HVAC Educational Needs Assessment

Current State Analysis

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EXECUTIVE SUMMARY

While Californians rely heavily on air conditioning to make living and workspaces comfortable and productive, few think about what is required to make air conditioning systems operate efficiently. In 2008, the California Public Utilities Commission (CPUC) published the *California Long Term Energy Efficiency Plan: Achieving Maximum Savings in California for 2009 and Beyond.* In the report, the heating, ventilation, and air conditioning (HVAC) industry is specifically identified as a sector that requires significant improvements in performance if statewide energy efficiency is to be enhanced. HVAC technologies, which control the temperature, humidity, and overall air quality in buildings, are increasingly becoming more energy efficient, which would lead one to believe that over time statewide energy savings in the HVAC sector will significantly increase. However, reality shows many opportunities still exist for improvement.

At present, California homes and businesses are plagued by widespread practices of poor installation and maintenance of HVAC systems. The California Energy Commission estimates that as many as 50 percent of all new HVAC systems and 85 percent of all replacement systems are not installed and maintained to a quality specification, meaning that the equipment consumes more energy than it needs to operate.[1] Since air conditioning makes up nearly 30 percent of peak electricity demand in California, it is evident that there are significant potential energy savings in improving industry practices. In fact, it is estimated that potential cumulative savings from higher quality HVAC installation in the residential and small commercial markets could reach 1,216 GWh and 1,096 MW by 2020.[2] In light of this potential, the CPUC has set the ambitious targets of improving HVAC performance by 50 percent by 2020 and by 75 percent by 2030.

In order to plan how to improve overall installation and maintenance of HVAC systems in California, one must first understand the scope, structure, and key trends of the state's HVAC industry. To say that the HVAC value chain in California is complex is an understatement; the statewide HVAC market consists of thousands of contractors, retailers, distributors, and manufacturers. In Southern California Edison's territory alone, there are 8,600 contractor firms providing HVAC services with over 46,000 employees.[3] This paper is based on the premise that improving HVAC installation and maintenance practices first requires an understanding of what skills and knowledge employees throughout the HVAC value chain need for the range of tasks they must perform on the job. Southern California Edison is taking the lead in examining this dynamic.

Research indicates that all effective training begins with a needs assessment that measures what skills employees have, what they need, and how to deliver the right training at the right time.[4] This paper aims to serve as the basis of such a needs assessment by reviewing existing roles and education infrastructure within Southern California Edison's territory. After conducting an initial baseline assessment, the evaluation team has made the following findings:

- While there is a wide range of roles in the HVAC industry, the most written-about role in terms of educational needs is the technician, who performs on-site installation and maintenance of HVAC systems.

[1] California Energy Commission (2008), p.22
[2] Engage 360 (2010), p. 6
[3] Better Buildings Incorporated (BBI, 2008), p.18
[4] American Society of Training and Development

- In contrast to the abundant literature on technicians, there is limited information available about other roles in the HVAC industry, especially those in HVAC manufacturing, distribution, and retailing companies.

- There are significant differences between the residential and commercial HVAC markets in customer needs, equipment design, demand for quality installation and maintenance services, and workforce dynamics.

- While the commercial HVAC sector has traditionally been treated as a single entity in HVAC literature, SCE HVAC program managers have emphasized the need to examine the small commercial and large commercial HVAC sectors separately. Overall, the minimal amount of information in current literature about defining and differentiating the sectors necessitates further inquiry as the needs assessment progresses.

- At present, there are many training opportunities for technicians of all experience levels in Southern California Edison's territory. However, the depth and quality of different programs appear to be significantly varied.

- In contrast to the plentiful literature on technician training, there is minimal information available about training opportunities for other roles involved in the HVAC industry, such as sales managers, customer service representatives, building officials, and commercial project managers.

Having conducted a baseline assessment to try to understand the HVAC industry in Southern California, the evaluation team recommends undertaking an in-depth research process that first prioritizes roles in the HVAC value chain that have a significant potential influence on energy efficiency practices and energy savings, and then aims to fully comprehend how these roles are currently performing on the aggregate and what skills they need to improve to better enhance energy savings. More simply put, an effective, definitive educational needs assessment can only be achieved with further primary research.

Key HVAC education and training documentation identified in the paper include the "California Workforce Education and Training Needs Assessment" by the University of California at Berkeley's Donald Vial Center on Employment in the Green Economy, the "Heating, Ventilation and Air Conditioning (HVAC) Action Plan for the California Energy Efficiency Strategic Plan" by Engage 360, and "Developing HVAC Workforce Education & Training 2010–2012: A Pre-Assessment Inventory" by Better Buildings Incorporated. Other primary literature and online sources include:

- Air Conditioning Contractors of America (ACCA) website http://www.acca.org/
- Air Conditioning, Heating, & Refrigeration News website http://achrnews.com
- California Energy Commission (2008). *Recommended Strategic Plan to Transform the Existing HVAC Industry and Achieve Additional Peak Savings, Sustainable Profitability, and Increased Customer Comfort.*
- California Public Utilities Commission (CPUC). (2008). *Long Term Energy Efficiency Strategic Plan: Achieving Maximum Energy Savings in California for 2009 and Beyond*
- Carlisle Power Transmission. (2003). *Institutional HVAC Market Overview*
- Davis Energy Group, Inc. (2010) *HVAC Energy Efficiency Maintenance Study*

- Energy and Environmental Analysis. (2005). *Light Commercial HVAC Market Assessment*
- Goldman et al. (2010). *Energy Efficiency Services Sector: Workforce Education and Training Needs*
- HVAC Excellence website http:///www.hvacexcellence.org
- North American Technician Excellence (NATE) website http://www.natex.org/
- Quantum Consulting. (2003). *Commercial and Industrial Equipment Supply Chains: An Assessment of the HVAC Industry*
- Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) website http://www.smacna.org/technical/
- United Association of Plumbers, Pipefitters and Refrigeration Mechanics (UA) website http://www.ua.org/apprenticeship.asp
- Western HVAC Performance Alliance (WHPA) website http://www.performancealliance.org/

1. HVAC INDUSTRY ROLES AND TASKS

1.1. Overview

While air conditioning equipment continues to improve in individual unit energy efficiency when first installed, the sheer amount of power required to cool millions of Californian homes and businesses continues to make air conditioning one of the largest electricity end-uses in the state. Air conditioning is the single largest contributor to peak power demand in California, making up nearly 30 percent of total electric demand during the summer.[5] This aggregate energy demand has major implications for California investor-owned utilities (IOUs), who stand at a unique intersection of economic and political pressures, and must invest intelligently to maximize service delivery and customer satisfaction today and in the future.

In the process of addressing these issues, IOUs have dedicated significant resources over the years to maximizing energy savings in the HVAC industry, yet utility program influence in the HVAC technical trades has been limited. As stated before, poor installation and maintenance practices are rampant throughout California. In the long-term, inefficiently performing HVAC systems will exacerbate seasonal fluctuations in electric demand and burden IOUs to develop more electric generation capacity that will only be used for a short time of the each year.

This problem is especially prominent for Southern California Edison (SCE), whose customer base relies heavily on air conditioning during Southern California's hot summer months. However, penetrating the HVAC industry to significantly impact its performance is a great challenge for SCE. First, as a utility, SCE does not have the regulatory or political clout to effectively catalyze market transformation.[6] Second, the HVAC industry in SCE's territory is large, fragmented, and complex—there are thousands of companies involved in the Southern California HVAC market. Finally, SCE's 4.5 million customers introduce additional complexity as their behaviors and needs related to HVAC usage are not widely understood.

Trying to identify the range of roles and job responsibilities in the HVAC workforce is a large, challenging task, so it is useful to use the various segments of the HVAC value chain and market as a means for understanding the different pieces that cumulatively make up the industry. After reviewing the different components of the HVAC value chain, it is evident that the most written-about role in the HVAC industry is the technician. Technicians—also commonly referred to as installers or mechanics—install, maintain, and repair heating, ventilation, and air conditioning systems. According to the U.S. Department of Labor's Bureau of Labor Statistics, there were 308,200 HVAC technicians in the United States in 2008. This number is projected to grow by 28 percent by 2018, reaching 394,800 workers.[7]

It is important to understand that the term "technician" is a very broad generalization when applied to the HVAC industry, since there are many types of heating and air conditioning equipment, requiring different skills to service. Equipment used in residential, small commercial, and large commercial/industrial facilities differ greatly in terms of size, configuration and technical complexity, and in each of these

[5] Donald Vial Center (2011), p. 92
[6] Interview with Paul Kyllo and Mel Johnson, SCE HVAC program managers
[7] U.S. Bureau of Labor Statistics Website http://www.bls.gov/oco/ocos192.htm#training

sectors there is great variety of equipment available, depending on application. Similarly, there are significant differences in customer needs even within the same HVAC market segment. This situation necessitates separate examinations of workers who specialize in residential, light commercial, and large commercial or industrial facilities.

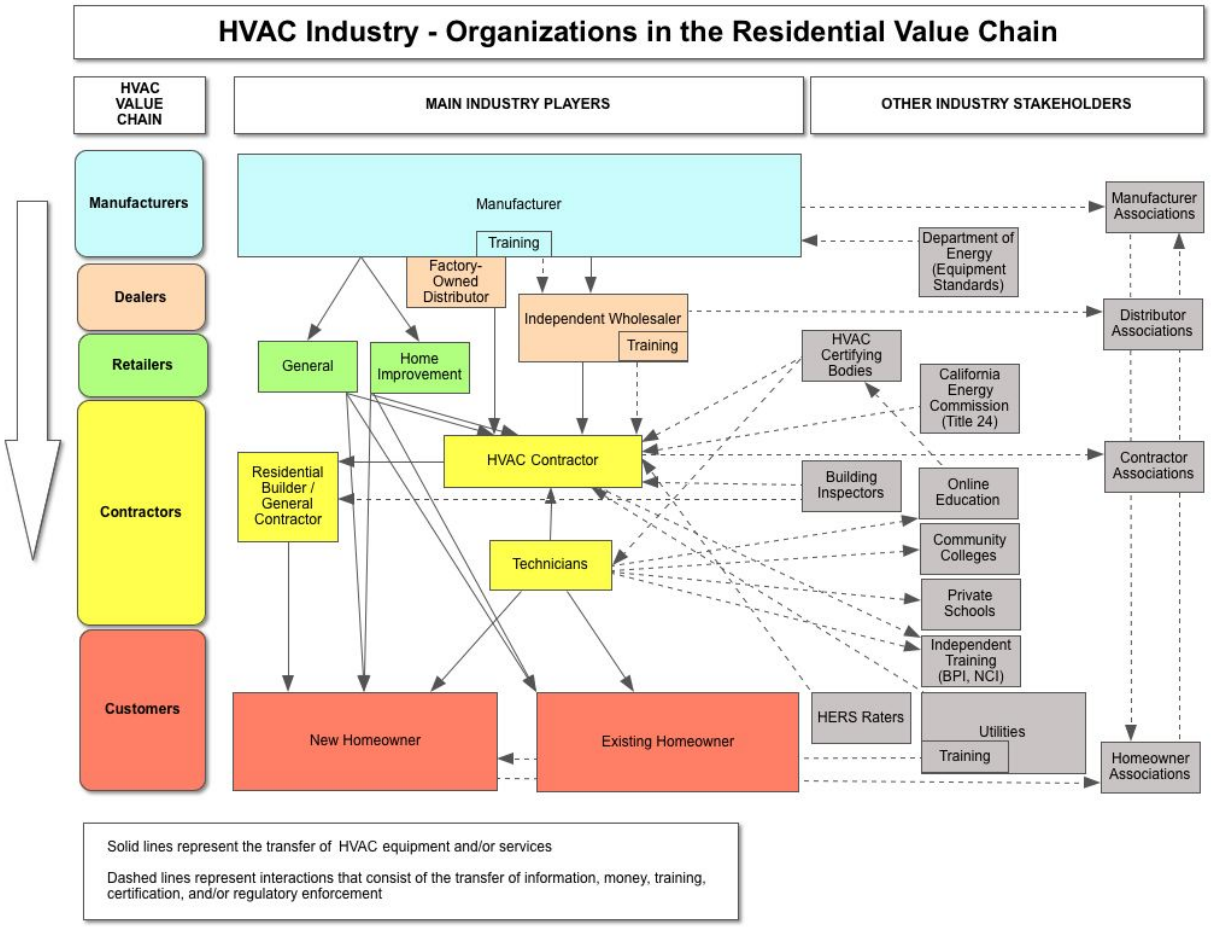
While the visibility into the role of the technician is encouraging, there is limited information in existing HVAC literature about the other professions within the industry value chain. If quality installation and maintenance are going to be improved in the future through education and training, it is first necessary to understand how other roles in the HVAC industry contribute to the installation and maintenance process. This section acts as a roundup of existing industry knowledge and lays the groundwork for the next phases of the SCE HVAC Educational Needs Assessment, which seeks to better understand the roles, responsibilities, and training needs of key HVAC market actors.

1.2. Residential Contractors

For residential homes, independent HVAC contracting companies most commonly perform installation and maintenance of HVAC systems. Contractors are defined as companies that are licensed and able to install HVAC equipment at customer facilities.[8] California law requires that contractors doing HVAC work must have a C-20 license issued by the Contractor State Licensing Board (CSLB), which entails contractors needing to have at least four years of experience or education in the trade for which they are licensed, to be fingerprinted, to have an FBI background check, and to be bonded. According to CSLB, any HVAC project in California valued at more than $500 for labor and materials must be done by a licensed C-20 contractor. Contractors are a key component of the value chain in the residential HVAC market, as shown below in Figure 1-1.

[8] California State Licensing Board website http://www.cslb.ca.gov/generalinformation/library/licensingclassifications/C20WarmAirHeatingVentilatingAndAirConditioning.asp

FIGURE 1-1: HVAC ORGANIZATIONS IN THE RESIDENTIAL VALUE CHAIN



A sample list of independent contractors in Southern California Edison's territory:[9]

- A.C. Dave Heating & Air
- Adalante Air Co. Inc.
- Air Tech Services
- BCS Mechanical
- BNB Mechanical
- Comfort Air Systems
- Cypress Heating and Air Conditioning
- E.G. HVAC & Refrigeration Co.
- London's A/C & Heating
- Magnolia Heating and Cooling
- McLay A/C Heating & Plumbing
- Pagel Service Co.

[9] HVAC Contractor Locator website http://www.hvacradvice.com/maps/locator.aspx?postal=91711

- Redlands Plumbing Heating & A/C Inc.
- Ricardo's Air Conditioning Company
- Select ACR, Inc.
- Temp Air System
- Total Comfort Inc.
- Western Equipment Service

It is important to distinguish HVAC contractors from general contractors and large commercial HVAC contractors. General contractors are hired to perform and oversee construction for new homes and major renovations. HVAC contractors specialize in heating and cooling system installation and maintenance, and are usually hired by customers to install HVAC equipment for new construction or major retrofit. Furthermore, compared to large commercial HVAC contractors, who install and service whichever HVAC equipment brand is included in the project bid, residential HVAC contractors most commonly only represent one major HVAC manufacturing line. While specific job titles differ among HVAC contracting companies, certain roles commonly exist within the residential HVAC market:[10]

[10] Air Rite website http://www.airrite.com/employee_list.asp; BCS Mechanical website http://www.bcsmechanical.com/aboutus.html; Direct communication with Dale Gustavson, President of Better Buildings Inc.

TABLE 1-1: RESIDENTIAL HVAC CONTRACTOR ROLES

Role	Job Titles	Frequency of References in Literature
Administrative	• Accounting Staff • Human Resources • Office Manager	Less Common
Customer Service	• Customer Service/Support	Less Common
Company Management	• Owner • President • Vice President	Common
Field Work	• Environment Systems Specialist • Installation Technician • Installer • Maintenance Technician • Mechanic • Service Technician	Very Common
Logistics	• Dispatcher • Service Coordinator • Warehouse Manager	Less Common
Marketing	• Project Sales • Maintenance Sales • Service Sales • Technician	Less Common
Project Management	• Sales and Marketing Manager • Project Coordinator • Project Manager • Production-Installation Manager • Service Support Manager	Common

The primary role in HVAC contracting companies identified in HVAC literature is the technician, who installs new equipment and maintains, diagnoses, and corrects problem in existing systems.[11] Heating and air conditioning systems in residential buildings can range from small window air conditioners to central heating and cooling systems that require duct systems. HVAC equipment consists of many mechanical, electrical, and electronic components, such as motors, compressors, pumps, fans, ducts, pipes, thermostats, refrigerant lines, and switches.

Technicians must be adept at using a variety of tools to work with these components, including hammers, wrenches, metal snips, electric drills, pipe cutters and benders, measurement gauges, and propane or MAP gas torches. They also must know how to use voltmeters, thermometers, pressure gauges, combustion efficiency instruments, manometers, and other testing devices to check airflow, refrigerant pressure, electrical circuits, burners, and other components. Increasingly, the technician must also be trained in the

[11] Better Buildings Incorporated (BBI, 2008), p. 56; Centers of Excellence (2009), 15. Donald Vial Center (2011), p. 98; EDF (2008), p. 30; REDI (2008), p. 5

use of sophisticated computer software for both analysis and control of equipment. Lastly, as technicians perform installations and maintenance procedures, they must be aware of proper safety practices in order to avoid hurting themselves, co-workers, and occupants of the building.

1.1.1. HVAC Installation and Maintenance Guidelines

For HVAC installation and maintenance procedures, the industry-wide accepted standards defining "quality" services are developed by the Air Conditioning Contractors of America (ACCA). The standards outline specific guidelines for HVAC installation and maintenance and are supplemented by ACCA's technical manuals, which instruct technicians how to properly conduct on-the-job procedures.

ACCA Standards and Technical Manuals

The Air Conditioning Contractors of America (ACCA) is a non-profit association that serves more than 60,000 professionals and 4,000 businesses in the HVAC industry, and works to promote professional contracting, energy efficiency, and healthy, comfortable indoor environments. ACCA's primary goal is to make the HVACR industry and other allied professional contracting businesses more successful by bringing contractors together through learning opportunities; providing technical, legal, and marketing resources; and lobbying for HVAC business interests at multiple levels of government.

In recent years, ACCA has developed industry standards and technical manuals for HVAC system design, installation, and maintenance. ACCA's standards define quality installation and maintenance of residential and commercial HVAC systems. The organization's technical manuals set the procedures and calculations used by technicians during installation and maintenance jobs, and are intended to ensure that HVAC systems meet code requirements, ensure customer comfort, and maximize potential energy savings: [12]

- **ACCA Standard 4**: In 2008, ACCA published "Standard 4: Maintenance of Residential HVAC Systems (ANSI/ACCA 4 – 2008)", which includes a set of screening tasks for HVAC servicing.

- **ACCA Standard 5**: In 2007, ACCA published "Standard 5: "HVAC Quality Installation Specification (ANSI/ACCA 5 QI – 2007)", which covers the proper installation of air conditioners and ducts.
    - Standard 5 defines a "quality installation" as one "where the heating, cooling, and ventilation system has been installed per a nationally recognized standard."

- **ACCA Standard 9**: In 2009, ACCA published "Standard 9: HVAC Quality Installation Verification Protocols (ANSA/ACCA 9 QIVP – 2009)", which sets forth the procedures for verifying adherence with Standard 5.

- **ACCA/ASHRAE Standard 180 (Commercial HVAC)**: While this section of the report focuses on residential HVAC work, it is important to note that ACCA has also published standards for the installation and maintenance of commercial HVAC systems. Prior to 2008, inconsistent inspection and maintenance of commercial HVAC systems meant that some facilities followed rigorous maintenance policies while others adopted a run-to-failure approach. As a result, "Standard 180-2008: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems" was developed to cover the full range of commercial equipment.

[12] ACCA website https://www.acca.org/

  - Standard 180 defines "quality maintenance" as when "an HVAC unit is maintained to preserve the condition of the HVAC system and its elements in a manner that enables the system to provide the intended thermal comfort, energy efficiency, and helps to achieve the intended indoor air quality required for the building."

- **Manual D - Residential Duct Systems:** Provides a single set of duct sizing principles and calculations that apply to all duct materials.

- **Manual J - Residential Load Calculation:** Produces equipment sizing loads for single-family-detached homes, small multi-unit structures, condominiums, town houses and manufactured homes.

- **Manual N - Commercial Load Calculation:** Details the load calculation procedure that addresses the advances in the commercial construction industry: new materials, methods of assembly, and operational requirements.

- **Manual Q - Low Pressure, Low Velocity Duct System Design**: Provides a detailed reference book on the low-pressure, low-velocity systems used in small and mid-size commercial buildings.

- **Manual S - Residential Equipment Selection:** Details how to select and size heating and cooling equipment to meet Manual J loads based on local climate and ambient conditions at the building site.

- **Manual T - Air Distribution Basics:** Details how to prevent drafts and stagnant air problems caused by improper sizing or incorrect equipment selection.

Installation and Maintenance Tasks Outlined in ACCA Manuals

As evidenced in the previous list, technicians and contractors must be able to apply the content of numerous technical manuals in their daily work. Each manual focuses on a different facet of installation or maintenance processes and the ACCA Standards provide technicians and contractors with easy-to-follow, step-by-step guides for these tasks. For instance, ACCA Standard 5 contains a checklist that technicians and contractors can use to ensure that an HVAC system is installed correctly:[13]

- The contractor shall ensure that ventilation calculations are performed.
- The contractor shall ensure that heat loss and heat gain load calculations are performed.
- The contractor shall ensure that all equipment is properly sized and selected prior to being installed.
- The contactor shall verify that the airflow through the indoor blower unit (e.g. furnace, fan coil, air handler) is within acceptable CFM ranges.
- The contractor shall verify that water or antifreeze that flows through the refrigerant-to-water, water-to-water, or water-to-air heat exchanger is within acceptable ranges.
- The contractor shall ensure that the HVAC system has the proper refrigerant charge.
- The contractor shall ensure that all electrical requirements are met as related to the installed equipment.

[13] ACCA (2010), "Standard 5: HVAC Quality Installation Specification"

- The contractor shall ensure that equipment combustion is "on-rate", for gas-fired or oil-fired equipment, and is at the equipment nameplate value.
- The contractor shall ensure proper sizing, design, material selection and assembly of the combustion gas venting system.
- The contractor shall ensure proper selection and functioning of system and operational safety controls.
- The contractor shall ensure the ducts are sealed and that air leakage (CFM) is minimized.
- The contractor shall ensure room airflows meet the design/application requirements.
- The contactor shall ensure water flows meet the design/application requirements.
- The contractor shall provide records pertaining to the HVAC system installation.
- The contractor shall inform the customer on how to both operate and maintain the installed equipment and will promote system maintenance to aid in the continuing performance of the installed equipment.

To ensure that technicians perform these procedures correctly, the ACCA standards detail specific tasks, as shown in the following example from Standard 180:[14]

TABLE 1-2: AIR DISTRIBUTION SYSTEM INSPECTION/MAINTENANCE TASKS

Inspection/Maintenance Task	Frequency
Check control system and devices for evidence of improper operation. Repair, adjust or replace components to ensure proper operation	Semi-annually
Visually inspect grilles, registers and diffusers for dirt accumulation. Clean as needed to remove dirt build up	Semi-annually
Lubricate field serviceable bearings	Annually
Check for proper damper operation. Repair, replace or adjust as needed.	Annually
Visually inspect areas of moisture accumulation for biological growth. If present, clean or disinfect as needed.	Annually
Visually inspect exposed ductwork until the first turn or up to 20 feet into the supply plenum from air handler for	Annually
Visually inspect internally lined ductwork until the first turn or up to 20 feet into the supply plenum from air handler for visible biological contamination and, if necessary, take corrective action.	Annually

1.1.2 Handling Refrigerant[15]

When servicing stationary air conditioners and refrigeration equipment, HVAC technicians are required by law to conserve, recover, and recycle chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants used in the cooling systems. According to Section 608 of the Clean Air Act, all technicians who purchase or work with refrigerants must be certified in their handling and disposal, and must also know how to document the capture and disposal process.

To become certified to purchase and handle refrigerants, technicians and contractors must pass a written examination specific to the type of refrigerant in which they specialize. The three possible areas of certification include small appliances, high-pressure refrigerants, and low-pressure refrigerants. Exams can only be administered by organizations approved by the U.S. Environmental Protection Agency.

[14] ACCA Standard 180 (2008), p.5
[15] U.S. EPA website http://www.epa.gov/Ozone/title6/608/technicians/608certs.html

According to the U.S. Environmental Protection Agency's website, there are five locations in California where technicians and contractors can take EPA Section 608 certification programs[16]:

1. HVAC/R Training, Inc. in Modesto, CA
2. California Career Center in Manteca, CA
3. Katlin Engineering Consulting in Antioch, CA
4. San Diego City College in San Diego, CA
5. Operating and Maintenance Engineer Trade Training Trust Fund (OME) in Los Angeles, CA

1.1.3. Customer Interactions

While residential HVAC technicians must be proficient in the technical procedures of installing or servicing HVAC equipment, they also must regularly perform a variety of customer service tasks. Technicians often perform a preliminary assessment of a customer's home and then, based on their findings, recommend equipment and sell installation and service contracts to the client. Therefore, technicians need to possess strong interpersonal skills—such as language proficiency (English or Spanish) and general courtesy—to effectively communicate with customers.[17]

In trade publications, numerous residential HVAC contractors emphasize the importance of technicians having good communication and interpersonal skills: [18]

- Greg Benua, Human Resources Manager at Atlas Butler Heating & Cooling in Columbus, Ohio: "Some individuals seem to have gotten into the industry because they like to fix things, and they don't like interacting with people. But we believe we are more than technicians—we are consultants. We are not only at a client's house to fix a specific problem, but also to look at their whole system to see what other products and services we can offer to help the client be more comfortable."

- Ray Grimm, President of Air, Water, Energy (A.W.E.) in Carol Stream, Illinois: "Communication skills and interpersonal relationships are probably more important than the technical training itself. Technicians have to be able to talk to a client, listen to a client, pay attention to what that client has to say, and acknowledge the client in a very positive manner. We always talk in terms of the clients' interests and not the interests of the service technicians. We are selling ourselves, and we don't want that client to feel that we're more important than they are."

- Adam Gloss, Vice President of Bel Red Energy Solutions in Mukilteo, Washington: "We've found that our most successful new hires have turned out to be those who may not have all the technical training or experience needed, but those that have good character and attitude. If we hire based on who we need, we can train for what we need."

[16] U.S. Environmental Protection Agency website, http://www.epa.gov/Ozone/title6/608/technicians/608certs.html
[17] U.S. Bureau of Labor Statistics website http://www.bls.gov/oco/ocos192.htm
[18] Turin, J. (2011), p. 2

1.3. Small and Large Commercial Contractors

There are an estimated 4.5 million commercial buildings in the United States, including airports, elementary schools, universities, hospitals, warehousing operations, correctional facilities, office buildings, military bases, shopping malls, and industrial complexes.[19] In Southern California, HVAC systems are a key part of commercial operations to keep facilities comfortable for workers and to maximize the efficiencies of industrial processes. This section analyzes the commercial HVAC sector by identifying the roles within commercial HVAC contracting companies, differentiating small commercial and large commercial HVAC services, and examining the service profile of the mechanical contractor McKinstry Co. to understand the structure of commercial HVAC contractors.

1.3.1 Contracting Companies and Associated Roles

Like residential HVAC contractors, the most written about role in small and large commercial HVAC contracting companies is the technician. However, the structure of small and large commercial HVAC contractors is much different from residential companies, as evidenced in below:

[19] Carlisle Power Transmission (2003), p. 3

Figure 1-2: Organizations in the Small Commercial HVAC Value Chain

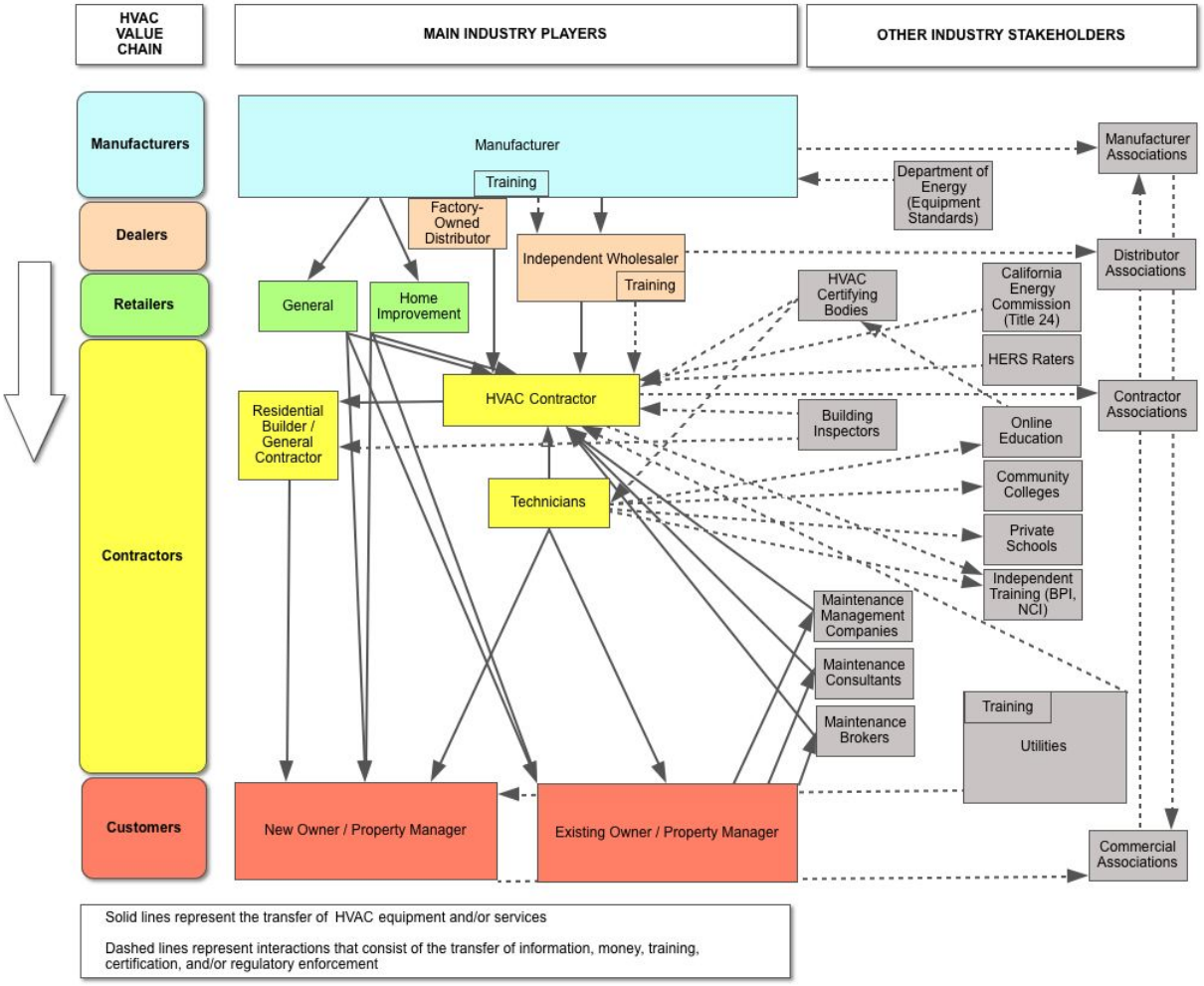
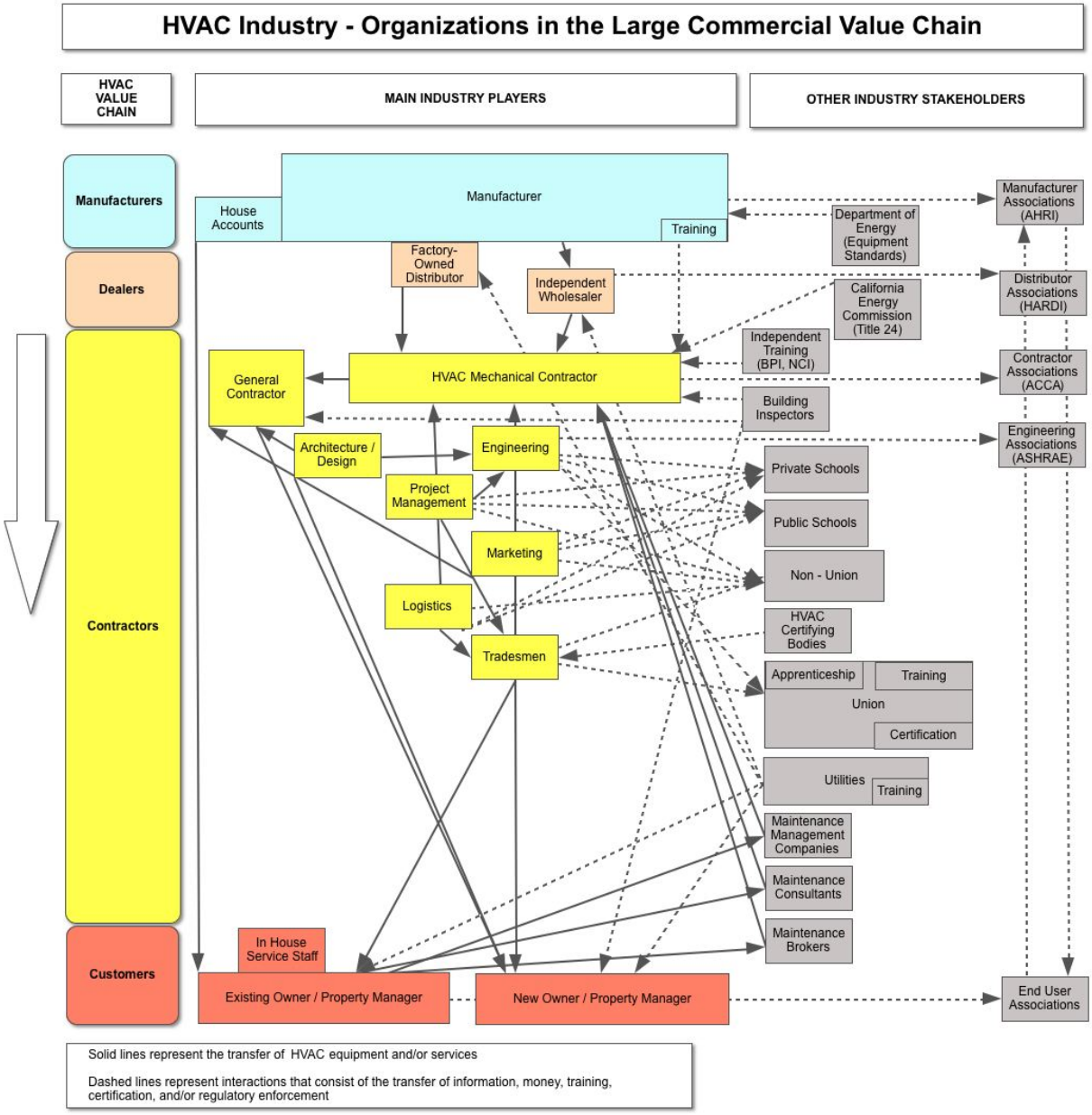


Figure 1-3: Organizations in the Large Commercial HVAC Value Chain



The national market for commercial HVAC equipment is dominated by five manufacturing companies: Carrier, Lennox, McQuay, Trane, and York .[20] That being said, there are additional commercial HVAC brands produced by the parent companies of these five manufacturers under different names to extend market share and tap into more price sensitive markets. For large commercial HVAC projects, HVAC mechanical contracting companies perform actual installation and maintenance of equipment in a subcontracting capacity to a large general contractor. Large regional and national HVAC contractors in

[20] Quantum Consulting (2003), p. 14

SCE territory include:[21]

- ACCO
- Carrier
- Comfort Systems USA
- Emcor Group
- Honeywell Building Services
- Johnson Controls
- York
- Service Experts
- Siemens
- Southland Industries
- Trane
- Turner Construction, Inc.

These contracting companies have a much more complex structure than residential contractors. For instance, the "technician's role", meaning the tasks that are performed in the field, is usually performed by a number unionized tradesmen commonly known as "journeymen". This means that an HVAC system's ductwork might be done by sheet metal workers and duct installers, its electrical work by electricians, and installation of its piping, condensers, and other components by pipelayers, plumbers, pipefitters, or steamfitters.[22]

Other roles in the large commercial HVAC segment are included in **Error! Reference source not found.** below, and are further detailed in section four:[23]

[21] Better Buildings Incorporated (BBI, 2008), p. 21
[22] U.S. Bureau of Labor Statistics website http://www.bls.gov/oco/ocos192.htm
[23] Interview with Dave Rost, Vice President, McKinstry Co.; Direct Communication with Dale Gustavson, President of Better Buildings Inc.; see "Exhibits" on p. 55 for detailed description of 4 large commercial HVAC job roles

Table 1-3: Large Commercial HVAC Contractor Roles

Role	Job Titles	Frequency of References in Literature
Administrative	• Accounting Staff • Billing Coordinator	Less Common
Customer Service	• Customer Service Representative	Less Common
Company Management	• Owner • President/CEO • Vice President/CFO	Common
Field Work	• Apprentice • Controls Technician • Electrician • Installation Technician • Foreman • Lead Mechanic • Lead Repair Specialist • Pipefitter • Plumber • Refrigeration Mechanic • Service Technician • Sheet Metal Worker • Steamfitter	Very Common
Logistics	• Dispatcher • Fleet Manager • Logistics Manager • Service Coordinator • Service Operations Coordinator • Warehouse Manager	Less Common
Maintenance Broker	• Maintenance Consultant	Less Common
Marketing	• Account Manager • Project Sales • Sales Manager • Service Maintenance Sales	Less Common
Manufacturer Liaison	• Specialty Services Team	Less Common
Controls Monitoring	• Remote Communications/Systems Monitoring Manager • Information Technology Manager	Less Common
Project Engineering	• Applications Engineer • Controls Engineer • Design Engineer	Common
Project Management	• Project Coordinator • Project Director • Project Engineer • Project Manager • Senior Project Manager	Common

1.3.2 Differentiating Small Commercial and Large Commercial HVAC

According to SCE HVAC Program Managers, the significant differences in customer needs, equipment types, and labor skill requirements among commercial facilities requires the small commercial and large commercial HVAC sectors to be differentiated and examined separately.[24] However, according to the U.S. Department of Energy, "to date there is no study or survey that gives an adequate breakdown of the U.S. commercial building stock by building type and HVAC system type."[25] Therefore, it is helpful to review existing studies that define commercial HVAC and those that attempt to differentiate small and large commercial HVAC services.

ACCA Standard 180 defines commercial HVAC as "any non-residential or non-process or manufacturing-related HVAC application, including but not limited to, applications for government and educational facilities, healthcare and hospitality facilities, institutional buildings, offices, places of assembly, restaurants, and retail and wholesale businesses."[26] To date, the most prevalent and prominent literature published on commercial building stocks has been produced by the U.S. Department of Energy. In February 2011, the National Renewable Energy Laboratory (NREL) published "U.S. Department of Energy Commercial Reference Building Models of the National Commercial Stock", a report for the Department of Energy's Building Technologies program that details the development of standard energy models for U.S. commercial buildings to serve as starting points for energy efficiency research.

Using the U.S. Energy Information Administration's "2005 Commercial Buildings Energy Consumption survey" and commercial building stock assessments conducted by the Pacific Northwest National Laboratory and the Lawrence Berkeley National Laboratory, NREL claims that the models produced in the study represent realistic building characteristics and construction practices for the commercial building stock in the United States. That being said, EIA does not address the workforce that installs and maintains HVAC with sufficient granularity to differentiate small and large commercial HVAC services. The study's assumptions about commercial facilities' average square footage and HVAC equipment are presented in Table 1-4.

Similar to NREL's study, the U.S. Department of Energy has published a three-volume set of reports on energy consumption in commercial building systems in the U.S. The first volume focuses on energy use for generation of heating and cooling. The second volume focuses on "parasitic" energy use or the energy required to distribute heating and cooling within a building, reject to the environment the heat discharged by cooling systems, and move air for ventilation purposes. The third volume addresses opportunities for energy savings in commercial building HVAC systems. For the purposes of this report, the first volume, "Energy Consumption Characteristics of Commercial Building HVAC Systems: Chillers, Refrigerant Compressors, and Heating Systems" is the most helpful due to its clear differentiation of commercial HVAC system designs.

According to the study, commercial HVAC systems can be classified into three broad categories: centralized systems, packaged systems, and individual AC systems.[27] Central systems are defined as any HVAC system that uses chilled water as a cooling medium, which includes systems with air-cooled chillers as well as systems with cooling towers for heat rejection. Packaged systems include both unitary systems such as rooftop units, and split systems. These are systems do not use chilled water as an intermediate cooling medium. Instead, the cooling is delivered directly to the supply air in a refrigerant

[24] Interview with Paul Kyllo and Mel Johnson, SCE HVAC Program Managers
[25] U.S. Department of Energy (1999), p. 5-4
[26] ACCA Standard 180 (2008), p. 3
[27] U.S. Department of Energy (2001), p. 3-1

evaporator coil. Lastly, individual room air conditioning includes window AC units, packaged terminal air-conditioners (PTAC's), packaged terminal heat pumps (PTHP's), and water-loop heat pumps (WLHP's).

The only study found that differentiates small and commercial HVAC was conducted by the Virginia-based consulting firm Energy and Environmental Analysis for the Northwest Energy Efficiency Alliance. The study is an assessment of the light commercial HVAC market in the Pacific Northwest, and differentiates small commercial and large commercial facilities according to the tonnage of the building's HVAC unit and the area of the building's floor space. According to the study, large commercial facilities have more than 10,000 square feet of floor space and have HVAC units with capacities exceeding 25 tons.[28] A ton of cooling capacity is approximately equal to the cooling power of one ton of ice melting in a 24-hour span, and is defined as 12,000 BTU per hour or 3,517 watts.[29]

According to Five Borough A/C, a New York-based contracting firm that offers installation and maintenance services for residential and commercial HVAC systems, residential, small commercial, and large commercial HVAC facilities' different cooling requirements necessitates different HVAC system designs.[30] Window and through the wall air conditioners are typically used for smaller spaces; the capacity of residential HVAC systems ranges between one and five tons. In contrast, centralized systems are usually used when cooling requirements exceed 20 tons. Packaged air conditioners are designed to fit somewhere in between, and are typically available in fixed capacities of three, five, seven, ten, or fifteen tons.

Using the metrics outlined in the studies mentioned thus far, which are presented below in Table 1-4, one can being to organize different ways to differentiate small and large commercial HVAC services.

[28] Energy and Environmental Analysis (2005), p. 10
[29] National Institute of Standards and Technology website, http://physics.nist.gov/Pubs/SP811/appenB9.html
[30] Five Borough A/C website, http://www.fiveboroughac.com/air-conditioners-systems.php

TABLE 1-4: CRITERIA FOR DIFFERENTIATING SMALL AND LARGE COMMERCIAL HVAC

Criteria	Sector	
	Small Commercial	Large Commercial
Type of end-use customer[31]	• Buildings that house small-scale commercial service providers or small business owners • Buildings that contain residential customers, such as multifamily units and apartments or student dormitories	• Buildings that contain large business or warehouse operations
Facility management	Does the end-use customer have a facility or energy management staff that handles… • Energy accounting? • Monitoring of HVAC equipment operation? What is the structure of the end-use customer's… • Energy accounting needs? • Billing needs for HVAC services? • User interface with HVAC system? • Contract for HVAC maintenance?	
Customer needs	Is the HVAC system going to be used to… • Control indoor climate for human comfort? • Prevent overheating of machinery or electronic equipment? • Refrigerate/preserve products?	
Business operations of HVAC contractor	What is the structure of the company's… • Liability insurance for workers and services? • Staff size and capabilities? • Fleet dispatch process? • Sales/marketing strategy and capabilities?	
Building size (square footage)[32]	• Small office • Small retail • Quick service restaurant • Full service restaurant	• Medium office • Large office • Primary school • Large campus • Stand-alone retail • Strip mall • Supermarket • Small hotel • Large hotel • Large office • Large retail

[31] Interview with Paul Kyllo and Mel Johnson, SCE HVAC Program Managers; Trane website http://www.trane.com/Commercial/CaseStudies/CaseStudyList.aspx?CaseId=4

[32] This category applies Energy and Environmental Analysis' distinction of large commercial facilities having an area of floor space greater than 10,000 square feet to NREL's (2011) average square footage metrics of commercial facilities (p. 19)

			• Outpatient healthcare • Warehouse • Midrise apartment
Equipment cooling capacity[33]		5 - 20 tons	> 20 tons
System type according to floor space[34]	PACU (packaged AC)	• Small office • Small retail • Quick service restaurant • Full service restaurant	• Large retail • Primary school • Stand-alone retail • Strip mall • Supermarket • Outpatient healthcare
	PACU-SS (split system)		• Midrise apartment
	Chiller – air cooled		• Large campus • Large hotel
	Chiller – water cooled		• Large office • Hospital
	PACU, IRAC (individual room AC)		• Small Hotel
System design according to cooling capacity[35]	Unitary packaged system	• Full service restaurant • Midrise apartment • Outpatient healthcare • Primary school • Quick service restaurant • Small hotel • Small office • Stand-alone retail • Strip mall • Supermarket	
	Built-up central chiller system		• Hospital • Large hotel • Large office • Large campus • Large retail

There are evidently many ways to differentiate commercial HVAC. However, since research indicates that technicians are the focal role in the commercial installation and maintenance process, it seems that for the purposes of the educational needs assessment it is helpful to being differentiating small and large commercial HVAC according to what skills and knowledge technicians need to provide quality services in each sector. As evidenced in the list of commercial HVAC equipment components addressed in ACCA 180, which is presented below, the range of commercial HVAC equipment requires a wide swath of expertise among the commercial technician workforce:[36]

[33] Engage 360 (2011), p. 152
[34] NREL (2011), p. 33
[35] NREL (2011), p. 33; Trane website http://www.trane.com/Commercial/CaseStudies/CaseStudyList.aspx?CaseId=4
[36] ACCA Standard 180 (2008), p. 4

- Air Distribution Systems
- Air Handlers
- Chillers (Absorption, Air-Cooled, Water-Cooled)
- Boilers
- Condensing Units
- Control Systems
- Cooling Tower and Evaporative Cooled Devices
- Dehumidification and Humidification Devices
- Engines, Micro-Turbines
- Free-Standing Heating or Cooling Coils
- Free-Standing Fans (e.g., Exhaust, Transfer, Return)
- Fan Coils, Hot Water & Steam Unit Heaters
- Furnaces, Unit Heaters
- Indoor Section Duct-Free Splits
- Package Terminal Air Conditioners
- Rooftop Units
- Steam Distribution Systems
- Terminal and Control Boxes (e.g., VAV, Fan-Powered, Bypass)
- HVAC Water Distribution Systems
- Water Source Heat Pumps

The point of examining ACCA 180 in this context is not to suggest that the average commercial technician should be able to install and maintain all or most of these HVAC components. Instead, it is to propose that any attempt to define small and large commercial HVAC should be considered from a viewpoint of the technical skills and expertise technicians and contractors need to possess. Further research is required to identify other factors that impact commercial HVAC contractors' involvement in small and large commercial facility services.

1.3.3 Service Profile: McKinstry Co.[37]

Founded in 1960, McKinstry Co. originated as a Seattle-area plumbing and piping contractor. Today, McKinstry has operations in eight states and has expanded its services to include sheet metal (HVAC), fire protection, temperature and fire/life safety controls. McKinstry's complete in-house capabilities make the firm the only mechanical design-build firm in the Northwest Region with full-service HVAC offerings. While McKinstry does not perform HVAC installation and maintenance jobs in SCE's territory, examining the company's structure and service ideology reveals important differences among residential, small commercial, and large commercial HVAC markets contractors.

McKinstry maintains a diverse account list of over 2,000 customers in the metropolitan Seattle and Portland markets. Its customer base includes Commercial Property Managers managing Class A & B office space, Bio Tech companies, Critical Environment Data Centers, Industrial Manufacturing Plants, Healthcare, K-12 Education, Higher Education, Casinos, Municipalities and local, state, and federal government facilities. McKinstry offers clients the following service capabilities:

- Preventive & Predictive Maintenance Programs

[37] Interview and direct communication with David Rost, Vice President, McKinstry Co.

- Heating, Ventilation & Air Conditioning
- Boiler Service and Certification
- Chillers - Reciprocating, Screw, Centrifugal
- Humidification/Dehumidification
- Water Treatment/Testing
- General Service and Repairs

The range of McKinstry's clientele and service capabilities is a prime example of how complex and varied the commercial HVAC sector is in terms of equipment types and customer needs. Furthermore, McKinstry's philosophy of properly maintaining a system throughout its life cycle highlights the continuous relationship between commercial HVAC contractors and their clients, and the link between proper HVAC maintenance and a system's energy efficiency. McKinstry utilizes analogies to human healthcare to help its customers understand the importance of maintenance strategies:

TABLE 1-5: HVAC MAINTENANCE STRATEGY CLASSIFICATIONS

Maintenance Strategy	Definition of Strategy	Technique Needed	Human Body Parallel
Reactive Maintenance	Repair or replace on failure	Large Maintenance Budget	Heart attack or stroke
Preventive Maintenance	Regular Maintenance according to schedule rather than condition	Periodic Component Replacement	Bypass or transplant surgery
Predictive Maintenance	Detecting warning signs of failure once they've already begun	Monitoring of heat, vibration, alignment, wear, debris	Detection of heat disease using EKG or ultrasonics
Proactive Maintenance	Concentration on root causes of failure instead of symptoms	Monitoring & correction of failing root causes (i.e. Contamination)	Cholesterol and blood pressure monitoring with diet control

TABLE 1-6: HVAC MAINTENANCE STRATEGY TASKS

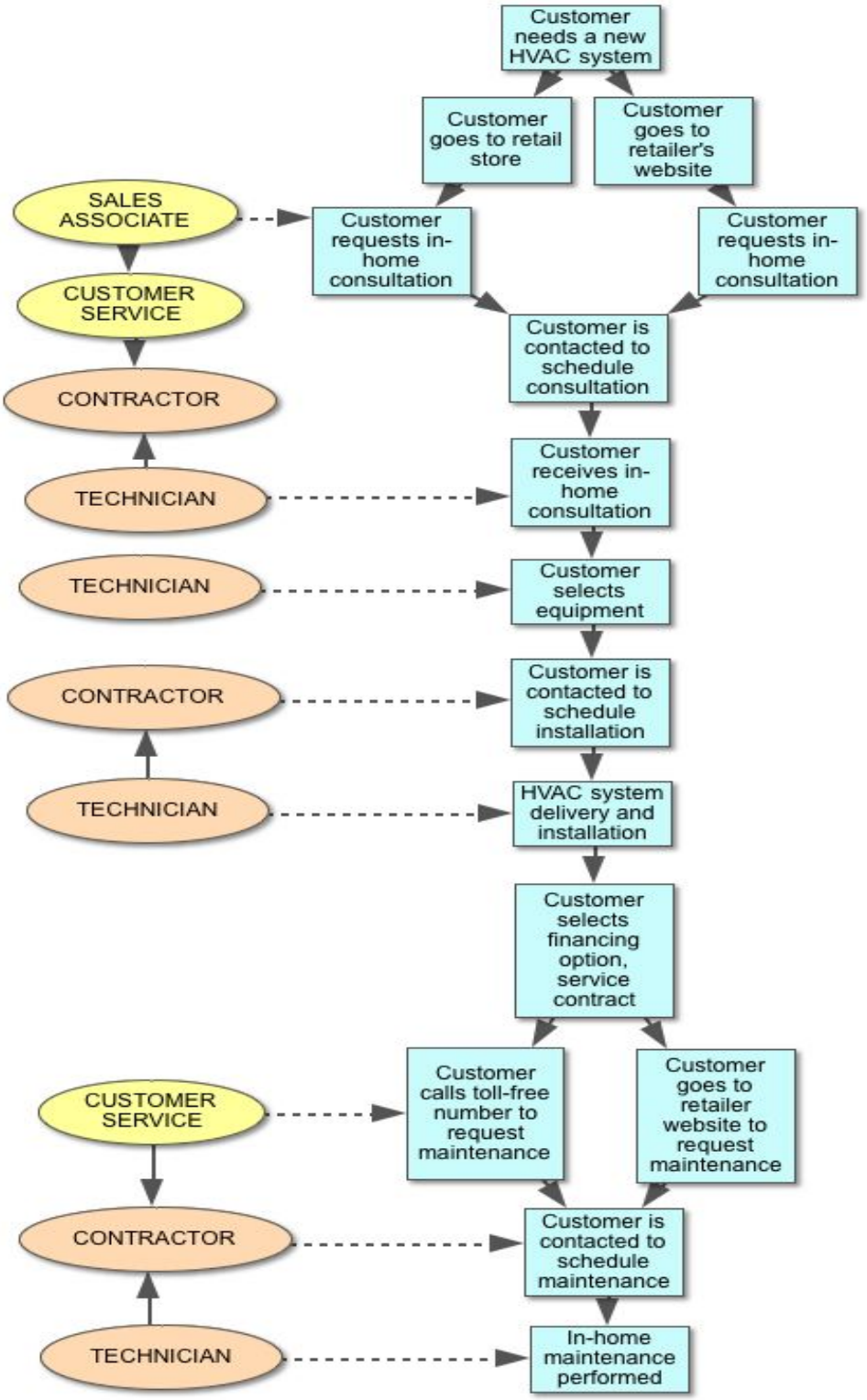
Reactive Maintenance	Preventive Maintenance	Predictive Maintenance	Proactive Maintenance
Breakdown based	*Time based*	*Condition based*	*Root cause based*
• Fix on failure • Replace on failure	• Inspections • Measurement • Minor repairs • Cleaning • Record keeping for tracking, failures & equipment utilization • Write ups of machine condition • Scheduling repairs • Using frequency & severity of failures to refine task lists • Fluid and filter changes • Minor adjustments • Log reports	• Vibration analysis • Bearing condition analysis • Laser alignment • Balancing • Thermography (heat detection) • Ultrasonic detection (sound) • Tribology (oil analysis) • Motor circuit analysis • Power condition monitoring • Information management/data analysis • Non-destructive testing • Eddy current analysis • Refrigerant analysis • Water treatment • Air quality testing	• Contamination control of - Lubrication fluids - Hydraulic fluids - Coolants - Air - Fuel • Contamination monitoring • Ferrography (metals) • Spectography (light) • Root cause failure analysis • Risk assessment/ inspections • CMMS- Computerized Maintenance Management Systems • Remote Monitoring • Info Centre- web based facility management

1.4. Retailers

Another segment of the HVAC value chain is the retail sector. Nationwide home improvement chains such as Home Depot and Lowes and general retailers like Sears offer residential and small commercial customers HVAC services by subbing out equipment sizing and installation services to independent HVAC contractors. From the moment a customer steps into the store or visits the retailer's website to the time that the HVAC unit is installed in his home or business, he interacts with a number of employees. This process is documented in the following flow chart:[38]

[38] Interview with Home Depot Sales Associate

FIGURE 1-4: PROCESS FOR HVAC INSTALLATION AND MAINTENANCE VIA RETAIL COMPANY



Key retail roles include in-store sales associates, customer service representatives (in-store and remote), and independent residential HVAC contractors and technicians. The technically trained persons who assist customers to evaluate their needs and select appropriate equipment, and those HVAC technicians who install and service the HVAC units (these may be the same or different people and organizations), are the focal role in the equipment distribution process. In addition to having to possess the technical knowledge and skills to successfully specify, install, and maintain HVAC equipment, technicians who are contracted by retailers must be licensed to drive a vehicle to deliver, install, and service equipment; must help customers select which type of equipment and warranty to purchase; must keep records of parts used and hours worked; and must prepare payment bills.[39] While information about the retail HVAC sector is limited, an examination of two prominent national retail brands, The Home Depot and Sears, provides some insight into the tasks a technician must perform on a daily basis.

1.4.1 Service Profile: The Home Depot[40]

The Home Depot is the largest home improvement retailer and the fourth largest general retailer in the United States, with over 2,000 full stores across the country. For air conditioning needs, The Home Depot offers Trane, Rheem, Lennox, and Mitsubishi models ranging from small window units to central cooling systems, and contracts local residential HVAC contractors to provide in-home installation and maintenance. According to the Home Depot website, there is a four-step process for installing a new air conditioning system:

Step 1: Schedule a Free In-home HVAC Consultation, which covers the following points:

- Visually inspect all visible ductwork
- Discuss customer's comfort and efficiency concerns
- Determine the best way of replacing the existing HVAC system
- Perform a load calculation to determine proper size of system for customer's home
- Establish proper comfort and efficiency to best fit customer's needs and budget
- Discuss dehumidification, humidification and air filtration options
- Review extended service agreement options
- Review financing options
- Provide an estimate on the cost of HVAC system replacement
- Identify installation date for new heating and cooling system

Step 2: Schedule HVAC Delivery and Installation

- Before delivery and installation of a customer's new heating and cooling system, the installation specialist will obtain any permits and licenses required for the local area. Once the permit(s) have been approved, the specialist will contact the customer to schedule the installation of the heating and cooling system at a convenient date and time.

[39] U.S. Bureau of Labor Statistics Website http://www.bls.gov/oco/ocos193.htm

[40] The Home Depot HVAC Buyer's Guide: http://www.homedepot.com/webapp/wcs/stores/servlet/ContentView?pn=SV_HS_Heating_Cooling_Systems_Installation&langId=-1&storeId=10051&catalogId=10053&cm_sp=heating_cooling_air_quality-_-pod1-_-body_link1-_-hvac_installation

Step 3: Delivery and Installation

- The HVAC specialist will manage the delivery and installation of the customer's new heating and cooling system from start to finish. The Home Depot's team of licensed and insured professionals will also remove and dispose of the customer's old HVAC system components and perform a thorough cleanup once the installation is complete.

Step 4: Inspection

- After the new air conditioning installation is complete, the HVAC specialist will conduct a 33-point quality audit to make sure it's working properly and set for the customer's preferences. The specialist also will provide detailed instructions for the customer on how to operate the new heating and cooling system and address any questions or concerns.

The Home Depot recommends that its customers have their HVAC system serviced twice a year, which entails the following elements as part of a 22-point inspection and tune-up of the unit and duct system:

- Carbon monoxide emissions
- Gas valve, lines and connections for leaks
- Burners and heat exchangers
- Visible ductwork and flue pipe for leaks
- Unit for peak operating efficiency (adjust as necessary)
- Indoor blower motor and wheel (record amp draw of blower)
- Crankcase heater
- Unit wiring and electrical disconnect
- Ignition system and assembly
- Thermostat (with calibration as required)

The Home Depot claims that their services are superior to simply working with an independent contractor for the following reasons:

- **Licensed & Insured Installation Professionals:** "The Home Depot works only with installers and home service professionals who meet the highest standards for experience, know-how and customer service. The Home Depot screens and performs background checks on all of its installers before they are sent out on any job to ensure they have all applicable licenses and insurance."

- **Peace of Mind:** "The Home Depot offers superior warranties on its installation service labor and products, to give you peace of mind on the quality of your installation project. All of its installation services are backed by a one-year warranty on labor as well as warranties on all products."

- **Project Management, from Start to Finish:** "When you work with The Home Depot, you won't have to go to the trouble of finding multiple installers and home service professionals for different parts of your project."

- **Flexible Financing**: "For all of its home installation services, The Home Depot offers many ways to pay and will work with customers to find the financing option that is most convenient for them."

While The Home Depot does make an effort to inform customers about HVAC equipment installation and maintenance on its website and in its "HVAC Buyer's Guide", there is an evident lack of specific detail in the company's literature about its technicians' qualifications and training, as well as what procedures they follow to perform load calculations and size equipment. For instance, on both the website and the "HVAC Buyer's Guide", the benefits of a system tune-up are emphatically presented in large text:

- Improved system performance
- More energy-efficient operation for reduced utility bills
- Prolonged system life
- Prevention of expensive repairs

In contrast, the only indication of a Home Depot HVAC technician's qualifications is the constant referral to "HVAC specialists". This term appears on The Home Depot's website five times without any more detailed description of what qualifies the technician as a "specialist", leaving the customer to believe that any Home Depot HVAC technician is qualified to effectively perform all necessary installation and maintenance tasks.

1.4.2 Service Profile: Sears[41]

Sears Holding Corporation is the fourth largest general retailer in the United States, with over 926 full-size stores in the United States. According to Sears' website, customers who choose Sears for their HVAC installation and maintenance needs experience several advantages over working with an independent contractor:

- Sears can connect customers with over 10,000 licensed specialized service pros
- Sears technicians call before they arrive
- Customers get an estimate before HVAC repairs are done
- Sears technicians use a 10-point evaluation to get to the root of the problem
- Sears technicians fix it right the first time and guarantee their work

During maintenance appointments, Sears technicians conduct a mandatory 10-Point Check for air conditioning systems:

- Check overall operation of the air conditioner or heat pump
- Check & clean condenser coils
- Check & clean air filter
- Check evaporator
- Lubricate air handler blower
- Lubricate condenser fan motor
- Check condensate drain lines & clean if needed
- Check refrigerant charge & adjust as needed (up to 1lb)
- Check condensate pump operation
- Check for loose parts or unusual vibration

[41] Sears Website http://services.sears.com/central-heating-air/improve

1.5. Manufacturers and Distributors

HVAC manufacturers and distributors are the originating sources of equipment in the HVAC industry. Manufacturers produce and sell HVAC equipment, automation controls, and diagnostics at the wholesale level to distributors or contractors, while also offering technical support and training. HVAC equipment is distributed through regional sales offices that are owned and operated by either the manufacturer or by an independent wholesaler. Over 90 percent of distributors' sales are to HVAC contractors, and independent distributors – commonly known as "dealers" – tend to specialize in smaller HVAC units for residential and small commercial buildings. For large commercial customers like general retailers (e.g. WalMart) and large restaurant chains (e.g. McDonalds), manufacturers frequently have national "house" accounts where the sale is negotiated directly between the manufacturer and the customer, with little or no involvement from a distributor.[42]

There are an estimated 247 manufacturers of HVAC equipment, controls, and diagnostics in the United States.[43] Allied Refrigeration, an independent wholesale distributor of HVAC equipment and controls with several locations throughout Southern California, offers HVAC parts, systems, and controls from 197 different HVAC manufacturers alone.[44] Manufacturers whose equipment is distributed and installed in Southern California Edison territory include:

- Baltimore Air Coil
- Carrier
- Coleman
- Emerson Climate Technologies
- Friedrich Air Conditioning
- Goodman
- Honeywell
- Ice Energy
- Johnson Controls
- Lennox
- McQuay
- Mitsubishi
- Panasonic
- Trane
- York

Unlike company-owned HVAC distributors, which tend to only carry their own line of products, wholesale distributors commonly carry multiple manufacturing lines of HVAC equipment, ranging from mechanical system components to building automation controls. While independent wholesalers often "lead" with a specific HVAC brand, many carry at least two other major manufacturing lines to cover the range of sales opportunities in the HVAC market.[45] HVAC distributors in SCE territory include:[46]

- ABCO Refrigeration
- Air Cold Supply

[42] Quantum Consulting (2003), p.9
[43] Carlisle Power Transmission (2003), p.13
[44] Allied Refrigeration website http://www.allied-refrig.com/manufacturers.html
[45] Direct communication with Bob Sundberg, Owner, BNB Consulting Services
[46] Better Buildings Incorporated (BBI, 2008), p. 22

- Allied Refrigeration
- American Refrigeration Supplies
- Baker Distributing
- Charles D. Jones
- Controlco
- CSD Southern California
- FW Webb
- Geary Pacific Supply
- George T. Hall Company
- Global HVAC Distributors
- Heating & Cooling Supply
- Meier Supply
- MSI HVAC
- RE Michel
- U.S. Airconditioning
- West Coast HVAC Supply

While manufacturers do not publish company roles and job responsibilities online or in literature available to the public, independent distributors do. U.S. Airconditioning is an independent wholesale distributor offering 45 HVAC manufacturing brands that is headquartered in City of Industry, California. According to the company's website, the following job titles exist within the distribution segment of the HVAC industry:[47]

TABLE 1-7: HVAC DISTRIBUTOR ROLES

Role	Job Titles	Frequency of References in Literature
Administrative	• Accounts Payable Manager • Credit Manager • Director of Credit • Director of Purchasing	Less Common
Branch Management	• Branch General Manager • Parts Store Manager	
Customer Service	• Customer Assurance Manager • Warranty Representative	Less Common
Company Management	• President/CEO • Vice President	Less Common
Logistics	• Warehouse Manager • Delivery and Transportation Manager	Less Common
Marketing	• Commercial Sales Manager • Residential Sales Manager • Sales Order Manager	Less Common
Training Services	• Technical Trainer	Common

[47] U.S. Airconditioning website http://www.us-ac.com/about_People.asp

2. EXISTING HVAC TRAINING AND EDUCATION INFRASTRUCTURE

As evidenced in the previous section, there is a wide range of roles and tasks in the HVAC industry that require a similarly expansive variety of skills and knowledge. That being said, at present, the majority of HVAC literature focuses on the role of the technician. In the *California Long Term Energy Efficiency Plan*, the CPUC envisions a revitalization of the HVAC industry in which quality installation and maintenance become common practice. A key component identified in achieving this vision is for industry stakeholders to provide increased training and certification opportunities for installation and maintenance technicians.[48]

Research indicates that there are many training options for those who want to enter the HVAC industry and for individuals in the current HVAC workforce who need to update their knowledge or certifications or want to advance their careers. Entry-level HVAC education primarily trains students as installation or maintenance technicians, and is offered through community colleges, technical schools, occupational schools, union apprenticeships, and online programs. The primary focus of mid-level and advanced training is preparing HVAC technicians for certification exams.

There are a wide range of HVAC training categories. In its "Pre-Assessment Inventory", Better Buildings Inc. identifies at least nine types of education currently available to the HVAC workforce:[49]

- **Online Asynchronous, Cohort Group, Instructor Led**: Group of students in same online course with an instructor on a predetermined schedule.
- **Online, Asynchronous, Mentored, Self-Paced**: Individual student enrolled in a course with a predetermined finish with a mentor available.
- **Online Asynchronous, Non-Mentored, Self-Paced**: Archived Webinars, self-study courses.
- **Online, Synchronous, Webinars, Instructor-Led**: Live Webinars.
- **Blended programs using online theory and hands on exercises**: Online program with a mix of hands-on activities.
- **Classroom Style (Lecture)**: Traditional face-to-face seminars, courses of any duration.
- **Laboratory of Field (Hands-On Interactive)**: In-lab or in-field activities that are intended to demonstrate real-world situations and allow practical experience in a controlled environment.
- **Mentoring/On-the-Job-Training**: Real world working conditions supervised by a mentor where practical experience can be applied.
- **Apprenticeship**: Structured program, typically multi-year; can be a combination of face-to-face, online, field/lab, as well as mentoring.

Once a technician has completed an entry-level program, there are a number of certifications and designations administered by trade organizations, unions, and third-party accreditors that measure one's experience and technical expertise. While the focus of this section is education and training, it is vital to understand the certification process since it serves as the keystone of the technician's continued training throughout his career. Technician certifications include such designations as North American Technician Excellence (NATE), United Association (UA) Star, and HVAC Excellence, to name but a few. Certification training programs are offered throughout the HVAC value chain, from manufacturers to

[48] California Energy Commission (2008), p. 6
[49] Better Buildings Incorporated (BBI, 2008) p. 29

distributors, retailers, and trade organizations. Of the 15 HVAC associations and 22 HVAC distributors that Better Buildings Inc. identifies as having operations in Southern California:[50]

- 5 of the 15 trade associations offer online training programs
- 4 of the 15 trade associations offer in-person NATE training
- 2 of the 15 trade associations offer in-person technical training
- 11 of the 22 distributors offer training

While there are many education and training opportunities in the HVAC industry, the depth and quality of programs greatly vary.[51] Moreover, there is a distinct lack of entry- and mid-level training opportunities for roles in the HVAC industry other than installation and service technicians.[52]

2.1. Entering the Industry

2.2.1 School Programs

One traditional path for entering the HVAC industry is enrolling in a postsecondary trade school or community college. Programs at these institutions usually last between six months and two years and are a mix of classroom-based lecture and hands-on field seminar. These programs can lead to a number of careers in the HVAC industry, including design, manufacturing, operation, sales, distribution, installation, maintenance, and repair. For example, graduates of the Antelope Valley College Air Conditioning and Refrigeration Program can pursue the following career paths:[53]

- AC&R Contractor
- Dispatcher
- Manufacturers Service Representative
- Sales Engineer
- Service Engineer
- Service Manager
- Service Technician

Today, there are more than thirty classroom lecture-based educational institutions in SCE territory that offer HVAC training programs. Programs are offered at the following community colleges:[54]

- Antelope Valley College
- Barstow Community College
- Citrus College
- College of the Desert
- Contra Costa Community College
- Cypress College
- El Camino College

[50] Better Buildings Inc. (2008), p. 23
[51] Better Buildings Inc. (2008), p. 18
[52] Better Buildings Inc. (2008), p. 56
[53] Antelope Valley College website http://www.avc.edu/information/catalog/common/documents/ac.pdf
[54] Western HVAC Performance Alliance website: http://www.performancealliance.org/

- Long Beach City College
- Mt. San Antonio College
- Orange Coast College
- Oxnard College
- Palo Verde College
- San Bernardino Valley College

Programs are also offered at public training centers throughout Southern California:

- Abram Friedman Occupational Center
- Baldy View Regional Occupational Center
- Center for Employment Training
- Central County Regional Occupational Center
- East LA Occupational Center
- Harbor Occupational Center
- West Valley Occupational Center

Lastly, someone may decide to attend a private institution for HVAC training. Programs at private schools in Southern California include:

- Ashworth College
- Brownson Technical School
- Charter College
- Community Business College
- Institute for Business & Technology
- Institute of Technology
- Kaplan College
- Mayfield College
- North American HVACR Training
- San Joaquin Valley College

It is evident that there are many educational opportunities for people who want to pursue a career as an HVAC technician in SCE's territory. However, a review of HVAC program curriculums revealed that the depth of programs greatly varies among institutions.[55] A comparison of two HVAC education programs in the Inland Empire illustrates the sharp contrast in the experience and skills graduates gain. The Baldy View Regional Occupational Center is located in Chino Hills and is one of seventy-three Regional Occupational Centers in California that aim to provide career preparation services to public school graduates. Accredited by the Western Association of School and Colleges, Baldy View provides "entry-level and upgraded instruction" in the following in heating, air conditioning and refrigeration topics:[56]

[55] Antelope Valley College website http://www.avc.edu/information/catalog/common/documents/ac.pdf; Baldy View Regional Occupational Center curriculum, http://baldyviewrop.com/students/course_offerings_industry.htm; Brownson Technical School curriculum http://brownson.edu/programs/hvacrefrigeration-and-ddc-technology; LA Trade & Technical College curriculum http://college.lattc.edu/files/2009/04/2011-2012catalog.pdf; Mt. San Antonio College curriculum http://www.mtsac.edu/catalog/2010/section07.pdf; North American HVACR Training curriculum http://www.nahatrainingfacts.com/ac_refrigeration.html

[56] Baldy View Regional Occupational Center website http://www.baldyviewrop.com/students/course_offerings_industry.htm

- Basics of air conditioning
- Fundamentals of heating
- Troubleshooting
- Basic electricity
- Electrical circuits and motors used in refrigeration
- Silver brazing and soldering
- Recovery refrigerant systems

However, Baldy View only offers a single one-semester HVAC training course. The course has no associated certification, so HVAC employers have no means of knowing how qualified and skilled graduates of the course are when they enter the workforce. In contrast, Mt. San Antonio College in Walnut offers a comprehensive two-year HVAC training program, and is the only educational institution in California certified through the Partnership for Air Conditioning, Heating, and Refrigeration Accreditation (PAHRA). The college's HVAC program includes the following courses:[57]

- Technical Mathematics in Air Conditioning and Refrigeration
- Welding for Air Conditioning and Refrigeration
- Air Conditioning Codes and Standards
- Refrigeration Fundamentals
- Electrical Fundamentals for Air Conditioning and Refrigeration
- Heat Pump Fundamentals
- Gas Heating Fundamentals
- Heat Load Calculations
- Commercial Electrical for Air Conditioning and Refrigeration
- Air Properties and Measurement
- Air Distribution Systems
- Advanced Mechanical Refrigeration
- Pneumatic Controls
- Building Automation Systems

In order to graduate, Mt. San Antonio College students have to pass the PAHRA Industry Competency Exam (ICE), which is widely recognized by the HVAC industry as proof that students have the necessary entry-level skills and knowledge to enter the HVAC workforce.[58] However, PAHRA is not the only accreditation agency for postsecondary HVAC programs. HVAC Excellence is a nonprofit, independent third-party accreditor of HVAC educational programs whose mission statement is to improve HVAC competency through validating the technical education process and allowing the public to identify competent technicians.[59] According to the organization's website, there is currently one HVAC education program in SCE territory:

- North American Heating & A/C Training Center in Redlands, CA

[57] Mt. San Antonio College website http://www.mtsac.edu/catalog/2010/section07.pdf
[58] Better Buildings Inc. (2008), p. 53
[59] HVAC Excellence website http://www.hvacexcellence.org/AccreditedPrograms.aspx

2.1.2 Apprenticeships

The second traditional path for entering the HVAC industry is to complete a formal apprenticeship program which normally lasts between three and five years and consists of a combination of in-class instruction and paid on-the-job training. Apprenticeships in Southern California are managed by joint committees that represent the local chapters of the following HVAC unions and organizations:

- Mechanical Contractors Association of America
- Plumbing-Heating-Cooling Contractors National Association
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
- Sheet Metal Workers' International Association (SMWIA)
- United Association of Journeymen (UA)

Multiple reports emphasized that apprenticeships provide much more comprehensive HVAC training and education than community college and private trade school programs.[60] For example, UA apprentices are exposed to five one-year segments of training in different HVAC fields, each of which includes 1,700 to 2,000 hours of on-the-job training and a minimum of 246 hours of related classroom instruction.[61] In its "California Workforce Education and Training Needs Assessment", the University of California at Berkeley's Donald Vial Center on Employment in the Green Economy firmly asserts that apprentices receive the best technical education in the industry: [62]

> Graduates of apprenticeship programs are better prepared to solve problems in the field and have a stronger background to understand changing work specifications and new technologies. Apprentices also have the opportunity to earn a number of certifications throughout their training, which certify their skill level and provide a baseline knowledge that can be built upon through journey upgrade training.

That being said, it appears that simply comparing apprentices to community college or technical school students is problematic because the two education structures put young HVAC workers on very different career tracks. More specifically, apprenticeship graduates are funneled into the large commercial HVAC market because a large number of employers in this segment have collective bargaining agreements with labor unions. [63] What is less clear is to what extent graduates of community college or trade school HVAC programs penetrate the large commercial HVAC workforce, and whether the poor installation and maintenance problems in the residential and small commercial markets are influenced at all by unionized labor.

In conclusion, HVAC industry stakeholders have a range of opinions how to transfer the successes of the apprenticeship system to other industry education and training programs:[64]

- Doug Barnard, HVAC Instructor at Fresno City College (Fresno, CA): "Our trade encompasses such a wide range of skills it is not possible for students to be completely proficient in all areas. I would like to see the contractors encourage their employees of all levels to be more engaged with the various trade organizations which can provide a lot of the continuing training needed by service technicians."

[60] Better Buildings Inc. (2008), p. 31; Donald Vial Center (2011), p. 98; Goldman et al. (2010), p. 6
[61] United Association of Journeymen website http://www.ua.org/apprenticeship.asp
[62] Donald Vial Center (2011), p. 98
[63] Donald Vial Center (2011), p. 98
[64] Turpin, J. (2011), p. 3

- Kevin Livingston, HVAC Instructor at Oconee Fall Line Technical College (Dublin, GA): "HVAC students also need more opportunities to gain real-world work experience, so they can apply what they learn in class in order to become better prepared for employment. We need contractors to help sponsor mentoring programs, internships, and permanent job commitments for our students in air conditioning programs nationwide. While the government can provide a framework for success and recognition for the best of our air conditioning programs, it is up to the private sector to back up our programs and commit to the future workforce we all so desperately need."

  Joanna Turpin, Contributing Editor at Air Conditioning, Heating, and Refrigeration News: "Ultimately, creating an effective future workforce in the HVAC industry is going to require more extensive partnerships between schools, contractors, and manufacturers. Those in industry—contractors and manufacturers—are in a position to provide input on the HVAC skills needed, while schools have the means to tailor their programs to fill those needs. Creating more internships and apprenticeship programs would also help teach real-world skills that cannot be taught in the classroom. In addition, those who have been successful in HVAC could do a better job of promoting the trade in order to get people interested."

2.2 Certification and Accreditation

As HVAC students and apprentices enter the workforce, they have a number of certification testing options to validate their competencies in HVAC work. Training does not stop once students and apprentices enter the full-time HVAC workforce though; there are numerous certifications that require field and classroom training experience, and offer HVAC workers career advancement opportunities in the form of increased wages and job responsibilities. It is important to understand industry certifications in the context of exploring HVAC roles because the certification process has a significant bearing on how HVAC training programs are currently developed.[65]

2.2.1 Technician Certifications

There are numerous certifications for HVAC technicians, each of which is designed to measure a technician's work skills and knowledge. Certification criteria vary by agency in terms of examination format and required field experience.

Industry Competency Exam (ICE) [66]

The Partnership for Air-Conditioning, Heating, and Refrigeration Accreditation (PAHRA) is an independent, third-party organization that connects HVAC educators and the industry stakeholders by awarding accreditation to programs that prepare students to be able to succeed in the HVAC workforce. PAHRA's main goal is to improve the quality of training offered at all levels of HVAC education.

In order to become PAHRA accredited, an HVAC education program must administer the Industry Competency Exam (ICE) to students as a graduation requirement. The ICE measures basic competency of entry-level technicians who have one year or less of field experience. The ICE is supported by a number

[65] Interviews with Paul Kyllo and Mel Johnson, SCE HVAC program managers
[66] PAHRA website http://www.pahrahvacr.org/Content/WhatIsPAHRA_32.aspx

of HVAC organizations, including Air Conditioning Contractors of America (ACCA), Heating, Air Conditioning & Refrigeration Distributors International (HARDI), North American Technician Excellence (NATE), Plumbing, Heating, and Cooling Contractors Association (PHCC), and Refrigeration Service Engineers Society (RSES). Three separate ICE exams are offered:

- **Residential Air-Conditioning and Heating**: focuses on equipment up to 72,000 Btuh (6 tons); 3.5-hour exam (35 minutes per section, timed)
- **Light Commercial Air-Conditioning and Heating**: focuses on equipment up to 360,000 Btuh (30 tons); 2-hour exam (100 questions)
- **Commercial Refrigeration**: focuses on refrigeration equipment; 2-hour exam (100 questions)

North American Technician Excellence (NATE)[67]

North American Technician Excellence (NATE) is considered to be the industry-wide accepted certification for residential and small commercial HVAC maintenance. In fact, NATE recently received ANSI/ISO/IEC 17024 certification. ANSI, which stands for the American National Standards Institute, has served as the coordinator of the voluntary standardization system for the U.S. private sector for more than 90 years. UA STAR is the only other HVAC certification to achieve this. To become NATE-certified, technicians must pass a core and specialty test. The core test covers general knowledge, construction knowledge, and HVAC specific knowledge in the areas of safety skills, tool skills, soft skills, heat and transfer comfort, and electrical systems. The specialty test covers installation, service maintenance, and repair of HVAC systems. NATE requires recertification every five years, which entails 60 hours of continuing education courses. Technicians have the following choices for the service maintenance specialty exams:

- Air conditioning service
- Air distribution service
- Air to air heat pump service
- Gas heating (air) service
- Oil heating (air) service
- Hydronics gas service
- Hydronics oil service
- Light commercial refrigeration service
- Commercial refrigeration service

One portion of the core NATE requirement covers the technician's role in sales as follows:

- Determining technician involvement in sales
- Determining customer needs
- Understanding features and benefits
- Making a good sales presentation
- Understanding customer sales requests
- Planning reaction to sales requests
- Importance of accurate and crisp communication

At present, there are 195 contractors in SCE territory that have at least 50 percent of their technicians NATE certified.[68] In terms of individual technicians, there are currently 1,1017 and 2,142 NATE-

[67] NATE website http://www.natex.org/

certified technicians in SCE territory and California respectively.[69] While the NATE exam is not designed to pass 100 percent of those who take it – only 69 percent of the 19,000 candidates (nationally) that sat for a NATE exam in 2010 passed – HVAC literature indicates that NATE-technicians are not yet widely available in California.[70]

HVAC Excellence[71]

HVAC Excellence is a nonprofit, independent third-party accreditor of HVAC educational programs with the goal of improving competency through validating the technical education process and allowing the public to identify competent technicians. The organization offers two levels of technician certification: Professional and Master Specialist. Professional Level Certifications are earned by passing a closed-book comprehensive exam and require at least two years of verified field experience. Master Specialist Certifications entail passing the same written exam, but require a minimum of three years of verifiable field experience. Areas of certification include:

- Residential Air Conditioning
- Gas Heat, Oil Heat
- Heat Pumps
- Light Commercial Air Conditioning
- Light Commercial Refrigeration
- Low Pressure Hydronic Heat
- Combustion Analysis

U.A. STAR[72]

The United Association of Journeyman and Apprentices' (UA) STAR Certification requires that technicians complete five years of training as an apprentice and pass the UA certification exam. The STAR certification also earns technicians 30 college credits toward an Associates Degree in HVACR or Construction Supervision. Technicians are prepared for the UA STAR certification exam throughout their five-year apprenticeship, and are tested in the following topics:

- Mechanical Systems
- Electrical Systems
- Controls
- AC & Refrigeration
- Heating
- Steam Systems
- Plumbing
- Ventilation
- Piping
- Lifting Equipment
- Safety
- Mathematics
- Customer Service

[68] Direct communication with Kathy Corr, Director of Strategic Relationships, NATE
[69] Direct communication with Dale Gustavson, President, Better Buildings Inc.
[70] Better Buildings Inc. (2008), p. 52
[71] HVAC Excellence Website http://www.hvacexcellence.org/Certifications.aspx
[72] U.A. STAR website http://www.uastar.info/hvacr_contractor.htm

Building Performance Institute (BPI) Certification[73]
While not accepted industry-wide like the NATE certification, Building Performance Institute (BPI) is in the process of getting accredited by American National Standards Institute (ANSI). According to BPI's website, the value of being a BPI Certified Professional is:

- Understanding the relationship between all the systems in the house and its effect on occupant health, safety and comfort, energy efficiency and durability
- Finding the real problem and fixing it, instead of putting a bandage on one of the symptoms
- Getting the edge over low-bid contractors
- Assuring customers that their work was done right the first time

The following professional designations are offered through BPI certification:

- **Building Analyst –** go beyond a traditional energy audit to perform comprehensive, whole-home assessments, identify problems at the root cause and prescribe and prioritize solutions based on building science.
- **Envelope –** quantify performance and prescribe improvements to help tighten the building envelope (shell), stop uncontrolled air leakage and optimize comfort, durability and HV/AC performance.
- **Manufactured Housing –** apply house-as-a-system fundamentals to the specific needs particular to the various types of housing technologies.
- **Heating –** optimize the performance of heating equipment to help save energy and ensure occupant comfort, health and safety.
- **Air Conditioning and Heat Pump –** understand the role of these systems within the whole home and how to diagnose and correct problems properly to achieve peak performance.
- **Multifamily –** apply building-as-a-system fundamentals to diagnose problems and improve the performance of larger, more complex residential structures.

National Comfort Institute (NCI)
The National Comfort Institute is a national training organization whose stated goal is to help HVAC and Plumbing contractors transform their businesses, improve their bottom line and deliver outstanding service to their customers. According to NCI's website, they work towards accomplishing this objective by focusing on the delivery of true heating and cooling system performance in the systems our contractors design, sell, install, and service. NCI offers diagnostic and air balancing courses that aim to help contractors understand how air pressure and air flow control true comfort.

AABC[74]
The Associated Air Balance Council (AABC) is a non-profit association of qualified, independent test and balance agencies. AABC's National Standards were the industry's first comprehensive standards for field measurement and instrumentation. The AABC Technician Certification Program requires that technicians have at least four years of test and balance experience, can demonstrate competency in air, water, sound, and vibration testing, and can perform all work in accordance with the AABC National Standards.

[73] Better Performance Institute Website http://www.bpi.org/professionals_designations.aspx
[74] AABC website http://www.aabc.com/about/

NEBB[75]
The National Environmental Balancing Bureau (NEBB) is an international certification association for individuals and firms that deliver high performance building systems. Members perform testing, adjusting and balancing of heating, ventilating and air-conditioning systems, execute sound and vibration testing, and test and certify laboratory fume hoods and electronic and biological cleanrooms.

According to NEBB, certified professionals must be able to accurately measure the efficiency of building systems, and must have strong communication skills to create practical solutions for business owners. Individuals must pass required testing in order for their firm to be NEBB certified in one of the following disciplines:

- Building Systems Commissioning
- Building Envelope Testing
- Cleanroom Performance Testing
- Retro-Commissioning
- Sound and Vibration Measurement
- Testing, Adjusting, and Balancing

2.2.2 Union Journeyman Designations

For union apprentices, there are two primary types of designations that demonstrate an individual has successfully completed an apprenticeship and is able to work unsupervised. While the United Association's STAR program is open to non-union pipefitters, there are few non-union holders of the certification.[76] That being said, the STAR certification is different from journeyman status in the union. Only UA members can become journeymen, which are required to complete their initial training as apprentices and adhere to the union's ongoing training requirements and membership guidelines.

SMWIA Journey Card[77]
Like UA journeymen, Sheet Metal Workers International Association (SMWIA) members who complete an HVAC apprenticeship receive the designation of "journeyman", which ensures that they are competent according to SMWIA's standards. ANSI, the American National Standards Institute, has accredited SMWIA as an HVAC standard-setting organization, which means all SMWIA apprentices must be fully competent in their organization's standards before working alone.

2.2.3 Contractor Certifications

In addition to the array of certifications available to individual technicians, HVAC contractors have a number of certification options to easily build trust with customers and expand their clientele. According to a survey by *Contracting Business* magazine, 87 percent of customers prefer a certified HVAC technician to a non-certified technician to service their heating and cooling systems. And of this 87

[75] NEBB website http://nebb.org/index.php?option=com_content&view=article&id=57&Itemid=72&PHPSESSID=7d6ac5ba00497271ba4bfe8aefb32d96
[76] Direct communication with Dale Gustavson, President, Better Buildings Inc.
[77] Sheet Metal and Air Conditioning Contractors' National Associationhttp://www.smacna.org/technical/

percent, more than half said they have purchases, upgrades or retrofits they would like to make but are delaying because they do not know a reliable contractor.[78]

MSCA STAR[79]
Mechanical Service Contractors of America (MSCA) STAR is a certification program recognizing non-residential HVACR contractors that have demonstrated industry-leading practices in education, safety, customer service, training, and operations. MSCA STAR assures building owners that they are working with contractors whose references and work history have been independently verified, and the contractors' safety records are well documented and held to the highest industry standards.

MSCA STAR certification requires the following key competencies:

- Proven track record in HVACR or plumbing service business
- Involvement in the industry for a minimum of five years
- A minimum of 25 percent of the service technicians hold UA STAR certification
- Documented service safety and health program and maintain an outstanding safety record
- Ongoing educational training is provided to employees
- Employees attend at least one MCAA or MSCA sponsored national or local program each year
- An established truck inventory control system and major tool inventory program
- Photo ID cards must be worn by all field personnel so that technicians are easily recognizable
- The highest level of customer service is maintained

NATE C3[80]
The North American Technician Excellence Customer Connection (C3) Program is for contractors who have at least 50 percent of their technician workforce NATE certified. Advantages of the C3 Program include contractors being able to display the NATE logo on all of their promotional materials and free advertising via the NATE website.

NBC[81]
The National Balancing Council (NBC) is a professional organization that provides standards and procedures for companies who are engaged in testing, balancing, and adjusting air and hydronic systems in commercial building environmental systems. Companies seeking NBC certification must have been in business for a minimum of one year prior to applying and must employ at least one full-time technician who is qualified to be designated as an NBC Supervisor. Candidates for Certified Balancing Supervisor must have four years of demonstrable experience in commercial air and hydronic testing and balancing, or two years experience combined with completion of a recognized testing and diagnostic training course. NBC certification is valid for two years and recertification must be completed prior to the original certification's expiration.

2.3 Career Advancement through Continued Training

As stated before, training and education does not end when an HVAC technician enters the workforce. In the course of preparing for any of the certifications described in the previous section, technicians and

[78] NATE website www.natex.org
[79] MSCA STAR website http://www.mscastar.org/starForCustomers.php
[80] NATE Website http://www.natex.org/contractors/consumer-connection/
[81] NBC website http://www.nbctab.org/index.cfm?p=page&id=21

contractors have an array of training options to choose from. That being said, the overall effectiveness of mid-level HVAC training is not well understood.

2.3.1 Computer-Based Training

In recent years, software- and internet-based training has increasingly been used in the HVAC industry as an educational tool.[82] Interactive software programs allow students to proceed through an established curriculum at their own pace, whenever they choose, and also to continue to use course materials as a convenient reference after course completion. Internet-based programs have the added advantages of easy wide-scale distribution and high-speed access to information through a range of web-based forums, such as virtual classes, discussion groups, interactive video, simulations, and chatting. HVAC students who complete computer-based education programs can study at their own pace at home, eliminating the financial and time costs of travel to classroom-based institutions.

Online programs available in Southern California include:[83]

- 360 Training (www.360training.com)
- ASHRAE Learning Institute (www.ashrae.org/education)
- Air Conditioning Contractors of America ComfortU (www.acca.org/comfortu/)
- American TrainCo (www.americantrainco.com/default.aspx)
- Association of Energy Engineers (www.aeecenter.org/training)
- Fluid Market Strategies (fluidms.com)
- Penn Foster Workforce Development (http://www.workforcedevelopment.com/)
- Ed2go (http://www.gatlineducation.com/hvaccertification.htm)
- GreenCollar Edu (HVACRedu.net)
- VGI Training (http://www.vgitraining.com)

GreenCollarEdu.net

GreenCollarEdu.net was founded in 1998 as a professional organization of HVAC educators working together to provide challenging and comprehensive online assessments, reviews, courses, and programs for the HVAC industry. The Program's primary goals are to help HVAC technicians prepare for a successful certification and licensing exams to be able to advance their careers. The online curriculum consists of a mix of beginner and advanced HVAC courses, all of which are aligned with the National Standards for HVACR education and the Home Performance industry as dictated by numerous industry groups, such as ANSI/ACCA Quality Standards, AHRI, BPI, PAHRA, PHCC, and RSES. Furthermore, the Program's curriculum is recognized by NATE and BPI to be applicable to each organization's certification and re-certification training requirements.

GreenCollar Edu's courses are open-entry, self-paced, and open-exit. A student has access to each course for 60 days and can spend as much time as he needs on a certain subject or can move along more quickly. The institute does provide instructor support; at the beginning of each course, students are assigned to an Instructor who can be accessed via e-mail and responds to questions within 24 hours. In terms of presentation, course materials include text reading assignments, website tours, applied exercises, online

[82] Better Buildings Incorporated (BBI, 2008), p. 26
[83] Western HVAC Performance Alliance website http://www.performancealliance.org/HVACTraining/PrivateSchools/tabid/235/Default.aspx

quizzes, industry terminology definitions, video clips, animations, and images and downloadable/printable handouts. Each module concludes with a 20-question exam, and a course concludes with a 25 question comprehensive final exam. A minimum passing score of 75 percent is required for successful course completion. HVAC training programs that are offered at HVACRedu.net include:[84]

- **HVACR Core Technician Program:** This is a comprehensive HVACR training program encompassing heating, ventilation, air conditioning, and refrigeration. It is specifically structured to enrich the skills of installers and technicians who are either just beginning in the HVACR industry, continuing education for upgrading knowledge and skills, or preparing for NATE or ICE certifications.

- **HVACR Technician Essentials Program:** This is a comprehensive online HVACR education program encompassing heating, ventilation, air conditioning, and refrigeration. In addition to the rich selection of basics courses, each technician may choose their last course to be either 103 Basic Sheet Metal, or 191 Hydronics. This flexibility allows the student to focus on knowledge used in their line of work or home geographic area. It is specifically structured to provide a well-rounded introduction of the basic skills of installers and technicians who are either just beginning in the HVACR industry, continuing education for upgrading knowledge and skills, or preparing for HVAC Excellence Work Ready Exams, or NATE Service certification.

- **HVACR Wholesale Employee Training**: This comprehensive online education program is designed to provide the knowledge and skills needed by people working in the HVACR Wholesale Distribution Industry. The goal of this program is to increase the Wholesale Employee's basic understanding of the industry and HVACR systems in general, so they can sell, serve, and communicate with their contractor customers more effectively.

- **ANSI Quality Standards Program:** This program instructs professional HVAC technicians in the common service procedures performed on conventional residential/light commercial cooling systems. HVAC contractors and technicians qualify their knowledge in four critical areas that support the Quality Installation & Maintenance of residential and light commercial air conditioning and air source heat pump systems: Air Flow, Equipment Sizing, Refrigerant Charging, and Duct Sealing.

- **Building Automation Systems Program (Controls)**: This provides entry-level knowledge for those aspiring to become Direct Digital Controls (DDC) Technicians. It starts with the fundamentals of building controls and then works through general web based DDC networking knowledge. Next, it is on to control drawing fundamentals and a simulated Graphic User Interface (GUI) used to practice troubleshooting and DDC point identification. Finally, students are introduced to some common types of DDC programming. The last two courses of the program allow students to practice applying DDC technology to common pieces of commercial HVAC equipment.

The programs consist of a selection from the following courses, each of which is composed of at least 18 hours of instruction:

- HVACR Fundamentals

[84] GreenCollarEdu website http://www.greencollaredu.net/Master_catalog.pdf

- HVACR Safety
- HVACR Basic Sheet Metal
- Copper Works
- HVACR Electrical DC Theory Plus
- Indoor Air Quality Basics
- Principles of Building Science
- Performing the Comprehensive Building Assessment
- HVACR Electrical AC Theory Plus
- HVACR Systems Air Properties and Measurement
- HVACR Oil Heat I
- HVACR Gas Heat I
- HVACR Heat Pump/Air-to-Air
- HVACR Refrigeration I
- Building Automation Systems I
- HVACR Boilers I
- HVACR Boilers Low Pressure License Prep
- HVACR Hydronics I
- HVACR Electrical Common Components
- Economizer
- HVACR Electrical Motors
- HVACR Systems II, Load Calculations
- HVACR Air Distribution
- HVACR Oil Heat 2
- HVACR Refrigeration II
- HVACR Into to Cooling System Troubleshooting
- HVACR Advanced Troubleshooting
- Building Automation Systems II
- Building Automation Systems DDC Networking I
- Building Automation Systems DDC Networking II
- Building Automation Systems GUI Points
- Building Automation Systems Basic DDC Programming
- Refrigerant Technology for HVACR Technicians

2.3.2 The Institute of Heating & Air Conditioning Industries (IHACI)

The Institute of Heating & Air Conditioning Industries (IHACI) is an HVAC trade association that provides training at California IOU facilities to prepare students for NATE certification. A partnership between Southern California Edison, San Diego Gas and Electric, Southern California Gas, and IHACI resulted in 15,000 technical trainees in 2010.[85] In 2012, IHACI is offering training programs at Southern California Gas, Southern California Edison, and San Diego Gas and Electric facilities. SCE's Energy Education Centers in Irwindale and Tulare are hosting six "California Quality Installation, Maintenance and Service" courses and two "NATE Training" courses over the course of the year.[86]

[85] Engage 360 (2010), p.22
[86] IHACI, "2012 Training Class Schedule"

2.3.3 Distributor Training Programs

As stated before, wholesale distributors of HVAC equipment, controls, and diagnostics offer training programs for contractors in Southern California in addition to their equipment distribution services.

HARDI
Heating, Air Conditioning & Refrigeration Distributors International (HARDI) represents over 450 wholesale HVAC distributors, who account for 80 percent of the dollar value of the HVACR products sold through distribution. HARDI offers an online education program with the goal of providing up-to-date training courses for HVACR industry employees outside the confines of a physical classroom. Class prices range from $85 to $200, and include:[87]

- **Wholesaling 101 For HVACR Distributor Personnel**: Helps participants develop an understanding of the HVACR wholesale distribution business focusing on the following areas: the makeup and purpose of a marketing channel, warehouse operations, the impact of regulations on the wholesale business, the functions performed by traditional HVACR distributors, and wholesale sales and the customer.

- **Introduction to Comfort Cooling**: Provides an overview of the how and why of mechanical cooling. Discusses basic cooling concepts and operating principles of air conditioning units. The course is tailored for those who are new to cooling and sales personnel who could benefit from a review of factors affecting heat gain, controls, duct systems and balancing for small central cooling applications.

- **Principles of Heating & Cooling Controls**: Learn to trace HVACR control wiring circuits, trace electrical control diagrams, understand control terminology, and troubleshoot control problems. Servicing and circuit checkout procedures are detailed for gas/oil equipment and air conditioning controls.

- **Counter Service & Sales**: Discusses the duties and responsibilities of HVACR wholesale counter sales personnel. Topics include getting along with customers, counter sales merchandising, processing sales, handling defective/return goods and the importance of catalogs.

- **Small Heating & Cooling Systems - Course 1 General Installation Practices**: Provides background information on most common installation requirements for small heating and single-phase air conditioning systems. Lessons cover wiring and controls sequence, start up and balancing, heat pumps, and air side issues.

- **Small Heating & Cooling Systems - Course II General Service Procedures**: Lessons cover diagnosing poor performance, furnace checkout, fundamentals of evacuation and dehydration, refrigerant recovery, motors, checking and replacing compressors, servicing cooling towers, and safety.

U.S. Airconditioning
U.S. Airconditioning, a wholesale HVAC distributor in Southern California, offers three-hour service training seminars at its City of Industry facility for $45 each. The following training courses related to air conditioning service are offered in 2011-2012:[88]

[87] HARDI website http://www.hardinet.org/aws/HARDI/pt/sp/independentstudy_courses
[88] U.S. Air Conditioning website http://www.us-ac.com/dealerInfo_training.asp#2

- **Residential Airflow & Distribution**: Covers the basics of airflow, duct sizing, layout, and diagnosing airside systems.

- **Mitsubishi Mr. Slim:** Provides the participant with a brief overview of information required for designing, installing, commissioning and servicing Mr. Slim M&P series systems. Objectives include: a description of equipment components, refrigerant flow, appropriate tubing requirements, high and low voltage wiring, internal electrical circuits, typical operation, pressure and temperature reading and voltage measurements during a system check of the Mr. Slim system.

- **Air Conditioning Mechanical Troubleshooting:** Cover diagnostic troubleshooting of mechanical refrigeration systems.

- **Refrigerant Charging Techniques:** Covers procedures for correctly charging systems. With the introduction of Micro Channel Condensing coils and the changeover to R410A refrigerant, the charging procedures are considerably more critical. Course also reviews evacuation and dehydration procedures as they relate to R410A refrigerant and synthetic oils.

Sigler Controls[89]
Sigler Controls is a wholesale HVAC distributor with locations throughout the southwestern United States. The company specializes in Carrier residential and commercial systems, including rooftop and split system air conditioning units, and provides HVAC and building automation systems for both Carrier and non-Carrier systems and projects. Sigler offers ongoing training throughout the year on Carrier CCN and Carrier Open BACNET control technologies.

2.3.4 Manufacturer Training

In addition to distributors and trade associations, manufacturers offer a number of training opportunities for HVAC distributors and contractors.

Honeywell Homes and Building University[90]
Honeywell offers online and classroom-based training for its residential and commercial HVAC automation and component control products. Participants have the option to attend a three-day training program for either course in Golden Valley, Minnesota, or can subscribe to an online program that covers the same subject matter. The program aims to teach managers, sales, counter staff, and installers to sell appropriate Honeywell product features and benefits, install and wire products correctly, and identify opportunities to meet the needs of today's consumer. Emphasis is also placed on personal and business growth through sales scenarios, decision-making and team building exercises. The “Homes University” training program covers the following product information:

- IAQ Industry Overview
- Air Cleaners
- Humidifiers
- UV Treatment Systems

[89] Sigler Controls Website http://siglercontrols.net/images/stories/docs/2011training.pdf
[90] Honeywell University Website http://customer.honeywell.com/Business/Cultures/en-US/Training/Homes/Default.htm

- Ventilation Systems
- Thermostats
- Zoning

Honeywell technical product specialists and HVAC industry experts teach each course with a mix of lecture, discussion, hands-on lab exercises, and advanced multimedia presentation. Participants receive a set of reference materials to take back to their offices, including a training program binder, class notes and lab exercise materials, product samples, support materials CD/DVD.

Carrier[91]

Carrier, through the brand "Carrier University", provides technical, system design, and professional accreditation training to HVAC industry professions such as designers, contractors, engineers, dealers, distributors, technicians, operators, maintenance personnel, and building managers. Carrier University offers three online courses and over forty classes at Carrier facilities in New York, Oklahoma, and Tennessee.

Two classroom-based courses include B.A.S.I.C. and i-Vu Open VVT Controls:

1. B.A.S.I.C. is designed to help entry-level HVAC residential technicians with minimum training or field experience become a useful and profitable member of an installation team. The class lasts for four days and is a combination of classroom and hands-on training. B.A.S.I.C. provides practical hands-on training to show students the right way to install and start residential equipment to promote customer satisfaction and eliminate costly callbacks. Course objectives include:

    - Describe fundamental HVAC system concepts
    - Plan an installation
    - Use common heating and cooling tools and test equipment
    - Use refrigerant P/T charts
    - Calculate superheat and subcooling
    - Describe furnace venting issues
    - Check duct size in forced air duct systems and describe installation issues
    - Read wiring diagrams (to install and hook-up power and control wiring)
    - Develop customer relation skills
    - Identify EPA certification tips
    - Model appropriate safety precautions

2. i-Vu Open VVT Controls covers Carrier's new line of i-Vu Open controls DDC controls, which allow for easy integration on many HVAC systems. This course covers the use of the i-Vu open controls system when used with Variable Volume Variable Temperature (VVT) systems. Participants will learn the proper design, application installation, and configuration, start-up, wiring of a VVT system using a UCXP controller and VVT Zone Controller. Course objectives include:

    - Identify on a diagram the control components of a VVT system
    - Describe zoning constraints for a VVT system and using a floor plan properly select VVT zones
    - From memory sketch a typical VVT system and label components

[91] Carrier University Website http://www.carrieruniversity.com/

- Using the design checklist identify proper VVT design criteria
- Describe the building applications for VVT and explain changeover for a VVT system
- Design a system network riser diagram layout for a typical VVT system with RTU and develop a bill of material using VVT project builder
- Using a simulator configure appropriate linkage parameters to commission a system
- For a sample project determine what configuration essentials are required for VVT system operation

Carrier University's most popular online class is the interactive NATE Core Exam Online Prep Course. The course is designed around topics found on the actual NATE core exam, and is designed to prepare HVAC technicians for the 50 questions drawn from NATE's bank of over 5,000 questions, covering topics such as:

- Communication skills
- Mathematics
- Personal ethics and conduct
- Fabrication tools
- Safety
- Basic construction designs
- Heat transfer and comfort

The training focuses most heavily on those areas that test takers typically have the most difficulty: electricity and motors. The course is suited for both first-time certifying technicians and NATE-certified technicians who are trying to become recertified.

Trane[92]

Trane offers HVAC clinics at factory facilities across the country that cover topics such as:

- Air Conditioning Service: Factory Training
- Commercial Systems Service
- HVAC Electrical Troubleshooting
- Cooling and Heating Load Estimation
- HVAC For Facility/Property Managers
- HVAC Maintenance Series #4: Preparing for Winter
- Indoor Air Quality
- HVAC Motor Fundamentals

There are five Trane facilities in California, located in Sunnyvale, San Francisco, Fresno, Rocklin, and the City of Industry. These locations offer the following HVAC clinics:

- Boiler Operation and Maintenance
- Cooling Towers, Evaporative Condensers, and Water Treatment
- Heat Pumps for Service Contractors
- HVAC Systems and Service for Service Contractors and Maintenance Supervisors
- EPA Certification- Section 608
- R-410A Refrigerant Safety and Certification

[92] TRANE website http://www.trane.com/COMMERCIAL/Training/EventsList.aspx?i=696

- Rooftop Heating
- VAV (Variable Air Volume) Systems
- Light Commercial Rooftop Heating Systems

3. KEY HVAC WORKFORCE EDUCATION AND TRAINING (WE&T) THEMES AND KNOWLEDGE GAPS

In the course of identifying HVAC roles and training programs within Southern California Edison's service territory, several key themes and knowledge gaps were highlighted in HVAC literature. These themes include the existence of multiple HVAC labor markets (residential, small commercial, and large commercial) and known technical performance issues in existing HVAC systems. Important knowledge

gaps include widespread technician-oriented training and the unknown impacts of new types of training like online programs.

3.1 HVAC WE&T Themes

The following themes were identified in the literature as contributing to the current lack of widespread quality installation and maintenance practices.

3.1.1 Multiple HVAC Markets

At present, research indicates that a major obstacle to increasing energy savings in the HVAC sector is the poor quality of installation and maintenance in residential and small commercial HVAC buildings. [93] According to the University of California at Berkeley's Donald Vial Center on Employment in the Green Economy, the residential and small commercial HVAC markets contain many contractors who perform poor HVAC installation and maintenance because they gain a competitive advantage through cutting costs. In contrast, quality installation and maintenance practices are more common in the large commercial and industrial HVAC market because large commercial and institutional building owners or property managers often tend to understand the payback benefits of properly installed and maintained equipment, and thus are willing to invest in high quality work up front.

While current HVAC literature does clearly identify the differences between the residential and large commercial HVAC markets and the problems associated with installation and maintenance practices in each market, there is minimal informational about the structure of and problems in the small commercial HVAC market. The following characterizations about the residential and large commercial HVAC markets have been identified in HVAC literature:

Residential:

- The residential HVAC market is highly competitive and price-driven. Barriers to entry for firms in the market are fairly low, but an estimated 25 percent of all HVAC firms go out of business in a given year. This appears to undermines professionalism and regulatory compliance. [94]

- Customers have difficulty in distinguishing among contractors on the basis of quality because many of the attributes that contribute to energy efficiency—such as unit sizing, duct sealing, airflow, and refrigerant charge—cannot be easily appraised. As a result, homeowners often assume that all contractors will provide the same degree of quality in their respective installations, and therefore rely on simple price comparisons in choosing an HVAC contractor.[95]

- Contractors committed to quality practices often do not or cannot easily point out specific benefits of their "quality installation" and the issues, problems and costs that result from poor quality installation at once or in the future. According to the Donald Vial Center, these contractors charge homeowners 40 percent more for quality installation services than the average contractor, which is significant disadvantage in the highly price-driven market.[96] .

[93] Davis Energy Group (2010), p. 1; Donald Vial Center (2011), p. 100
[94] Donald Vial Center (2011), p. 93
[95] Direct communication with Bob Sundberg, Owner, BNB Consulting Services
[96] Direct communication with Bob Sundberg, Owner, BNB Consulting Services

Large Commercial:

- Larger firms serving the large commercial markets tend to be more stable, adhere to existing standards, invest more time in the sales process identifying the key benefits to their proposed solution and compete on the basis of quality. [97]

- The more complex technical requirements and sheer size of larger buildings require that firms have higher levels of technical expertise and greater capital investment in equipment. These factors make it difficult for firms to start up without a great deal of experience, training investment, and initial capital. [98]

- In many cases, large commercial building owners are also very knowledgeable and concerned about the energy consumption in their buildings and they may have a dedicated energy management staff. Overall, the value proposition of HVAC installation and maintenance is completely different between commercial and residential customers. Commercial customers often utilize sophisticated modeling tools to understand the long-term cost savings of quality HVAC services, whereas residential customers commonly only focus on the upfront costs of HVAC service. [99]

As a result, training and education needs appear to be much different between the residential/small commercial and large commercial segments of the HVAC market. However, the Donald Vial Center's treatment of the residential and small commercial HVAC sectors as a single market contradicts SCE's expressed interest in examining educational needs of workers in the residential, small commercial, and large commercial markets separately. That is not to say that the Donald Vial Center's conclusions are wrong, but rather to emphasize the need for further research.

3.1.2 Identified HVAC Performance Issues

Oversizing

Equipment oversizing was identified as the most significant issue in residential HVAC installations that is currently prohibiting maximum energy savings.[100] It is estimated that 70 percent of air-conditioned homes have units that exceed the home's cooling needs.[101] Units that are too large have a greater impact on peak demand since they will technically have shorter run times due to oversizing and will use the same kilowatt-hours as a properly sized system.[102] In addition, these units will cost more to run, and have shorter operational lives due to undue stress on components. While HVAC technicians are supposed to know how to properly perform residential load calculations as outlined in ACCA Manual J, many do not know how to correctly use ACCA's technical manuals. Oversizing occurs for the following reasons:[103]

[97] Donald Vial Center (2011), p. 93
[98] Donald Vial Center (2011), p. 93
[99] Direct communication with Bob Sundberg, Owner, BNB Consulting Services

[100] Butler, D. (2009), p. 4
[101] Southern California Edison AC Quality website http://www.ac-quality.com/homeowners/qi
[102] Direct communication with Paul Kyllo, SCE HVAC Program Manager
[103] Butler, D. (2009), p. 6; Direct communication with Bob Sundberg, Owner, BNB Consulting Services

- **Fear of undersizing: "**Homeowners often falsely believe that their HVAC system is too small and complain to contractors. Comfort complaints account for more callbacks than any other issue in new construction. Contrary to popular belief, undersized equipment is rarely the problem. The major culprit is usually poorly designed and constructed ducts. Whether consciously or not, HVAC contractors tend to compensate for substandard workmanship by oversizing the source equipment."

- **Incorrect rules of thumb: "**Many HVAC contractors size by rules of thumb developed decades ago when homes were far less efficient. Many who use software-based load calculation tools do not completely trust the results, and round up at every chance to protect against undersizing."

- **Contractors often use worst-case assumptions: "**Equipment is typically sized during the estimation process before the job is secured. At this point, it is hard to justify the time required to accurately model a home. Rather than tracking down detailed window, orientation and other construction details, most HVAC estimators use worst-case assumptions, resulting in larger equipment than necessary. Once a job is secured, it is rare that the contractor will go back to fine tune the load analysis."

- **Lack of knowledge about oversizing: "**Few builders understand the importance of proper sizing and those who are aware that oversizing is a problem are hesitant to push too hard."

- **Quality is disadvantaged in price-driven market: "**Consider the HVAC contractor who hires top-notch labor and follows best practices. In all likelihood, his bids will be higher and his systems smaller than the competition. Despite all efforts to convey his value proposition, this contractor routinely loses jobs to installers who do only what is required to meet code. Moreover, many of these low-cost contractors do not pull permits that would trigger installation inspections, which puts the quality contractor at a further disadvantage."

- **Manufacturers only offer products with fixed capacity: "**Air conditioning equipment most commonly is only offered in fixed capacity (tons). In other words, systems are only produced by incremental tonnages, such as 2, 2.5, 3, or 4 tons. If these units would be capable of delivering variable capacity to meet demand while maintaining high efficiency, slight over-sizing would be less of an issue.

Other Technical Issues Impacting HVAC Performance

Additional performance problems in HVAC systems are highlighted in a study conducted by New Buildings Institute (NBI) that reviews recent commercial rooftop unit field studies in the Pacific Northwest and California. The primary objective of the study was to aggregate the results of four recent investigations into operational efficiencies of packaged rooftop heating, ventilation and air conditioning units and to suggest recommendations for programmatic approaches to capture energy savings potential.

NBI concludes that all of the field studies found the following similar problems occurring with similar frequencies:[104]

1. Refrigerant Charge

[104] National Buildings Institute (NBI, 2004), p. 3

- Refrigerant charge was found to be out of range on an average of 46 percent of the units tested.
- Estimates of energy savings associated with correcting the refrigerant charge range from 5 to 11 percent of the cooling energy and are highly dependent upon how far out of spec the charge is.

2. Economizer
   - Economizers failed or required adjustment on an average of 64 percent of the units for all of the studies.
   - Estimates of energy savings associated with repairing a failed economizer range from 14 to 40 percent of the cooling energy between the different studies.
   - Common failure modes included:
     - Broken, frozen or missing drive system components
     - Outside air or mixed air sensor failure
     - Faulty repairs
     - Low changeover temperature set point

3. Airflow
   - Airflow was found to be out-of-range on an average of 42 percent of the units tested.
   - Estimates of energy savings associated with the correcting airflow range averaged around 10 percent of the cooling energy.

4. Thermostats
   - Problems were found with the thermostats on an average of 58 percent of the units tested.
   - Savings from thermostat corrections range up to 40 percent of the cooling energy.
   - Thermostat problems included:
     - Improper thermostat (single-stage cooling only)
     - Cycling fans during occupied periods
     - Continuous fans during unoccupied periods
     - Improperly installed resistors
     - No nighttime setup or setback

5. Sensors
   - Sensors were problematic in approximately 20 percent of the units tested.
   - Savings may be modest by replacing a snap disk to one that raises the economizer changeover set point or may be on the order of 40 percent if it enables a nonfunctioning economizer.
   - Problems included:
     - Failed sensors
     - Snap discs that cannot be calibrated or adjusted.
     - Broken wires As with thermostats, the energy savings for repairing failed sensors varies greatly.

3.2 HVAC Knowledge Gaps

In contrast to the themes discussed in the previous section, knowledge gaps refer to specific areas in HVAC education and training that are identified in HVAC literature as needing to be addressed for HVAC students and workers to be able to better perform installation and maintenance procedures.

3.2.1. Expanding Beyond Technician-Oriented Training

The majority of HVAC education programs in SCE's territory focus on providing technicians with technical training. What is much less clear is the extent to which other roles in the HVAC industry, such as customer service staff, sales staff, project managers, and building officials, impact quality installation and maintenance practices and if the training they receive enables them to do their jobs successfully.[105]

HVAC Marketing and Sales

In the *California Long Term Energy Efficiency Strategic Plan*, it is stated that **"**quality installation and maintenance practices must be easily recognized by customers, and customers must understand the impact of high quality installations on customer comfort, system reliability, and indoor air quality. This industry will provide high quality installation and maintenance services in response to increased customer demands for quality and through more consistent enforcement of existing building standard requirements.**"**[106]

As this excerpt indicates, growth in customer demand for quality HVAC installation and maintenance is essential for expanding the contractor base offering quality services, especially in the residential HVAC market. Since the quality of HVAC installation and maintenance practices is difficult for the layman to see or measure, contractors that provide quality services need to make a substantial outreach effort to teach all customers how they will benefit from paying more for proper installation and maintenance of their HVAC systems. Key benefits include:[107]

- Financial savings through more energy-efficient performance
- Improved equipment reliability
- Increased equipment longevity
- Improved health from better indoor air quality
- Increased comfort

In its "HVAC Workforce Education and Training Pre-Assessment Inventory", Better Buildings Inc. proposes that Southern California Edison could develop and deliver training curriculums to serve sales and management personnel by educating them on topics related to high quality installation and service, including: [108]

- Benefits of high-quality installation to contractors, customers and utilities
- Benefits of high-quality service to contractors, customer and utilities
- Features of high-quality installation compared to standard installation
- Features of high-quality service compared to standard maintenance
- Resource requirements for high-quality installation and service
- Time requirements for high-quality installation and service
- Sales and marketing methods for high-quality installation and service

In the report, a number of well-known consultants who conduct HVAC training and marketing programs

[105] Better Buildings Incorporated (BBI, 2008), p. 56
[106] California Energy Commission (2008), p. 7
[107] The Home Depot website http://www.homedepot.com/hdus/en_US/DTCCOM/Home_Services/Heating_Cooling_Systems_Installation/Docs/HVAC_Trane_ENG_Online.pdf
[108] Better Buildings Incorporated (BBI, 2008), p. 56

are identified for potential collaboration. BBI advises that SCE should take the following issues into consideration if it decides to design such a program: [109]

1. Most successful HVAC salespersons in the HVAC field do not enter it to be salespeople, but are technicians who end up in sales due to good customer relation skills. As a result, HVAC sales and marketing personnel are more likely to respond favorably to and learn from sales and marketing trainers who have successfully sold goods and services in the HVAC industry.

2. Attendance for the sales and management program should be stimulated through various marketing and promotional strategies. SCE and the contractor would work through prominent industry trade associations and HVAC marketing channels. Incentives would be established to encourage participation, such as offering the course at reduced costs underwritten by SCE. Also, fees per participant may be adjusted using group discounts.

3. It's anticipated that the sales and marketing program would be offered in the form of classroom training. However, consideration should also be given to online or remote training, such as through Webcasts. This can be accomplished once the curriculum has been established and tested in the classroom setting.

4. Participants in the training would receive a certificate of completion and their organization would receive recognition for participating in the SCE quality installation and quality maintenance program. This would not be a certification program for the organization.

HVAC Instructors

While HVAC education and training program websites clearly present information about the skills and knowledge participating students will obtain, there is little information about the qualifications of the men and women who are teaching the next generation of HVAC workers. HVAC Instructors are undoubtedly an integral part of the HVAC value chain, but there is a surprising lack of attention paid to their role in primary HVAC studies. According to an assessment of workforce education and training needs in the energy efficiency services sector by the Ernest Orland Lawrence Berkley National Laboratory, many community colleges in California rely on a small group of key instructors to teach courses, and many are nearing retirement age.[110]

The Council of Air Conditioning and Refrigeration Educators (CARE) was formed in 1998 as a means by which individual HVAC instructors and administrators could communicate with each other and the group as a whole. In the organization's constitution, three primary goals are identified:[111]

1. **Purpose**. The purpose of the Organization is to improve the quality of education to meet or exceed established industry standards in the Heating, Ventilation, Air Conditioning and Refrigeration (HVAC/R) industry or related HVAC/R trade practitioners.

2. **Mission**. The Organization's mission is to address the needs of the industry practitioner with technical educational opportunities to acquire and maintain marketable skills and competency necessary to compete successfully in a constantly changing, technologically advancing market.

[109] Better Buildings Incorporated (BBI, 2008), p. 56
[110] Goldman et al (2010), p. 17
[111] Council of Air Conditioning and Refrigeration Educators (CARE) website http://carehvac.org/constitution.html

3. **Vision**. The Organization is dedicated to advancing the education of all industry practitioners by adopting and/or creating standards for secondary and post-secondary educational training facilities.

Every year CARE hosts a three-day national conference for HVAC instructors and administrators. At the 2011 conference presentations included:[112]

- Writing NATE Test Questions
- Intro Energy Auditing and Building Performance Contracting
- Recommended Practices- Flexible Duct Installation
- Refrigerant Pipe Sizing
- Job Site Safety
- Train-the-Trainer: Parts One, Two, and Three
- What Instructors Need to Know about New Quality Assurance Programs
- Vacuum Pump Do's and Don'ts
- Going Green in the Classroom
- New Compressor Technologies and Control Applications
- Introducing Proper Belt Maintenance, Safety and Energy Savings
- Heat Load Calculations and How to Teach Utilizing Computer Technology
- Refrigerant Recovery
- Understanding Zoning
- Electric Modulation
- Using New Testing Technologies in the Classroom
- Maximizing Your Use of Instructor Resources from the Publisher

HVAC Excellence hosts a similar annual conference for HVAC educators in Las Vegas, Nevada. The 2011 conference had 550 attended, who had the opportunity to attend the following sessions:[113]

- Beginning Duct Leakage Testing
- EPA Regulatory Update
- Helping Your Students Get Hired
- Integrating R-410A Into Your Training
- Strategies for Connecting with Today's Student in the Age of Electronics
- Training in the Multifamily Environment
- Translating High Performance to the Future of HVACR
- Why Teach Customer Service?

Buildings Officials

A fundamental goal of the *California Strategic Long-Term Energy Efficiency Plan* is to improve building code compliance and enforcement throughout California.[114] In the near term of 2009-2011, the Plan identifies the following five strategies for making progress towards the goal's 2015 target of having

[112] CARE website http://carehvac.org/workshop2011.html
[113] HVAC Excellence website http://www.hvacexcellence.org/nhetc/Archive/2011/Documents/2011.NHETC.Program.pdf
[114] Engage 360 (2010), p. 4

HVAC-related permits obtained for 50 percent of installations:[115]

- Conduct research to determine high-priority tactical solutions for code compliance and focus efforts accordingly
- Increase training and support for local building code officials
- Investigate regulatory tools such as licensing/registration enforcement
- Evaluate proposed changes to the code and compliance approaches to simplify and expedite compliance
- Work with local governments to improve code compliance, adopt above code ordinances, and provide training/education

While increasing building code compliance appears to be an important component in improving HVAC installation and maintenance procedures throughout California, there is minimal mention in HVAC studies and trade publications about the Building Officials' role and training needs required to improve enforcement and increase HVAC code compliance.

In California, building officials are hired by municipalities to enforce state and local building codes. However, according to SCE HVAC program managers, the building code enforcement system is currently broken, and Building Officials severely lack the resources needed to increase statewide compliance.[116]

In order to become a building official in California, one must either gain journey-level experience with a public agency or graduate from a postsecondary institution in the inspection field. Building officials have to pass a 100 question multiple-choice exam to become certified by the ICC. A Code Council-certified individual must:[117]

- Place the public's welfare above all other interests and recognize that the chief function of government is to serve the best interest of all the people.
- Demonstrate integrity, honesty and fairness in all transactions and constantly strive for excellence in all matters of ethical conduct.
- Recognize the continuing need for developing improved safety.
- Maintain professional competence in all areas of employment responsibility and encourage the same for all associates at all levels.
- Accept no personal favors for public services rendered and conscientiously avoid all circumstances that could compromise professional integrity.

One of the primary responsibilities of a building official is to enforce contracting work. If a contractor performs contracting work without a permit and is caught, he is subject to a civil penalty by to $5,000 and suspension or revocation of his C-20 license. The California Mechanical Code (CMC) requires a building permit for HVAC installations and modifications including, but not limited to, the following:

- New HVAC installations
- HVAC change outs or replacements, including the air handler, coil, furnace or condenser
- Relocation of an existing HVAC unit
- Removal of an HVAC unit or system

[115] California Public Utilities Commission (CPUC, 2008), p. 73
[116] Interview with Paul Kyllo and Mel Johnson, SCE HVAC program managers
[117] International Code Council (ICC) website http://www.iccsafe.org/Accreditation/Bulletins/National_Certification_EIB.pdf

- Adding ducting

California Building Officials (CALBO) is a non-profit organization dedicated to promoting public health and safety in building construction through responsible legislation, education, and building code development. CALBO offers a range of training classes for Building Officials in San Ramon and Ontario, including the following courses:[118]

- **California Electrical Code:** This full-day course will provide you with an interactive approach to understanding the numerous and significant changes to the 2007 California Electrical Code. The material presented is intended to help participants understand the provisions and provide the background and intent of the new changes to make subjective decisions on a case-by-case basis. The course will cover the four entirely new articles, explanations of new terminology and definitions, new commercial, industrial and residential requirements, new swimming pool bonding requirements, differences between the CEC and the NEC, how to locate information you are seeking in the code book, and how to customize your code book for easier usage. This course applies toward the Code Enforcement, Counter Technician, and Field Inspector Credentials.

- **California Mechanical Code**: Based on the 2006 Uniform Mechanical Code with California Amendments, this full-day seminar provides a full overview of the California requirements covering: Combustion Air Openings & Sizing Calculations, Sources of Combustion Air, Ducts and Dampers, Prohibited Sources, Vent Installation and Construction Requirements, Sizing Gravity, Induced & Forced Draft Systems, Multiple Appliance Venting, Chimneys and Vents, Mechanical Draft Systems, Return and Outside Air: Area Requirements, Prohibited Sources, Limitations, Vented Decorative Appliances, Room Heaters, Overhead Radiant Heaters, Incinerators, Direct Gas/Fired, Make Up Air Heaters and Individual Heaters, Clearances & Access. This course applies toward the Field Inspector, Counter Technician, and Code Enforcement Credentials.

- **California Plumbing Code:** Based on the 2006 Uniform Plumbing Code with California Amendments, this full-day seminar provides a full overview of the California requirements covering: Sizing of Drainage Systems, Cleanouts, Slope & Change of Direction of Drainage Flow, Use of Joints, Drainage Fixture units, Installation and Sizing of Building Sewers, Sumps & Sewage Ejectors, Indirect Waste Piping, Chemical Waste, Steam and Hot Water Drainage, Condensers and Sumps, Vent Sizing and Termination, Island Venting, Combination Waste and Vent and Wet Vents. This course applies toward the Field Inspector, Counter Technician, and Code Enforcement Credentials.

- **Combination Field Inspection:** This full-day course presents selected misconceptions, methodologies, and resources pertaining to the application of the California Codes. It is ideal for the beginning field inspector and those interested in "brushing up" his/her field techniques. Selected building, electrical, plumbing and mechanical subjects and their inspection methodologies will be explored. This course applies toward the Field Inspector, Counter Technician and Code Enforcement Credentials.

3.2.2 Measuring the Effectiveness of Different HVAC Training Options

[118] California Building Officials Website http://www.calbo.org/documents/CALBO%20Education%20Weeks.pdf

While there is already a substantial education and training infrastructure in place in SCE territory, the following factors make it unclear whether current HVAC education is effectively preparing technicians to be able to successfully do their jobs:[119]

- Depth and scope of training varies significantly
- Quality of trainers and training organizations varies widely
- Balance between theory and practical hands-on lessons varies widely

Furthermore, there seems to be a lack of coordination between all the different training elements in the industry. Schools, distributors, and third-party certification organizations all have their own standards for training outcomes. This fragmented approach to training appears to make it quite difficult to improve training purposes. If training programs all led to a standardized certification, SCE might be better able to influence the certification process, and then training would adapt. Without such a focus, it seems that having any real impact could be very difficult.

According to Adam Gloss, Vice President of Bel Red Energy Solutions in Mukilteo, Washington, training for entry- and mid-level HVAC workers is either focused too much on book knowledge and theory with too little practical experience, or it is too hands-on and does not provide enough understanding of the fundamentals:[120]

- "Sometimes we find the schools rushing through their programs and not verifying the students have mastered the subject material. After a short time, it is evident these new technicians may lack even a basic understanding of electricity, the combustion process, or how refrigeration works. This is disappointing because instead of focusing on advanced skills, we must start training from scratch."

- "It's not just recent trade school graduates who are missing the technical skills; contractors often see seasoned technicians lacking those abilities as well. While technicians can have years of 'experience,' they often lack a basic understanding of the underlying principles needed to diagnose, repair, or commission equipment. They have learned a way to do things based on repeating a pattern they've observed, and unfortunately, it is often not the right way."

In addition to the difficulty of evaluating the preparedness of students in different HVAC programs, it is also unclear how student retention among different teaching styles is currently measured for comparison. For instance, how do you measure whether a classroom-based training program at a community college where instructors lecture in person is "better" than an online program where students can pace themselves and use an array of interactive media tools?

The problem is further complicated when one examines how to increase the number of participants in mid-level career training courses. The issue of multiple teaching styles appears to be an important consideration in this scenario, as some technicians may learn best in a classroom-based setting but cannot attend courses in person because they struggle with time management for work and family and are inhibited by travel costs.

[119] Better Buildings Incorporated (BBI, 2008), p. 18
[120] Turpin, J. (2011), p. 4

3.3 Conclusion

After reviewing literature on the responsibilities of existing roles in the HVAC value chain, it is evident that further research is needed to gain a more thorough understanding of the industry. As a part of this educational needs assessment, it is vital that the EMI research team first obtains insights from stakeholders that have a broad view of industry workings and trends. This will help to ensure that the research team does not miss any important roles and is able to begin prioritizing roles for in-depth analysis.

Upon completion of this step, it is necessary to engage employers and employees that correspond to the identified roles to fully understand what skills they need to successfully do their jobs. This deeper research and analysis will enable the research team to make the best possible recommendations for how Southern California Edison can tailor its HVAC WE&T training program to effectively incorporate all roles in the HVAC value chain that have significant potential to enhance energy savings in SCE territory.

4. EXHIBITS

Exhibit 1: Account Manager (Sales) Job Description[121]

Position Title:	**Account Manager**
Position Level:	**Junior Sales**
Reports to:	**Vice President Service**
Department:	**Service**

[121] All Exhibits were obtained through direct communication with Dave Rost, Vice President, McKinstry Co.

General Position/Summary of Position Requirements:

Responsible for introducing new clients into the McKinstry Cycle of Services. Mission includes prospecting, qualifying, interviewing to determine client needs. Efforts focus on developing target territory or vertical markets. Develop and manage customer base to fullest potential and assure client satisfaction.

Essential Functions/Responsibilities:

Presentation Skills

The Account Manager needs to be able to prepare presentations that are tailored to the audience. Presentations should address the audience's needs, engage and focus their attention, and inspire them to action. Information is presented in a logical, persuasive manner and difficult questions and situations need to be handled appropriately.

Consultative Selling

In order to present solutions that meet customer objectives, the Account Manager must qualify potential customers, asking questions that help identify their business needs then apply product market knowledge effectively. He/she needs to build rapport and establish trust with the customer. Sales process is managed and documented.

Communications

Communication means expressing ideas and thoughts verbally and in written form as well as exhibiting good listening and comprehension skills. The Account Manager is also expected to keep others informed using appropriate communication methods.

Customer Service

Customer needs must be responded to promptly and in a courteous and sensitive manner, including difficult or emotional customer situations that require special management. An Account Manager must meet commitments and solicit feedback to improve service.

Business Acumen

The Account Manager must display orientation to profitability, conduct cost-benefit analyses and understand business implications of their decisions. He/she will align work with strategic goals and demonstrate knowledge of market and competition.

Cooperation

In a group situation, the Account Manager works cooperatively, offering assistance and supporting co-workers and working actively to resolve conflicts when they arise. He/she displays a positive outlook and pleasant manner, exhibits tact and consideration, and maintains effective relations.

Planning and Organization

By working in an organized manner prioritizing and planning work activities, the Account Manager will use time effectively, setting and achieving goals and objectives. He/she should plan for additional resources and integrate changes smoothly.

Judgment

The Account Manager needs to exhibit sound and accurate judgment, making decisions that are timely and based on sound and accurate judgment. He/she includes the appropriate people in decision making process and supports and explains reasoning for their decisions.

Dependability
The Account Manager commits to doing the best job possible and takes responsibility for their own actions. He/she can be depended on to respond to requests for service and assistance and keep commitments. He/she must also meet attendance and punctuality guidelines, follow instructions, and respond to management direction.

Quality
In his/her performance and work, the Account Manager displays a commitment to excellence through accuracy and thoroughness. He/she looks for ways to improve and promote quality, monitoring their own work as well as applying feedback from others.

Teamwork
Contributing to building a positive team spirit means giving and welcoming feedback with objectivity and openness and putting the success of the team above personal interests. The Account Manager needs to balance team and individual responsibilities.

Secondary Functions/Responsibilities:

- Perform relief and/or project duties and responsibilities such as substituting for others in the department. Also responds to day-to-day concerns and resolves existing or anticipated problems
- Performs other duties and responsibilities as required
- Available an hour before and after start and/or end times to assist the team during unscheduled peak times that is required due to the nature of Service work (basically 7-5 schedule flexibility)
- Must have a vehicle for offsite meetings and/or emergency pick-ups and deliveries.

Specific Job Skills/Requirements:

- Uses technology appropriately
- Follows established procedures & processes
- Meets mutually agreed upon personal goals
- Understands and keeps focus on corporate & departmental goals
- Working knowledge of the service product lines offered by McKinstry Service and our corporate "cycle of services"
- Demonstrate the ability to identify, qualify and secure opportunities to propose maintenance contracts and service
- Maintain thorough records and forward accurate information to account managers to complete a thorough contract start up
- Provide accurate and timely reporting on pipelines, account assignments, expenses and mileage reimbursements

Education and/or Experience:

- Equivalent of four years college training in business, engineering, construction, management, or business administration. This should include seminars, technical and other training

Equivalent of five years previous sales experience with a mechanical contractor or a related organization, i.e. manufacturer's representative or controls, with responsibilities for identifying leads and closing sales

Exhibit 2: Service Mechanic Job Description

POSITION: Service Mechanic

REPORTS TO: Lead Mechanics for Technical Support & Quality Reviews
Dispatcher for scheduling and procedural clarification
Operations Manager or VP Service for other issues

JOB SUMMARY:

Provide solutions and service to customer's satisfaction. Professionally complete assigned tasks as scheduled and within budget. Demonstrate McKinstry's Values.

REQUIRED SKILLS:

Technical knowledge in all aspects of mechanic's chosen trade, verbal and written communication skills, customer service skills, up to date certifications pertaining to trade, good driving record and standing with your UA Local.

BASIC RESPONSIBILITIES:

1. Standard hours are 8:00 a.m. to 4:30 p.m. (includes 1/2hr. for lunch) Monday through Friday. Mechanics will be working on their first assigned job at 8:00 a.m. unless otherwise specified by dispatch. Personally notify dispatch between 7:00 a.m. - 7:30 a.m., if you are unable to work.

2. Before jobsite departure, the mechanic is required to notify dispatch of job status (complete/incomplete), total hours charged to job and a brief description of work performed. Recommendations and/or quotations must be immediately relayed to inside sales.

3. Mechanics are responsible to act as a sales representative: identify sales opportunities, relay leads and all pertinent information to inside sales.

4. Timesheets and service/maintenance tickets must be turned in by 7:30 a.m. Monday or mailed in by 5:00 p.m. Friday. Overhead and non-emergency overtime charges must be pre-approved by dispatch.

5. Service and maintenance tickets will be filled out legibly and completed on a job by job basis. Customer or representative indicating work performed must sign all tickets. All COD service calls must be collected daily.

6. Mechanics must keep the customer informed of job progress. If additional time is needed for service calls, quoted work or maintenance, call in to dispatch or inside sales before exceeding allotted hours. Check voicemail daily and mail slot when in office. Maintain Mechanic File Boxes.

7. Mechanics must represent McKinstry in a professional manner at all times. You will be responsible for wearing assigned uniforms and OSHA approved boots. Positive attitude, clean appearance and appropriate language must be used at all times. Avoid gossip and rumor spreading.

8. Company vehicles and tools are considered a privilege and trust... revocable at any time. Follow policy outline in your "McKinstry CO. Drivers Contract" and coordinate repairs/maintenance through dispatch.

9. Continue technical training by actively participating in union courses, company training, meetings, vendor sponsored seminars and reading industry related books/articles.

Service mechanics will be responsible for following all policies and procedures established by McKinstry Company.

Exhibit 3: Lead Mechanic Job Description

POSITION: Lead Mechanic

REPORTS TO: Department Manager/Project Manager
VP Service for other issues

WORKS WITH: Dispatch, Payroll/Billings, Purchasing/Warehouse, Sales Personnel, Safety

SUPERVISES: All Mechanics in regards to McKinstry policies, procedures, vision, and values.

JOB SUMMARY:

Commit to TEAM goals by demonstrating a superior ability to coach and mentor other mechanics in order to strengthen the Service/SPG group. Provide leadership by setting a good example for mechanics. Observe and demonstrate the values, rules, procedures, and mission statement established by McKinstry. Recommend alternatives for improvement in policies, procedures, and communication.

DUTIES AND RESPONSIBILITIES:

1. Actively support the blending of all departments (Service, SPG, Electrical, Facility, Construction, Fire, etc) into one cohesive unit so we can provide a seamless delivery to the customer and continue to enhance our leadership in the industry.

2. Follow and enforce mechanic job descriptions. Establish and support consequences for non-compliance. As a worker and leader, demonstrate a real concern and positive attitude towards customers.

3. Actively participate in the performance review of assigned tradesmen, apprentices & technicians, etc.

4. Act as mentors by helping to develop fellow employees in areas in which you excel. Demonstrate a willingness to share your ideas and information. Help dispatchers and vertical PM's sell needed work while on site.

5. Help establish training priorities based on opportunity and need. Develop and maintain an experience matrix for mechanics employed at McKinstry. Regularly review journeyman progress & curriculum choices for continuing education. Must have current first aid card certification.

6. Participate in the establishment of budgets, task definitions and quality standards necessary for completing typical maintenance, service & SPG work. Recommend material, tool and equipment inventory level/staging improvements.

7. Provide technical assistance to sales, purchasing, project managers, and accounting staff as needed. Support their requests and needs for accurate and timely information.

8. Take personal responsibility to end rumors. Positively influence both office and field staff by fixing the problem not the blame.

9. Assist in the scheduling of mechanics when requested. Review & constructively assess work performance, call backs, diagnostics, and warranty issues as assigned.

10. Participate in the evaluation of un-billable hours, actual hours exceeding estimate and warranty call backs. Recommend solutions and influence change.

11. Demonstrates a superior understanding of the Mechanic Skills required to compete in today's marketplace. Perform additional duties and responsibilities as requested.

Exhibit 4: Project Engineer Job Description

Title	Project Engineer	**Dept**	Project Management
Exempt/Non-exempt	Exempt	**Reports to**	Sr. Project Manager/ Operations Vice President
Supervises	No One		

General Position Summary/Job Scope

Responsible for assisting Senior Project Manager or Project Manager with daily tasks as required to keep assigned project(s) operating efficiently.

Essential Functions/Major Responsibilities:

• Maintain project documentation; organize network and hardcopy files per the Project Manager's Manual. Keep project status logs (Change Order, RFI, Correspondence) updated.	
• Prepare Submittals, Operation & Maintenance Manuals, Expediting Reports, etc.	
• Communicate with Purchasing Dept. and outside vendors to order and expedite material.	

• Assist in preparation of Job Start and Project Closeout meeting materials.	
• Assist in preparation of monthly ETC. Attend monthly project review meetings.	
• Help create billing breakdown and prepare billing substantiation.	
• Attend project-related meetings, in-house and with General Contractor, Architect, Engineer or Owner.	
• Respond to questions raised by Field Foremen. Review contracts, drawings, specifications and other res questions in a timely manner. Consult with Sr. PM if necessary to resolve issues.	
• Communicate with General Contractor, Architect, Engineer and Owner, to assist the Project • Manager with daily duties.	
• Maintain as-built drawings with all field changes and change documents (field orders, change • orders, RFI's, etc.).	

Secondary Functions:

Performs other duties and activities as required or directed.	

Specific Job Skills:

Working knowledge of MS Word, Excel, Project, and Outlook.	
Good oral and written communication skills with other departments, customers, vendors and subcontractors.	
Good organizational skills.	
Sense of responsibility and ownership for work assigned.	
Demonstrate ability (or ability to learn) to read and interpret construction plans, specs, contracts, proposals, estimates, and other regularly encountered items.	

Education and/or Experience:

Equivalent of four year's college level training in construction management, engineering or other related field.	
Some construction or engineering related work experience.	

Exhibit 5: Project Manager Job Description

Title	Project Manager	**Dept**	Project Management
Exempt/Non-exempt	Exempt	**Reports to**	Sr. Project Manager/ Operations Vice President

Supervises	Project Coordinator/ Project E		

General Position Summary/Job Scope

Responsible for ensuring the success of assigned project(s). May assist Senior Project Manager in managing his/her project or run own projects with supervision from Senior Project Manager. Requires additional decision making capacity, supervision/leadership skills and ability to make more global decisions, considering the best interests of the company in lieu of a particular project.

Essential Functions/Major Responsibilities:

• Ensure proper documentation and monitoring of designated project; create and maintain network and hardcopy files as outlined in the Project Manager's Manual. Prepare or supervise the preparation of Submittals, Operation & Maintenance Manuals, Expediting Reports, Change Order Log, RFI Log, Correspondence Log, etc.
• Submit billings, estimates to complete, change order proposals, and other cost related items in a • timely manner, ensuring their accuracy.
• Create a monthly billing breakdown and develop billing strategies. Demonstrate an • understanding of overbilling, front loading, "time and material" versus "lump sum • contracts", and making cash flow projections.
• Generate an Estimate to Complete. Understand costs as well as outstanding change • orders and their expected value.
• Assess any potential job cost impacts and price, submit, negotiate and track all change order requests.
• Supervise Project Engineers, Project Interns or Clerical Staff.
• Prepare Job Start and Project Closeout materials. Establish and lead associated meetings.
• Respond to questions raised by Field Foremen. Review contracts, drawings, specifications and other resources to answer questions in a timely manner. Consult with Sr. PM if necessary to resolve issues.
• Communicate effectively with General Contractor, Architect, Engineer and Owner, and represent McKinstry properly in outside meetings.
• Ensure that all material and equipment is purchased in a timely and cost-effective manner.
• Work with Safety Director to create a Job Specific Safety Program.
• Evaluate bid estimate, develop cost codes, establish definitive budgets, develop manpower plan with Superintendents, and monitor field labor progress. Communicate the necessary information to Field Foremen. Assess and communicate manpower needs to the Sr. Project Manager if appropriate.
• Take responsibility for the development and implementation of a comprehensive construction plan. • Monitor progress towards goals to anticipate potential problems.
• Communicate with other departments (Engineering, Sales, Purchasing, Accounting, Warehouse, etc.) to successfully manage a project. • Develop, coordinate and manage the scope of work and contract for subcontractors.

Secondary Functions:

Performs other duties and activities as required.	

Specific Job Skills:

Working knowledge of MS Word, Excel, Project, and Outlook.	
Good leadership skills and the ability to plan for, schedule, supervise and delegate to Project Engineer or other support staff.	
Understanding of the basics of labor relations including union contract requirements, hiring practices, etc.	
Ability to manage multiple projects and to develop a construction plan at job start-up.	
Good oral and written communication skills.	
Capable of handling day-to-day problems. Demonstrates sound decision-making when solving problems; able to make recommendations to the Senior PM if appropriate.	
Sense of responsibility and ownership for project.	
Excellent customer service skills.	
Understand and follow protocol for the proper lines of communication (i.e. understand whom our contract is with).	
Clear understanding of McKinstry Co. mission and values.	

Education and/or Experience:

Equivalent of four year's college level training in construction management, engineering or other related field.	
Minimum three years of project management experience.	

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