to the training.

Technician Background

1 year of Professional HVAC Experience

Some experience with Bluetooth Diagnostic Tools

Prior Completion of HVAC Trainings

Behavioral Difference 1: Decreased performance with respect to three observation points.

Several differences we observed between pre- and- post-training observations were negative. In fact, the technician scored higher on three observation points in the pre-training observation than in the post-training observation (Table 35). We do not attribute these negative differences to training but to the alignment of the tasks in the pre-training observation and the types of tasks with which the technician has prior experience. Namely, the pre-training observation involved issues with the system's airflow, a topic addressed in trainings that the technician completed before enrolling in this study.

Behavioral Difference 2: Increase ease of use with diagnostic tools to measure refrigerant charge.

One area in which the technician improved was in their use of diagnostic tools to collect measures related to the refrigerant charge. The technician did not check the refrigerant measures during the pre-training observation until we prompted them to do so. At that point, the technician was unsure how to collect and interpret the refrigerant side measures. Conversely, they collected refrigerant measures in the post-training observation without prompting and were more comfortable using the tools.

It is difficult to determine if this difference is attributable to their participation in the training or the first round of observations. On the one hand, it is possible that the interaction between the technician and the pre-training observation tasks influenced their process in the second observation. On the other hand, the technician completed a training dedicated to understanding refrigeration in HVAC equipment, which could be why the technician measured the refrigerant charge without prompting in the second observation.

Table 35 Pre-Training and Post-Training Observation Points

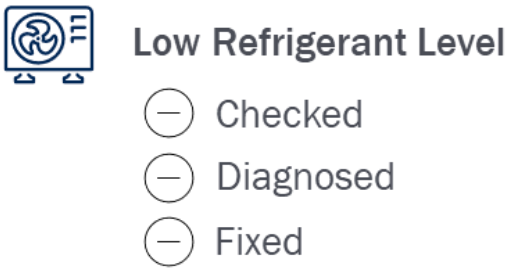
Observation Points	Pre-Training Score	Post-Training Score
1. Asks customer pertinent questions for deeper understanding of symptoms.	2	2
2. Gathers diagnostic information to identify the issue using diagnostic tools.	3	3
3. Uses calculations, comparison, and other additional techniques to identify root cause of the issues.	2	2
4. Reports diagnostics, root causes, and corrective actions to the customer.	2	1
5. Takes proper corrective action to fix the system as authorized and directed by the customer	2	1
6. Re-evaluates the system to verify that the solution has eliminated all the symptom(s) and root cause(s).	2	1

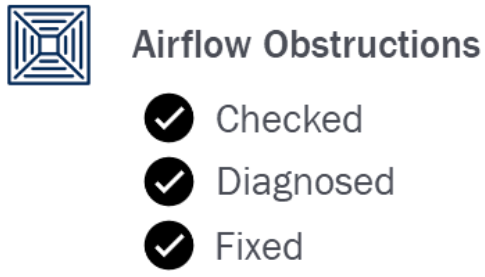
Important Lack of Differences

There were several behaviors that the technician displayed in both rounds of observations that are important to note because they are related to the training objectives. First, the technician did not measure the static pressure in either observation. This is an important way the technician did not demonstrate the training objective related to tracking reported symptoms to root

causes. Second, the technician did not know how to measure or interpret the subcooling and superheat in either observation; understanding how and when to collect the subcooling and superheat is another training objective. Finally, at one point in the post-training observation, the technician commented that they did not realize the unit was a heat pump. Although this comment is difficult to associate with one training objective, it is nonetheless notable because it suggests a disconnect between the technician's skillset and topics addressed in the training.

Detailed Narrative





Pre-Training Observation

Technician #3 asked several follow-up questions prior to inspecting the system. They asked us to clarify if they were experiencing issues with airflow, temperature, or both. They also asked if the compressor was single-stage or two-stage. They started their diagnostic process by checking that the compressor and thermostat were getting power and correctly identified that the thermostat was not receiving power.

Next, the technician checked air side temperatures using diagnostic tools and physically inspected the dampers, ductwork, air filters, and evaporator and condenser coils. Technician #3 identified both airflow issues: the dirty air filters and the closed dampers. In addition, the technician measured the amperage of the blower fan and noted the value was below a normal operating range for the system; however, they were unable to explain what that symptom indicated. The technician was communicative about the symptoms and issues they noticed while inspecting the thermostat and airflow components, and they were able to fix both issues easily.

The technician did not collect refrigerant side measures, and we prompted the technician to inspect the refrigerant lines. While the technician collected the refrigerant side measures, they were unable to interpret the subcooling and superheat measures. They asked multiple questions of the HVAC lab technician to help understand the normal operating range. The technician guessed the issue was a low refrigerant charge, which was correct, but they could not explain why. They also stated they would typically call their supervisor when they did not know what a measurement indicated. We confirmed the issue was a low refrigerant charge, and the technician began taking corrective action. They were comfortable preparing and attaching the equipment to the system but did not measure how much refrigerant they were adding. They communicated they did not know what to expect regarding changes in the readings as they added the refrigerant. They were not able to get the refrigerant charge back to the normal operating range.

Post-Training Observation

Technician #3 started the post-training observation by asking the "customer" to clarify if the system turned on. Then, they turned on the system and started to inspect the ductwork. They inspected the ducts and collected refrigerant side measurements using the appropriate diagnostic tools. Next, they measured the amps at the compressor and collected air side temperatures. The technician did not inspect the air filters, evaporator, or condenser coils. They also did not measure the static pressure in the system, check the thermostat settings, or note the system's normal operating ranges.

Technician #3 communicated several possible causes of the system fault but was unable to identify the root causes of any system faults. The technician was unable to identify the obstruction of the condenser coils because they did not inspect the condenser unit. Regarding the overcharged refrigerant level, there were three reasons why the technician was unable to conclude that the system had overcharged refrigerant levels. First, the technician did not measure the subcooling and superheat, measures that would help them track the source of the issue. Second, the technician struggled to interpret the measures that they did collect. At first, the technician posited that the system had a low refrigerant level; next, they suggested there was a restriction on a refrigerant line. Finally, they were unable to identify the cause of the refrigerant issue because they did not check the condenser coils. The blockage on the condenser coils caused the imbalance of the temperature and pressure that they were struggling to interpret. The technician also did not identify the cause of the thermostat error because they did not check the settings. To check the technician's ability to troubleshoot the thermostat, the lab technician and our team prompted them to check the settings; however, the technician could not check the settings without instruction.

APPENDIX C-IV. CASE STUDY #4

Technician #4 is an HVAC professional with about a year of experience in the field. They stated that their day-to-day work involves mostly system service and maintenance and minimal installation experience. They were familiar with some of the Bluetooth-enabled diagnostic tools but were not familiar with heat pump equipment. To date, they have taken another IHACI course about air distribution and completed a 10-month HVAC program at UEI College.

Technician Background

1 year of Professional HVAC Experience

Some experience with Bluetooth Diagnostic Tools

Prior Completion of HVAC Trainings

Table 36 Pre-Training and Post-Training Observation Points

Observation Points	Pre-Training Score	Post-Training Score
1. Asks customer pertinent questions for deeper understanding of symptoms.	1	2
2. Gathers diagnostic information to identify the issue using diagnostic tools.	2	3
3. Uses calculations, comparison, and other additional techniques to identify root cause of the issues.	2	3
4. Reports diagnostics, root causes, and corrective actions to the customer.	2	2
5. Takes proper corrective action to fix the system as authorized and directed by the customer	2	3
6. Re-evaluates the system to verify that the solution has eliminated all the symptom(s) and root cause(s).	2	2-3

The technician demonstrated positive differences between the pre-training and post-training observations. The technician's scores on five of the six observation points improved from pre-training to post-training, and their score on one observation point remained the same (Table 36). Key differences and their relationship to training objectives are described below.

Behavioral Difference 1: Using multiple methods to collect data and inform diagnosis.

In the post-training session, the participant employed multiple methods to collect data and synthesized the information they collected to inform their diagnosis. For example, they relied on physically and visibly inspecting unit components and collecting measurements via diagnostic tools. They also used multiple digital tools to understand the root causes of reported symptoms. For instance, Technician #4 first examined the refrigerant measurements using the test kit and then retook the measures using the digital manifold to ensure they were

working with accurate information. The technician did not engage in a similar iteration during the pre-training observation. This difference is related to the training objective regarding tracking reported symptoms to actual root causes; after the training, they exhibited an expanded repertoire of methods for understanding the causes of system faults.

Behavioral Difference 2: Demonstrating a greater understanding of mini-split functions.

The technician made comments throughout the second observation that demonstrated a deeper knowledge of how heat pump systems operate than they displayed in the pre-training observation. Specifically, they mentioned that the cold air they felt from the compressor and the heat of the refrigerant line indicated the reversing valve was not energized. Still, they also recognized that the misfunction of the valve was a symptom of the root cause and not the cause itself. These comments demonstrate several training objectives: (1) understanding how the AC and HP refrigeration system operates; (2) understanding how the components operate together in the refrigeration cycle; and (3) determining when a refrigeration system is operating correctly.

Detailed Narrative

Pre-Training Observation

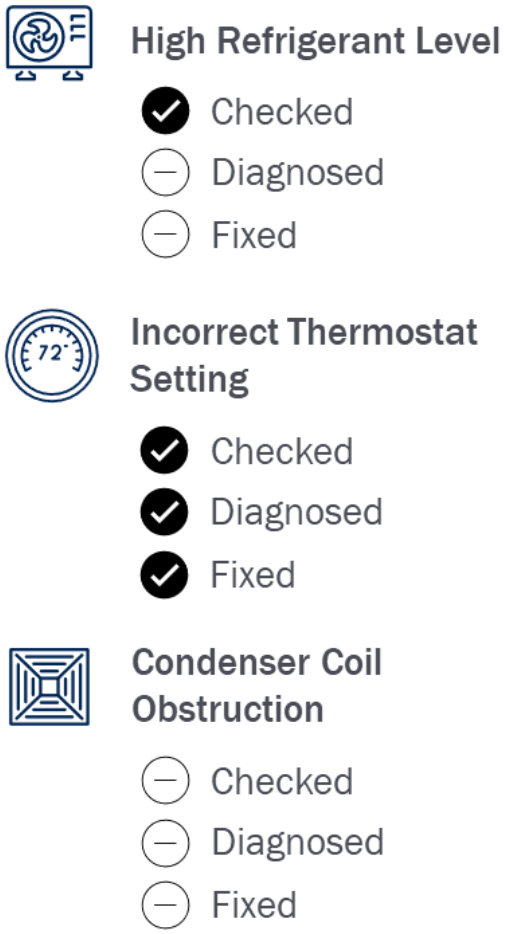
Technician #4 was presented with the customer narrative and started examining this system without asking follow-up questions about the unit. They started their diagnostic process by attempting to identify why the system was not turning on using the multimeter. Next, the technician collected air-side measurements. They measured the temperature difference between the supply and return duct using the psychrometer, inspected the air filter, and noticed it needed replacing.

There were several key measures that Technician #4 did not collect. They did not check the thermostat wiring and, therefore, did not identify the faulty thermostat was preventing the system from turning on. They also did not measure the static pressure in the ductwork and did not inspect the dampers. As such, they did not identify the dampers were shut. The technician did not inspect the evaporator and condenser coils. In addition, the technician did not take refrigerant side measurements.

To proceed with the observation, the HVAC lab technician and out team prompted Technician #4 to continue troubleshooting. They attempted to diagnose and fix system faults after a few prompts from the lab team. Still, they were unable to successfully identify most root causes of system failure or complete appropriate corrective action. For example, after being prompted to check the thermostat wiring, the technician did not know which wires to reconnect. After we suggested they collect refrigerant side measurements, they knew how to connect the tools to measure the temperature and pressure on the refrigerant lines. With guidance from the HVAC lab technician, Technician #4 took refrigerant side measurements but was unable to interpret the readings. The technician eventually guessed the refrigerant was low but could not explain why. They appeared uncomfortable and uncertain when attaching the tools to add refrigerant; they did not know how much refrigerant to add or check measurements while adding a refrigerant charge. In the end, they were unable to remedy the refrigerant charge issue.

Post-Training Observation

At the beginning of the post-training observation, Technician #4 engaged with the customer narrative by repeating details that we mentioned but did not ask questions to learn more about the system. They turned the unit on, checked the air filter, noted the system model information, including refrigerant type, and visibly inspected the wiring connections in the unit. They held their hand over the compressor, said the air felt cold, and correctly noted that the air from the compressor should be hot when the unit is in cooling mode. Next, they checked the temperature difference between the supply and return ducts using the psychrometer and attached the test kit tool to check the refrigerant side measures. While the diagnostic tools collected data on the air and refrigerant side, they physically inspected the temperature of the suction and liquid lines. They noticed the lines were hot to the touch, and the diagnostic tools indicated high refrigerant pressure and superheating. They stated they thought something was wrong with the reversing valve and decided to inspect the thermostat.



After confirming that there were no problems with the thermostat wiring, they correctly concluded there was a problem with the thermostat settings. However, they were not sure which setting to change. They used trial and error to change the settings. They eventually found the correct setting, but after fixing the thermostat, they mentioned they couldn't recall the setting that fixed the system.

With the thermostat fixed, the technician tried to fix the refrigerant charge issue. However, they misinterpreted the readings and stated that the system was low on refrigerant, which is incorrect. The technician added refrigerant, which was not the appropriate corrective action. Technician #4 was also unable to fix the issue with the condenser coils because they did not inspect the coils when they examined the unit.

APPENDIX D. BEHAVIORAL ASSESSMENT SAVINGS CALCULATION

The evaluation team estimated deemed annual electricity savings for both observation scenarios by assigning each scenarios' faults a savings estimate from the California Electronic Technical Reference Manual (eTRM) based on specific pertinent characteristics from the observation, such as the climate zone where we conducted the observations (see Table 37). Because the annual savings estimates are provided per tonnage of cooling capacity of the HVAC system, we then multiplied the annual savings value by the equipment cooling capacity (3 tons) to calculate the savings estimates for each fault (see Table 38).

Table 37. Summary of Lab Study HVAC System and Accompanying Characteristics

Characteristic	Description
1. Cooling/Heating	Heat Pump
2. Expansion Valve	No
3. Capacity	3-ton
4. Climate Zone	CZ13
5. Building Type	Residential Single Family[13]

Table 38. Measure Package Assigned to Scenario Faults

Scenario and Fault	Source	Measure Package	Measure Offering ID	Energy Savings / Ton	Demand Savings / Ton	Energy Savings	Demand Savings
Scenario 1: Airflow obstruction (1) – closed dampers	California eTRM	SWSV009-01: Airflow Adjustment, Residential	A	6.97 kWh/ton	.00569 kW/ton	20.91 kWh	0.02 kW
Scenario 1: Refrigerant adjustment	California eTRM	WSV006-01: Refrigerant Charge Adjustment, Residential	G	59.1 kWh/ton	.0489 kW/ton	177.30 kWh	0.15 kW
Scenario 1: Airflow obstruction (2) – dirty air filter	Work Paper	SCE13HC011: Air Filter Alarm	n/a	n/a	n/a	8.47 kWh	0.00 kW
Scenario 2: Refrigerant adjustment	California eTRM	WSV006-01: Refrigerant Charge Adjustment, Residential	A	.506 kWh/ton	.0044 kW/ton	1.52 kWh	0.01 kW
Scenario 2: Condenser coil obstruction	California eTRM	SWSV007-01: Condenser Coil Cleaning, Residential	A	.0114 kWh/ton	.0114 kW/ton	41.70 kWh	0.03 kW

[13] Even though we conducted observations in an HVAC lab and not in a home, the evaluation team determined the residential single-family building type to be the most appropriate option because of how the HVAC system was set up in the HVAC lab setting. The unit was ducted to only cool one zone in the lab facility, which is more like the ducting of residential single-family units than units serving commercial or industrial applications.

APPENDIX E. PRIMARY DATA COLLECTION INSTRUMENTS

The following appendices include the Installer Survey instrument, the interview guide that we used to interview participants in our Behavioral Assessment, the revised exit survey instrument that we recommend IOUs administer following their trainings, and the interview guide that we used to interview training instructors.

APPENDIX E-I. INSTALLER SURVEY

This appendix contains the instrument from our online survey of HVAC installers who participated in relevant WE&T trainings administered through one of the four IOU energy centers during the 2019 or 2020 calendar years.

INSTRUMENT

INTRODUCTION

Thank you for agreeing to participate in our survey! We have some questions about your experience with the HVAC trainings sponsored by the California Investor-Owned Utilities (PG&E, SCE, SoCalGas, and SDG&E) as part of their Workforce Education and Training initiatives. Please note that we will refer to all of the utility-sponsored offerings, including courses, seminars, and webinars, as "trainings" for the remainder of this survey.

Your feedback will help us understand the effectiveness of the California utilities' trainings, including identifying opportunities for improvement moving forward. Your responses are important in order to develop the best possible training offerings to support career development for yourself and others in the HVAC industry.

The survey should take about 20 minutes to complete. Your responses will be kept confidential and only reported in the aggregate with responses from other trainees. If you need to exit the survey before completing it, you can use the survey link we emailed you to return to where you left off. **Upon completion of the survey, we will provide you with a $50 gift card as a thank you for your time**.

The California Public Utilities Commission (CPUC) tasked Opinion Dynamics, an independent research company, to conduct this study. If you have any questions about the study or the survey, please contact Taylor Williams (taylor.williams@opiniondynamics.com). If you would like to verify the legitimacy of this study, you may contact Jordan Christenson with the CPUC (Amanda.Christenson@cpuc.ca.gov).

Please click "Next" to continue.

[INCLUDE AS FOOTER ON EACH PAGE: "If you need any assistance with or have questions about this survey, please contact Taylor Williams at taylor.williams@opiniondynamics.com."]

SCREENING [ASK ALL]

[ASK IF RESPONDENT TOOK ONLY ONE COURSE]

S1. First, we would like to confirm that you completed the [COURSE] training provided by California utilities, is that correct?

1. Yes
2. No

[IF S1 = 2, THANK AND TERMINATE; DISPLAY TERMINATION SCRIPT: "Thank you for your interest in this study, but unfortunately you do not qualify. For this survey, we are speaking with participants who have completed HVAC trainings."]

[ASK IF RESPONDENT TOOK MORE THAN ONE COURSE]

S2. Our records indicate that you completed the following trainings sponsored by California utilities, is that correct? *Please indicate if you have complete all, some, or none of these trainings.* [MULTIPLE RESPONSE] [DISPLAY ALL COURSES RESPONDENT PARTICIPATED IN FROM SAMPLE; MOST WILL ONLY HAVE A FEW, MAX 5 COURSE NAMES]

[COURSE NAME_1]
[COURSE NAME_2]
[COURSE NAME_3]
[COURSE NAME_4]
[COURSE NAME_5]

1. Yes, I participated in all of these trainings
2. Yes, I participated in some of these trainings
98. No, I did not complete any of the above trainings [EXCLUSIVE]

[IF S2 = 98; DISPLAY TERMINATION SCRIPT: "Thank you for your interest in this study, but unfortunately you do not qualify. For this survey, we are speaking with participants who have completed HVAC trainings."]

S3. When answering questions throughout the remainder of the survey, please think only about the most recent training you completed.

S3a. Was the most recent training you completed conducted in-person or virtually? *Virtual trainings might have been an on-demand webinar or a training lead by an instructor over the internet.*

1. In-person
2. Virtually
3. Hybrid (mix of in-person and virtual training)

S4. Are you currently employed in the HVAC industry*?

**For the purposes of this survey we define the HVAC industry as those working in residential and commercial buildings to support indoor air quality and thermal comfort through heating, ventilation, air-conditioning and refrigeration systems and related infrastructure.*

1. Yes
2. No
3. I am not currently employed

[ASK IF 0=2]

S5. Which of the following best describes your current situation?

1. I am a student
2. I have a full-time job outside of the HVAC industry
3. I am currently seeking employment in the HVAC industry
4. I plan to seek employment in the HVAC industry in the future
5. Other, please specify: [TEXT BOX]

[IF 0= 2 or 3, THANK AND TERMINATE; DISPLAY TERMINATION SCRIPT: "Thank you for your interest in this study, but unfortunately you do not qualify. For this survey, we are speaking with people who are currently employed in the HVAC industry working on residential and/or small commercial jobs."]

S6. Please select the types of buildings you service through your current position. *Please select all that apply.* [MULTIPLE RESPONSE]

1. Single-family Homes
2. Multifamily Residences
3. Small Commercial Properties
4. Large Commercial Properties
5. None of the above [EXCLUSIVE]

[IF S6 = ONLY 4 OR 5, THANK AND TERMINATE; DISPLAY TERMINATION SCRIPT: "Thank you for your interest in this study, but unfortunately you do not qualify. For this survey, we are speaking with people who are currently employed in the HVAC industry working on residential and/or small commercial jobs."]

RESPONDENT CHARACTERISTICS

Q1. Next, we have a few questions about your position and career. What is your current job title?

1. [OPEN-END TEXT BOX]

Q2. How many employees, including yourself, work at your company?

1. 1
2. 2 to 4
3. 5 to 9
4. 10 to 24
5. 25 to 49
6. 50 to 99
7. 100 or more
98. Don't know

Q3. How long have you been working with HVAC systems in residential and small commercial buildings?

1. Less than 1 year
2. 1 to less than 5 years
3. 5 to less than 10 years
4. 10 or more years

Q4. Approximately what percent of your time at your job is spent on service calls, maintenance visits, installation jobs, and other types of work? *Your best estimate is fine, but please make sure your responses add up to 100%. Place a "0" in the box for any of the three tasks you spend no time doing at your job.*

- By service calls, we mean appointments that are made to fix a fault in HVAC systems that either shut the system down or inhibits the system's operation to the point that the customer detects a problem.
- By maintenance visits, we mean check-ups to inspect, test, measure, and preserve an HVAC system.
- By installation jobs, we mean projects where the primary purpose is to install new equipment or replace existing equipment.
- By other work, we mean your HVAC-related work that does not fit in one of the above categories.

[SET % TO SUM = 100%; Error Message not equal to 100%]

1. Service calls: __%
2. Maintenance visits: __%
3. Installation jobs: __%

4. Other work: __%
5. None of the above [EXCLUSIVE]

[ASK IF Q4 <> 4]
Q5. Which do you think best describes how you work with others when conducting HVAC system service, maintenance, and/or installation jobs?

1. I most often work alone.
2. I most often work with a superior.
3. I most often work with an assistant.
4. I most often work with a partner/team of coworkers.

[ASK IF Q4 = 4]
Q6. Which of the following best describes your current function in your company?

1. New hire/trainee
2. Administrative
3. Sales/marketing/communications
4. Supervisory
5. Other, please specify: [TEXT BOX]

COURSE MOTIVATION AND SATISFACTION

Q7. Again, thinking about the **most recent training you completed**, which of the following best describes your reason for participating in the training? *Please select all that apply.*

1. To acquire new skills
2. An employer required the training
3. To receive a promotion at work
4. To change a job
5. To find a job (if unemployed at time of training)
6. To obtain an industry certification
7. Other, please specify: [TEXT BOX]

[ASK IF Q7=6]
Q8. Please specify which certification you pursued.

1. [OPEN END TEXT BOX]

Q9. How did you learn about the training?

1. Employer
2. Utility-sponsored Energy Center (PG&E, Edison, SDG&E, and/or SoCalGas)
3. Communication directly from your utility company (PG&E, Edison, SDG&E, and/or SoCalGas)
4. Colleague
5. Friend or family member
6. Social media
7. Mass media/advertising (TV/radio/newspaper)
8. Other, please specify: [TEXT BOX]

Q10. Overall, how satisfied or dissatisfied were you with the training?

1. Very satisfied
2. Somewhat satisfied
3. A little satisfied

4. A little dissatisfied
5. Somewhat dissatisfied
6. Very dissatisfied

Q11. Overall, how satisfied or dissatisfied were you with the instructor?

1. Very satisfied
2. Somewhat satisfied
3. A little satisfied
4. A little dissatisfied
5. Somewhat dissatisfied
6. Very dissatisfied

Q12. Overall, how satisfied or dissatisfied were you with the training materials*?

**Training materials refer to any handouts, textbooks, homework assignments, exams, or any other documents used to support student learning during the training.*

1. Very satisfied
2. Somewhat satisfied
3. A little satisfied
4. A little dissatisfied
5. Somewhat dissatisfied
6. Very dissatisfied

Q13. Do you feel the following aspects of the training were too few, about right, or too many? [1=Too few, 2=About right, 3=Too many, 97=Not applicable, 98=Don't know] [ROTATE 1-6]

1. Number of activities and/or hands-on exercises
2. Number of exams/assessments to end each session/topic
3. Number of homework assignments
4. Number of topics covered

Q13A. Do you feel the time spent on the following aspects of the training was too little, about right, or too much? [1=Too little, 2=About right, 3=Too much, 97=Not applicable, 98=Don't know] [ROTATE]

1. Amount of time spent on each topic
2. Amount of student collaboration

Q14. In your opinion, what is the most effective way to deliver this training?

1. In-person delivery only
2. Mostly in-person delivery with some online
3. Roughly equal mix of online and in-person delivery
4. Mostly online delivery with some in-person
5. Online delivery only

Q15. Based on what you expected to learn, to what extent would you say that the training exceeded, met, or fell short of your expectations?

1. Far exceeded your expectations
2. Somewhat exceeded your expectations
3. Met your expectations
4. Fell somewhat short of your expectations
5. Fell far short of your expectations

Q16. How likely would you be to recommend the training to your colleagues and others in your industry?

1. Extremely likely
2. Somewhat likely
3. A little likely
4. Not at all likely

Q17. What improvements, if any, would you suggest for the training?

1. [OPEN-END TEXT BOX]
2. No additional areas of improvement

Q18. In your opinion, what was the most effective aspect of the training?

1. [OPEN-END TEXT BOX]

LEARNING DEVELOPMENT

Q19. Considering your employment goals and experience, how appropriate was the level of difficulty of the training?

1. Far too low; I was too experienced for this training
2. Somewhat too low; I was already familiar with most concepts
3. Appropriate for my level of experience
4. Somewhat too high; I needed more time and/or hands-on activities
5. Far too high; I should have had more preparation or experience before taking this training

Q20. Which of the following topics were covered in the training you completed? *Please select all that apply.* [MULTIPLE RESPONSE]

1. HVAC system sizing
2. HVAC system installation processes and techniques
3. HVAC system servicing and troubleshooting techniques
4. Airflow measurement and/or distribution
5. Ductwork sizing
6. Energy efficiency/energy fundamentals
7. Building decarbonization
8. Boiler fundamentals
9. Heat pump fundamentals
10. Heating and/or cooling load capacity
11. Motors fundamentals
12. Safety fundamentals
13. Building codes/Title 24 principles
14. Furnace fundamentals
15. Refrigeration fundamentals
16. Other, please specify: [TEXT BOX]

Q21. What additional topics, if any, would have been helpful to cover in the training that were not covered? *Please select all that apply. [Only show topics not answered in Q20; MULTIPLE RESPONSE]*

1. HVAC system sizing
2. HVAC system installation fundamentals
3. HVAC servicing and troubleshooting techniques
4. Airflow measurement and/or distribution
5. Ductwork sizing
6. Energy efficiency/energy fundamentals

7. Building decarbonization
8. Boiler fundamentals
9. Heat pump fundamentals
10. Heating and/or cooling load capacity
11. Motors fundamentals
12. Safety fundamentals
13. Building codes/Title 24 principles
14. Furnace fundamentals
15. Refrigeration fundamentals
16. Other, please specify: [TEXT BOX]
17. None [EXCLUSIVE

TRAINING IMPACT ON RESPONDENT SKILLS AND CAREER

Thank you for your responses so far. In this final section, we'll ask about how effective the **training you most recently completed** was in developing further knowledge and/or skills related to your position and career. To orient you to the questions that follow, it is important to first define the difference between knowledge and skills:

- *Knowledge:* body of information needed to perform a job's duties and tasks. It focuses on the understanding of the underlying concepts. It is theoretical as opposed to practical.
  - *Example:* a person can read a state's drivers' manual but has no practical experience driving a car.
- *Skills:* the practical application of theoretical knowledge. They reflect capabilities or proficiencies developed through training and/or actual experience.
  - *Example:* once a person passes their Department of Motor Vehicles' written test, they obtain a learner's permit to develop the skill of driving a car prior to taking the driving test.

Q22. Please rate how the training covered and impacted your knowledge on each of the following subjects.

The training…	1. Did not cover	2. Covered but did not change my level of knowledge	3. Covered and slightly increased my level of knowledge	4. Covered and moderately increased my level of knowledge	5. Covered and significantly increased my level of knowledge	Don't recall if covered
HVAC system installation and/or servicing processes						
Indoor air quality optimization						
Duct system maintenance and/or installation						
HVAC equipment selection and sizing						
Efficient building design and/or building decarbonization						
Title 24 building code						

The training…	1. Did not cover	2. Covered but did not change my level of knowledge	3. Covered and slightly increased my level of knowledge	4. Covered and moderately increased my level of knowledge	5. Covered and significantly increased my level of knowledge	Don't recall if covered
Building envelope and interactions with HVAC systems						
Energy efficiency programs and equipment rebates						

Q23. Which statement best describes how frequently you apply the **knowledge** that you acquired in the training in your current position?

1. I use my new knowledge on the job every day
2. I use my new knowledge on the job every week
3. I use my new knowledge on the job every month
4. I rarely use my new knowledge on the job
5. I do not use my new knowledge on the job

Q24. [DELETED]

Q25. What is the **biggest change you've noticed in your work so far** with the new knowledge acquired from this training?

1. [OPEN-END TEXT BOX]

Q26. **Compared to your confidence before the training**, please rate your new confidence in accurately applying the skills needed to perform your job.

1. Very confident
2. Somewhat confident
3. A little confident
4. Not at all confident
98. I do not use what I learned in the training in my current position

[ASK IF Q26 = 1-4]

Q27. Which statement best describes how frequently you apply the **skills** that you acquired in the training in your current position?

1. I use my new skills on the job every day
2. I use my new skills on the job every week
3. I use my new skills on the job every month
4. I rarely use my new skills on the job
5. I do not use my new skills on the job

[ASK IF Q26 = 1-4]

Q28. What challenges, if any, do you face in applying the skills you learned in your current position?

1. [OPEN-END TEXT BOX]
2. I do not face any challenges in applying these skills in my position

[ASK IF Q26 = 1-4]

Q29. Do you use the knowledge and skills that you acquired in the training to train others?

1. Yes

2. No

[ASK IF Q29 = 2]
Q30. Would you be able to teach the knowledge and skills you obtained in the training to your colleague(s)?

1. Definitely
2. Probably
3. Not sure
4. Probably not
5. Definitely not

Q31. Do you still work for the same employer as you did when you took the training?

1. Yes
2. No

[ASK IF Q31 = 1]
Q32. Did the training you received contribute to a change in responsibilities or promotion at your work?

1. Yes
2. No

[ASK IF Q31 = 2]
Q33. Did the training you received lead to a job with a different employer?

1. Yes
2. No

Q34. Do you plan to continue employment in the HVAC industry?

1. Definitely yes
2. Probably
3. Not sure
4. Probably not
5. Definitely not

CLOSING [ASK ALL]

Q35. If you have additional comments you would like to provide on the knowledge, skills, or abilities that you developed while completing your most recent training or about your experience participating in trainings sponsored by the California utilities, please provide them here.

1. [OPEN-END TEXT BOX]
98. Nothing to add

Q36. Thank you for your answers. As a token of our appreciation, we will be sending you a $50 Tango gift card that can be redeemed at one of many businesses, such as Amazon, Best Buy, Nike, Home Depot, and many more. Below, please enter your name and the email address you would like your Tango gift card sent to. [RESPONSE REQUIRED]

If you do not want to receive a Tango gift card, please select "I do not want my Tango gift card."

1. Name: [OPEN-END TEXT BOX]
2. Email Address: [OPEN-END TEXT BOX]

98. I do not want my Tango gift card [EXCLUSIVE]

Thank you very much for taking the time to share your experience participating in California utility-sponsored HVAC trainings. The California Public Utilities Commission appreciates your valuable feedback.

[IF Q36<98 DISPLAY "Please allow up to 2-4 weeks for your Tango gift card to be delivered."

APPENDIX E-II. BEHAVIORAL ASSESSMENT INTERVIEW GUIDE

This appendix contains the semi-structured interview guide used to conduct follow-up conversations with technicians following the completion of tasks during their pre- and post-training lab visits.

INSTRUMENT

Thank you for participating in our study today. Your participation has been extremely helpful to our research.

Before we wrap up, I will ask you some brief follow-up questions to get a better understanding of your experience working on the HVAC system and how you felt during the process.

Please remember that your responses are being used to evaluate the training, and this is not an evaluation of you. Also, remember that your answers will be kept confidential, so please speak freely.

1. I'd like to start by hearing you talk about your process for diagnosing the problem with the system. Walk me through how you diagnosed the problem with the HVAC system. [PROBE WITH THE QUESTIONS BELOW]
    a. When you heard "the customer" describe the problem, what was the first thing that came to mind to check?
    b. Besides the customer's description of the problem, what data did you collect to assess the situation?
    c. Is there a general process that you follow for diagnosing these types of HVAC systems? Can you explain that process?
    d. After you thought you had the issue diagnosed, how did you confirm your diagnosis?
    e. What do you think is the easiest part of diagnosing these types of HVAC systems? Conversely, what is the most challenging?
    f. Was there anything that surprised you as you worked to diagnose the system? If so, what was that?
    g. If you could repeat this process, what, if anything, would you do differently in the diagnostic stage?

2. [IF THEY DID EXPLAIN THE ISSUE TO THE "CUSTOMER" DURING THE OBSERVATION] I noticed that you explained your diagnosis and the corrective action to "the customer." What was that like for you? What is the hardest part about explaining situations like this to the customer? What do you think is the easiest?

3. Now, I'd like to learn about your thought process when you started fixing the system. [PROBE WITH THE QUESTIONS BELOW]
    a. When it came time to fix the system, where did you start? Is there an important order you need to follow in this type of situation?
    b. As you worked to fix the system, was there anything that surprised you?
    c. If you could do the "fixing stage" again, is there anything you would like to do differently? If so, what is that?
    d. What was the easiest part of fixing this? What was the most challenging?
    e. After you thought you had the system fixed, how did you check your work?

4. [PRE-TRAINING ONLY]: What prompted you to register for XX training?

5. [PRE-TRAINING ONLY]: What do you hope to learn in XX training?

6. [POST-TRAINING ONLY]: What learnings from the XX Module did you apply to the work that you did here today?

7. [POST-TRAINING ONLY]: How helpful do you feel the XX Module was in your ability to service the HVAC system?

8. [POST-TRAINING ONLY]: Is there anything you wish the XX Module covered that may have helped better prepare you for the tasks today?

9. Is there anything else you'd like to share about your experience today?

10. Additional questions to ask in the post-training:
    a. How many years of experience do you have in the HVAC field?
    b. Besides this IHACI training, how many other IHACI training modules have you completed?
    c. Outside of IHACI, what trainings have you completed?
    d. Do you have more experience with installation or more experience with maintenance? How many years?
    e. When did you start working on heat pumps?
    f. What types of tools do you typically use in the field? Analog or digital?

APPENDIX E-III. REVISED EXIT SURVEY INSTRUMENT

This appendix contains the revised instrument Opinion Dynamics developed from existing exit surveys administered by IOUs upon completion of a WE&T training. The goal of this survey was to gauge individuals' reactions to training interventions.

Opinion Dynamics developed this survey instrument to include only questions that correspond with topics that are critical of a Level 1 assessment according to Kirkpatrick's Model for evaluating adult learning interventions. Table 39 presents the critical topics and their associated questions in the survey instrument. For those questions that are critical, we indicated which topic they address in purple. Questions in red are the survey questions that are not critical to a Level 1 assessment according to Kirkpatrick's Model. Section 3.3 of this report details how the evaluation team developed this instrument.

Table 39. Question Topics Corresponding to Kirkpatrick's Level 1 and Associated Question in Revised Instrument

Question Topics Corresponding to a Level 1 Assessment	Question in Revised Instrument
1. Overall course quality	Q2, Q19, Q21
2. Instructor's abilities	Q7, Q9
3. Quality/usefulness of course materials	Q4
4. Appropriate level of instruction/interaction	Q8
5. How will participant directly apply skills learned from course	Q10
6. How often will participant apply skills learned from course	Q11
7. Appropriate length of course	Q3
8. Does participant recommend the course	Q18

INSTRUMENT

Read in Variables

[IOU] – Read in name of investor-owned utility that sponsored the training class.

[COURSE NAME] – Read in name of course

[COURSE] – IOUs may have different names for WE&T courses (e.g., trainings, seminars), which can be substituted as indicated by this variable.

Introduction

Thank you for participating in the [COURSE NAME] [COURSE]. Your feedback will help us improve future classes.

Survey Questions

[Response optional for Q1]

Q1) What is your name? (Optional) [OPEN END]
or
[If administered electronically] Please confirm that you are the individual that took [COURSE NAME]?

Please indicate your level of agreement with the following statements.
Q2) The learning objectives for this [COURSE] were clearly defined. [Topic 1]

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Q3) The [COURSE] was an appropriate length to address the learning objectives. [Topic 7]

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Q4) The [COURSE] materials (e.g. presentation, displays, handouts, etc.) were easy to understand. [Topic 3]

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Q5) The [COURSE] was a good use of my time. .

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Q6) As a result of participating in this [COURSE], I gained knowledge of the subject/topic.

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Q7) The instructor(s) demonstrated a good understanding of the material. [Topic 2]

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Q8) The level of instructor/student interaction was appropriate for class objectives. [Topic 4]

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Q9) The instructor successfully delivered the materials in a cohesive and understandable way. [Topic 2]

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Q10) How will you apply the information/skills from this course? (Please select all that apply.) [Topic 5]
[PROGRAMMER NOTE: RANDOMIZE ANSWER OPTIONS]

1. Current project(s)
2. Future project(s)
3. Professional development
4. Prepare for a career change
5. Earn continuing education credits
6. Other (please specify)
7. I will not apply the information/skills from this course
8. Educating my colleagues about what I learned

Q11) How frequently do you expect to use the information you learned in this course? [Topic 6]

1. Daily
2. Weekly
3. Monthly
4. Annually
5. Never
6. Not sure

Q12) What were your goals or reasons for attending the class? (Select all that apply.)

1. Career advancement (within same company)
2. Career advancement (not in current company)
3. Required by my employer
4. Suggested by my employer
5. To gain new customers
6. To deliver a higher level of service to customers
7. To stay competitive in the marketplace
8. To learn about new technologies and best practices
9. Personal interest
10. To help obtain a certification
11. I was unemployed or underemployed and I thought it would help make me more employable
12. Other (please specify) [OPEN END]
13. I did not have any reasons or goals

~~Q13) Are you currently participating in a Utility Rebate/Incentive Program or do you plan to participate in the next six months?~~

~~1. Yes~~
~~2. No~~
~~3. Unsure~~

~~Q14) Please indicate your level of agreement with the following statement:~~
~~*The course helped me understand a program or technology better so I can participate in a Utility Rebate/Incentive program.*~~

~~1. Strongly Agree~~
~~2. Agree~~
~~3. Neither Agree nor Disagree~~
~~4. Disagree~~
~~5. Strongly Disagree~~

Q15) Do you plan to share the information you learned in this course with your coworkers or colleagues?

1. Yes
2. No
3. Unsure

~~[If Q15 = 1]~~
~~Q16) With whom will you share this information [OPEN END]~~

Q17) How did you hear about this class? (Select all that apply.)

1. Social media (e.g., LinkedIn, Facebook, Instagram, etc.)
2. Professional or Trade Organization
3. Colleague
4. Internet Search
5. [IOU] Email
6. [IOU] Flyer Handout
7. [IOU] Website
8. Other (please specify) [OPEN END]

Q18) How likely is it that you would recommend this class? [Topic 8]

1. Very Likely
2. Somewhat Likely
3. Neither Likely nor Unlikely
4. Unlikely
5. Very Unlikely

Q19) Please provide any additional comments about the course content or the instructor. [OPEN END] [Topic 1]

Q20) What other [COURSE]s would you like us to offer? [OPEN END]

Q21) Are you okay being contacted by the [IOU] Workforce, Education, and Training Program with follow up questions to help us improve our courses? [Topic 1]

1. Yes
2. No

~~[ASK IF Q1=BLANK]~~
~~Q22) Please provide your name. [OPEN END]~~

APPENDIX E-IV. TRAINING INSTRUCTOR INTERVIEW GUIDE

This appendix contains the interview guide Opinion Dynamics developed to complete in-depth interviews with training instructors who taught the audited trainings listed in Table 5 of this report. The interviews focused on:

- The instructor's previous experience with and training in adult learning principles and practices;
- Ways in which instructors tailor the use of the materials to better meet the needs of the participants;
- Instructors' assessments of how training may improve energy efficiency projects and lead to additional energy savings;
- Delivery of course, including instructor affect and virtual vs. in-person presentation and,
- Instructors' suggestions for refining the course design and materials and enhancing processes related to design and delivery of courses within the program.

INSTRUMENT

INSTRUCTOR BACKGROUND

Q1) How long have you been teaching this course? Have long have you been an instructor for [Organization]?

Q2) What topics/subject matter do you have experience in teaching?

Q3) What experience do you have as a participant in professional HVAC trainings?

Q4) How long have you been working in the HVAC industry?

LEARNING APPROACH

Q5) How would you describe the primary audience of this course?

a. How many participants, on average, attend this training?

Q6) Are there any ways in which the course is tailored to cater to a specific audience, or is it intended to be applicable to a broad audience?

Q7) Is there anything that you think could be different about this course to improve the overall learning experience for participants? Have you made any changes in the past?

COURSE MATERIALS AND PRESENTATION

Q8) What is the process for designing course materials?

a. Process for developing course slides/presentation?
b. Process for developing assessments/in-class activities?

Q9) Can you think of any opportunities to improve course materials in order to best serve your students in the future?

COURSE DELIVERY

Q10) Were classes previously delivered in-person? If so, do you have any plans to resume in-person delivery in the future? When?

Q11) What effect (if any) has virtual delivery had on the course presentation?

a. What impact do you think this change to delivery has had on the instructor or student experience? Why?

Q12) Were there any new changes or differences in how this particular course was implemented that we have not already discussed?

Q13) Can you think of any opportunities to improve the delivery of this course in the future?

SUCCESSES AND CHALLENGES

Q14) What do you view as the most effective aspect of this course? What best practices for teaching these courses have emerged in your experience as a teacher?

Q15) What areas of improvement do you see for the course or these types of trainings in general? Is there anything about the training in terms of design or delivery that could change in order to create the best learning experience possible for students?

a. Changes to design, delivery, materials, student participation, and/or assessments?

Q16) Who is responsible for reading course surveys? To your knowledge, have any key themes or opinions emerge from the surveys that you hope to use to improve course design and/or implementation?

a. If you do see the results of the surveys, how are they used/implemented?
b. Are there any other modes of feedback for this course that we haven't already discussed?

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