THE ENERGY SKILLS COLLABORATIVE

The Energy Skills Collaborative

California's Clean Energy Workforce

California Skilled Energy Workforce Market Assessment

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ICF

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This report is a Labor Market Assessment of the California clean energy economy funded by the California Community Colleges. TESC and the California Clean Energy Fund (CalCEF) guided this research to assess current and future clean energy labor market conditions as part of TESC's mission to develop a reliable workforce that supports economic growth and positions stakeholders and policymakers to make data informed workforce initiative investment decisions for California.

This research and report was conducted by Dominic Modicamore, Alix Naugler, and Renee Rainey from ICF with support from consultant Brad Hurte.

I. Executive Summary

California has adopted ambitious policy goals to move the state to increased reliance on renewable and clean energy, including powering 100% of its electricity grid through renewable sources by 2045, reducing Greenhouse Gases (GHG) emissions, and a doubling of energy efficiency by 2030. These ambitious policy goals are driving market change. However, evidence of a growing workforce skills gap is impacting the state's ability meet these clean energy goals. The Energy Skills Collaborative (TESC), fiscally sponsored by California Clean Energy Fund (CalCEF), is a collaboration of labor, education, and environmental justice organizations that addresses the combined bottom line of Economy, Jobs, Environment and Equity, facilitating the development of a skilled workforce in critical occupations that will result in the reduction of greenhouse gas emissions in accordance with California climate policies. TESC issued a RFP and selected ICF, a global consulting firm, to conduct a market research assessment that can:

- Drive decisions supporting workforce initiatives by policymakers
- Advise on the development of initiatives and programs that fill workforce competency gaps, support disadvantaged communities, and align workforce development plans with the state's climate policies

The research was executed in two phases. Phase 1 articulated the current state of the workforce by determining the baseline number of clean energy-related jobs in California in 2018, the knowledge and skills needed for those jobs, and the available training and education. It also addressed how the California clean energy policies already enacted will affect demand for work in these occupations. Phase 2 examined impacts on clean energy jobs as a result of new and emerging technologies and additional skills needed by new and incumbent workers because of technological advances. Phase 2 also included projected growth for clean energy jobs for the years 2019 through 2022 and an analysis to quantify the gap between the supply and demand for workers in energy-related occupations.

Based on 12 job functions of interest in the clean energy economy, we identified 87 occupations from the Department of Labor (DOL)/Employment and Training (ETA) Occupational Information Network (O*NET)-Standard Occupational Classification System (SOC) taxonomy[1] associated with the job functions in clean energy related industries.

Phase 1 - Current State and Baseline Projections

- In 2018, there were almost 3.1 million jobs in energy-related occupations across all industry sectors and Emsi Labor Market Information (LMI) data forecasts another almost 275,744 jobs will be created in these occupations over the next 10 years in California, a 9% growth rate. In the short-term through 2022, almost 160,000 jobs are projected, a 5.2% growth rate.
- Of these occupations, 12 are expected to have more than a 15% growth in employment over the next 10 years. Roughly 250,000 employees work in these 12 occupations.
- The Automation Index[2] shows nine of the 12 high-growth occupations have an above average risk of being affected by automation, indicated by an index score of over 100. Despite the high

[1] The DOL/ETA O*NET Program is the primary source of occupational information in the United States. Based on the Standard Occupational Classification, the O*NET-SOC taxonomy defines a set of 974 occupations. ETA periodically revises the taxonomy to reflect changes in the occupational landscape and last did so in 2010. The SOC was revised in 2018.

[2] The Emsi Automation Index captures an occupation's risk of being affected by automation using four measures: the percent of time the occupation spends on high-risk work (in-terms of automation risk), the percent of time spent on low-risk work, the number of high-risk jobs in compatible occupations, and the overall

automation indexes, these occupations are still projected to continue to be in high demand and grow significantly over the next 10 years.

- Stakeholder interviews confirmed conventional construction jobs have been expanded because of California policies and operations and maintenance (O&M) jobs are being upskilled to support new technologies like automation. In addition, several surveyed respondents reiterated that core electrical and mechanical skills would continue to be foundational to the industry.
- Seven of the 12 occupations identified as high growth require either no formal education credential or a high school diploma, instead these occupations require on-the-job training (usually moderate- or long-term) or apprenticeship. Eleven out of the 12 do not require previous work experience, instead requiring training, either through an accredited institution or on-the-job with an employer, or education at a post-secondary level or bachelor's level.
- Interviewed employers frequently mentioned the need for vendor-specific training, driven by a lack of standardized equipment interfaces in the industry, as an existing training gap.

Phase 1 - Effects of Current Policies

- Policies directed at increasing energy efficiency are expected to have largely positive impacts on employment in energy related occupations and minimal to no negative impacts.
- The positive impacts on employment are driven by systems automation in the production and distribution of energy and efforts towards increasing energy efficiency in buildings.
- Energy and building automation systems are placing a large demand on occupations in the Information and Communications Technology (ICT) sector, including Computer Systems and Information Security Analysts, Software Developers, and Network and Computer Systems Administrators. Of the 12 highest growth occupations, Information Security Analysts have the third highest predicted growth rate (31.3% through 2028 and 16.6% through 2022) and the lowest Automation Index (86.4).
- Efforts towards increasing energy efficiency in buildings are also expected to increase the demand for construction and building related occupations, such as construction managers and supervisors, architectural and civil drafters, electricians, plumbers, heating, air conditioning and refrigeration (HVAC) installers and repairers, and stationary engineers.

Summary Exhibit ES-1: Key Findings from Phase I including High-Growth Occupations (2018-2028), Automation Risk and Level of Training

SOC	Occupation Name	Employed (2018)	% Change (2018-2028)	% Change (2018-2022)	Automation Index	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
47-2231	Solar Photovoltaic Installers	4,736	77.6%	38.0%	119.7	HSD	None	Moderate-term
49-9081	Wind Turbine Service Technicians	1,256	52.3%	25.5%	106.3	Postsecondary	None	Long-term
15-1122	Information Security Analysts	9,960	31.3%	16.6%	86.4	Bachelor's degree	Less than 5 years	None
47-5071	Roustabouts, Oil and Gas	2,493	27.1%	11.4%	123.5	No formal	None	Moderate-term

industry automation risk. A resulting index of "100" indicates that the occupation has an average risk of being impacted by automation; an index over 100 signifies that the occupation has an above average risk of being impacted by automation.

SOC	Occupation Name	Employed (2018)	% Change (2018-2028)	% Change (2018-2022)	Automation Index	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
49-9051	Electrical Power-Line Installers and Repairers	7,834	20.8%	11.2%	114.0	HSD	None	Long-term
47-5013	Service Unit Operators, Oil, Gas, and Mining	2,941	19.4%	6.9%	106.1	No formal	None	Moderate-term
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	34,468	19.0%	10.2	113.0	Postsecondary	None	Long-term
13-1161	Market Research Analysts and Marketing Specialists	120,101	17.9%	9.6%	88.6	Bachelor's degree	None	None
47-2152	Plumbers, Pipefitters, and Steamfitters	61,490	17.8%	9.7%	116.3	HSD	None	Apprenticeship
47-5011	Derrick Operators, Oil and Gas	672	17.4%	7.1%	106.6	No formal	None	Short-term
17-1021	Cartographers and Photogrammetrists	1,783	16.8%	8.2%	94.2	Bachelor's degree	None	None
47-5012	Rotary Drill Operators, Oil and Gas	1,296	16.0%	6.3%	110.9	No formal	None	Moderate-term

Source: Emsi

Phase 2: Impacts of Technology on Skills and Job Projections

New and incumbent workers in traditional occupations need up-skilling to include Information and Communications Technology (ICT) skills

- O&M occupations need up-skilling of workers to address new technologies driven by shifts towards to automation and digitization. The literature and the data support increased need for ICT skills in occupations that traditionally have been more mechanical or blue-collar in nature.
- Employer interviews reinforced that up-skilling of conventional trades are needed to support the increasing digitization of equipment and deployment of Building Automation Systems. Automation, and specifically Building Automation Systems, plays a key role in achieving the legislated doubling of energy efficiency mandate through lighting and HVAC controls.
- However, conventional electrical and mechanical skills will continue to be foundational as new ICT skills are layered onto traditional trade occupations.
- Employers indicated the merging of mechanical skills with computer and ICT skills is a major bottleneck for hiring; it is currently very difficult to find employees with both sets of skills.
- Due to the lack of qualified candidates and difficulty in staffing, virtually all employer respondents indicated that they conduct a high level of internal training with significant company investment and on-the-job training/mentoring.

Cybersecurity is emerging as a specific in-demand ICT skillset

- Non-traditional interconnectedness through automation and digitalization exposes previously autonomous systems to the threat of cyber-attacks. Cybersecurity is becoming a skillset of increasing importance, particularly in the utility industry and with the rise in smart buildings and smart cities that manage their energy consumption through networked controls.
- Information Security Analysts have the third highest projected growth rate across all industries – 31% (13,082 jobs in California) by 2028. In the short-term, this growth rate is 16.6% representing an additional 1,650 jobs between 2018 and 2022. Real-time job postings supports this – leading

the list of energy related occupations with the greatest percent increase in postings are ICT occupations, such as Computer Systems Analyst, Software Developers, and Information Security Analyst. Real time data also shows a demand for Certified Wireless Security professionals and virtually all of the ICT qualifications and certifications seen in the real-time data are related to information security. While some occupations (e.g., Software Developers) are predominantly held by those with four-year college degrees, for others such as Network and Computer Systems Administrators, Information Security Analysts, and Computer Systems Analysts the data show about only about 50% of those employed holding a bachelor's degree or higher.

- Community and technical colleges offer a number of training options for those seeking 2-year degrees, transfer to a 4-year university, upskilling of technical skills, and industry certifications. There are also four identified California ICT apprenticeship programs in the areas of cybersecurity, helpdesk-networking, and information security.

Construction occupations will remain in demand

- General construction occupations will remain in demand and almost all are expected to experience at least a 10% growth rate across all industries in the next ten years.
- Renewable energies such as wind and solar create more construction jobs per megawatt (MW) than conventional sources.
- A number of construction and building related occupations are projected to grow rapidly over the next four years, including Electrical Power-Line Installers and Repairers (11.2%), HVAC Mechanics and Installers (10.2%), Plumbers, Pipefitters and Steamfitters (9.7%) and Electricians (8.2%).

Solar jobs will continue to outpace wind energy jobs

- Analysis of the data supports high growth in both occupational areas but wind lags solar in both volume and growth.
- Wind Turbine Service Technicians and Solar Photovoltaic Installers, occupations specific to clean energy, have the highest rates of projected growth over the next ten years of any of the occupations we analyzed, at 52% and 78% respectively. Wind Turbine Service Technicians show a high growth rate but the volume of these jobs is relatively small compared to other occupations including Solar Photovoltaic Installers.

Automation and digitization will continue to drive demand for soft skills

- Soft skills are in high demand particularly communication and interpersonal skills – as repetitive work becomes more automated and technician and O&M work evolves to be more customer facing and focused on integration.

Phase 2 - Recommendations and Gap Analysis Findings:

- Occupations with the largest projected gap are business operations related occupations. However, examining shortages in these occupations at the state or regional level can be misleading, because these occupations generally require four-year college degrees and college graduates are very mobile, competing for jobs throughout the country. Workers for these occupations are generally recruited at a national level.
  - California colleges and universities may not graduating enough workers in these occupations to fill the demand from employers within the state, but labor completing programs in other states may migrate to California to fill these positions.

- Significant shortages in ICT related occupations, such as computer systems analysts and network and computer systems administrators, are also projected.
  - Many ICT related occupations also require four-year college degrees and the labor gap findings may also be mitigated when looking at supply on a national level.
  - However, many ICT occupations do only require certifications or shorter-term training acquired at community colleges, apprenticeships, and other accredited training institutions.
  - Workers in occupations that only require certifications and short-term training can be less mobile than four-year college graduates, therefore the gap in these ICT occupations may be more difficult to fill.
  - While there is often pressure to outsource ICT jobs due to lower wages abroad, it may be that because of the heavy emphasis on cybersecurity and the critical nature of the energy infrastructure, employers are less likely to fill these jobs through outsourcing than ICT jobs in other industries.
- Perhaps of greater concern are the large labor shortages projected in the construction and installation, maintenance, and repair occupations, such as electricians and plumbers, first-line supervisors, industrial machinery mechanics, HVAC mechanics and installers, and telecommunication line installers and repairers.
  - Demand for these occupations in the energy sector are projected to increase rapidly, as energy efficiency, particularly in buildings, becomes increasingly important. Workers in these occupations will also be required to learn new skills, in addition the traditional hard skills, as energy automation in buildings requires these workers to have knowledge of those systems. The credentials required for occupations in the skilled construction trades and installation, maintenance, and repair are primarily certifications and are acquired at community colleges, trade schools, and other training providers, and the workers for these occupations will generally be recruited locally.
  - A shortage of qualified labor in these occupations may become a major constraint on the energy sector in California.
  - A challenge employers noted for these occupations was a perception among students and their parents that these jobs as low-paid, low skill, blue collar work, when in reality these jobs are well-paid, high skill, and incorporating more traditionally white collar and ICT skills all the time.

II. Introduction

1. Purpose of Report

The Energy Skills Collaborative (TESC) and the California Clean Energy Fund (CalCEF) contracted ICF to a conduct comprehensive market demand analysis of the job functions that are supporting energy automation and Distributed Energy Resources (DERs) in California including new and enhanced skills workers need to fill these jobs. California has enacted ambitious clean energy legislation and policies oriented towards facilitating continued growth in the state's energy economy and making the state one of the most influential leaders at the forefront of climate change response. CalCEF fosters clean energy innovation in California through funding and job creation initiatives spearheading the transition to a clean

energy economy. TESC, funded by CalCEF, is a collaboration of stakeholders who have a goal of developing workforce capable of supporting the clean energy economy and the increasing number of highly skilled, energy-related jobs in high-demand. Intelligence gathered from this report will be socialized with industry stakeholders, regulators, policy leaders and educational institutions to inform workforce initiative investment decisions for California.

By some estimates, California's clean energy economy provides more than 500,000 jobs and contributes billions of dollars to the state economy[3]. There is a significant push to transition to renewable and sustainable sources of energy and the state has implemented several pieces of legislation that address decarbonization and reducing greenhouse gas (GHG) emissions. Meanwhile, other factors are at play as well, including increased automation and digitalization in the energy sector. There is evidence of a growing workforce skills gap and employers are struggling to find and hire the highly skilled workforce with the required skills to fill the jobs the policy goals and shifts in technology are creating. The adoption of automated technology and other emerging technologies has prompted a rapid shift in skills essential for existing jobs, further exacerbating the skills gap and potentially re-defining roles[4]. These shortages have prompted workforce development programs, labor unions, educational institutions, and employers over the last several years to collaborate in an attempt to provide training, work experience, and certification to help employ a profusion of skilled, qualified California workers considering the state's energy policies[5]. In addition to the technical skills that energy-related employers are demanding, soft skills will also become increasingly important as technology/automation/artificial intelligence (AI) proliferate and computers take over some technical job tasks leaving workers the responsibility to communicate and interpret processes more effectively.

In response to the policy and technology changes affecting the clean energy economy in California, this report is a comprehensive market demand analysis of the specified job functions that are supporting energy automation and Distributed Energy Resources (DERs) and will identify high-priority, in-demand occupations and their associated skill requirements. The job functions included in this report include the following:

- Systems design
- Systems integration
- Systems installation
- Systems commissioning
- Systems operation
- Systems maintenance
- Communications network design
- Cybersecurity
- Energy auditing, surveying, and benchmarking
- Energy performance modeling
- Digital programming and operation
- CAD/CAM/BIM

2. Methodology

ICF identified 87 occupations from the O*NET-SOC taxonomy (See Exhibit 1) associated with the job functions in clean energy related industries as determined in collaboration with CalCEF/TESC. (See Appendix A for the list of Industries). When available the data is reported by the full O*NET code,

[3] E2. (2018, September 10). California Advances Clean Energy Economy – 100% by 2045 [Press release]. Retrieved May15, 2019, from https://www.e2.org/releases/california-advances-clean-energy-economy-100-clean-energy-by-2045/.
[4] Coghlan, E. (2018, July 12). Delivering on California's energy goals is also workforce challenge. Retrieved May 18, 2019, from http://caeconomy.org/reporting/entry/delivering-on-californias-energy-goals-is-also-workforce-challenge.
[5] California EDGE Coalition. (2013, October). Moving Forward - Workforce Development in California. Retrieved May 15, 2019, from https://californiaedgecoalition.org/moving-forward-workforce-development-in-california/.

however, the Labor Market Information (LMI) data from Emsi is available only at the six-digit SOC level, and thus reported at that level. For example, LMI data is not available individually for Mechatronics Engineers (17-2199.05) and Wind Energy Engineers (17-2199.10), thus LMI data is reported for these occupations at the aggregate level of Engineers, All Others (17-2199).

Exhibit 1: Energy Job Functions and Associated Occupations

Job Function	SOC / ONET Code(s)	Occupation
Systems Design	17-2051	Civil Engineers
Systems Design	17-2071	Electrical Engineers
Systems Design	17-2072	Electronics Engineers, Except Computer
Systems Design	17-2081	Environmental Engineers
Systems Design	17-2112	Industrial Engineers
Systems Design	17-2141	Mechanical Engineers
Systems Design	17-2151	Mining and Geological Engineers, Including Mining Safety Engineers
Systems Design	17-2171	Petroleum Engineers
Systems Design	17-2199.05	Mechatronics Engineers
Systems Design	17-2199.10	Wind Energy Engineers
Systems Design	17-2199.11	Solar Energy Systems Engineers
Systems Design	17-2141.01	Fuel Cell Engineers
Systems Design	17-3029.02	Electrical Engineering Technologists
Systems Design	17-3029.03	Electromechanical Engineering Technologists
Systems Design	17-3029.04	Electronics Engineering Technologists
Systems Design	17-3029.05	Industrial Engineering Technologists
Systems Design	17-3029.07	Mechanical Engineering Technologists
Systems integration	17-2199.06	Microsystems Engineers
Systems integration	11-9199.10	Wind Energy Project Managers
Systems integration	11-3051	Industrial production managers
Systems integration	15-1199.02	Computer Systems Engineers/Architects
Systems installation	47-1011.03	Solar Energy Installation Managers
Systems installation	51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers
Systems installation	49-9052	Telecommunications Line Installers and Repairers
Systems installation	47-2111	Electricians
Systems installation	47-2152	Plumbers, pipefitters, and steamfitters
Systems installation	47-2231	Solar Photovoltaic Installers
Systems installation	47-4099.02	Solar Thermal Installers and Technicians
Systems installation	49-9012	Control and valve installers and repairers, except mechanical door
Systems installation	49-9051	Electrical Power-Line Installers and Repairers
Systems commissioning	51-8012	Power Distributors and Dispatchers
Systems commissioning	43-4051	Customer Service Representatives
Systems commissioning	11-2011.01	Green Marketers
Systems commissioning	13-1161	Market Research Analysts and Marketing Specialists
Systems commissioning	41-4011.07	Solar Sales Representatives and Assessors
Systems commissioning	41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products
Systems commissioning	41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products
Systems commissioning	41-3099.00	Energy Brokers/Sales Representatives, Services, All Other
Systems commissioning	13-2011	Accountants and Auditors
Systems operation	11-3071.01	Transportation Managers
Systems operation	11-3071.02	Storage and Distribution Managers
Systems operation	11-3071.03	Logistics Managers
Systems operation	11-9021.00	Construction Managers
Systems operation	11-3051.02	Geothermal Production Managers
Systems operation	11-3051.04	Biomass Power Plant Managers
Systems operation	11-3051.05	Methane/Landfill Gas Collection System Operators
Systems operation	11-3051.06	Hydroelectric Production Managers

Job Function	SOC / ONET Code(s)	Occupation
Systems operation	11-9199.09	Wind Energy Operations Managers
Systems operation	11-1021	General and Operations Managers
Systems operation	51-9061	Inspectors, testers, sorters, samplers, and weighers
Systems operation	47-5011	Derrick Operators, Oil and Gas
Systems operation	47-5012	Rotary Drill Operators, Oil and Gas
Systems operation	47-5013	Service Unit Operators, Oil, Gas, and Mining
Systems operation	47-5071	Roustabouts, Oil and Gas
Systems operation	49-9099.01	Geothermal Technicians
Systems operation	51-8013	Power Plant Operators
Systems operation	51-8021	Stationary engineers and boiler operators
Systems operation	51-8092	Gas Plant Operators
Systems operation	51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers
Systems operation	51-8099.01	Biofuels Processing Technicians
Systems operation	51-8099.02	Methane/Landfill Gas Generation System Technicians
Systems operation	51-8099.03	Biomass Plant Technicians
Systems operation	51-8099.04	Hydroelectric Plant Technicians
Systems operation	53-7073	Wellhead Pumpers
Systems operation	53-7071	Gas Compressor and Gas Pumping Station Operators
Systems operation	53-7072	Pump Operators, Except Wellhead Pumpers
Systems maintenance	49-9021	Heating, air conditioning, and refrigeration mechanics and installers
Systems maintenance	49-9041	Industrial machinery mechanics
Systems maintenance	49-9071	Maintenance and repair workers, general
Systems maintenance	49-9081	Wind Turbine Service Technicians
Systems maintenance	19-4041	Geological and Petroleum Technicians
Systems maintenance	49-1011	First-line supervisors/managers of mechanics, installers, and repairers
Systems maintenance	49-2094	Electrical and electronics repairers, commercial and industrial equipment
Systems maintenance	49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay
Systems maintenance	17-3023	Electrical and electronics engineering technicians
Communications network design	15-1143	Computer Network Architects
Communications network design	15-1142	Network and Computer Systems Administrators
Communications network design	15-1143.01	Telecommunications Engineering Specialists
Cybersecurity	15-1122	Information Security Analysts
Cybersecurity	15-1121	Computer Systems Analysts
Energy auditing, surveying, and benchmarking	13-1199.01	Energy Auditors
Energy performance modeling	17-2199.03	Energy Engineers
Digital programming and operation	15-1133	Software Developers, Systems Software
CAD/CAM/BIM	17-1021	Cartographers and Photogrammetrists
CAD/CAM/BIM	17-3012	Electrical and Electronics Drafters
CAD/CAM/BIM	17-3013	Mechanical Drafters
CAD/CAM/BIM	17-3011	Architectural and Civil Drafters

Source: Emsi and ICF

For the purposes of this report and summarizing the findings in this report, the occupations were also grouped into occupational clusters informed by the Center of Excellence, California Community Colleges Energy Construction & Utilities Sector occupational clusters. See Exhibit 2.

Exhibit 2: Energy Occupations Mapped to Occupational Clusters

SOC / ONET Code(s)	Occupation	Occupational Cluster
47-2152	Plumbers, pipefitters, and steamfitters	Construction
17-1021	Cartographers and Photogrammetrists	Drafters
17-3012	Electrical and Electronics Drafters	Drafters

SOC / ONET Code(s)	Occupation	Occupational Cluster
17-3013	Mechanical Drafters	Drafters
17-3011	Architectural and Civil Drafters	Drafters
11-3051.05	Methane/Landfill Gas Collection System Operators	Energy
19-4041	Geological and Petroleum Technicians	Energy
47-2111	Electricians	Energy
47-2231	Solar Photovoltaic Installers	Energy
47-4099.02	Solar Thermal Installers and Technicians	Energy
47-5011	Derrick Operators, Oil and Gas	Energy
47-5012	Rotary Drill Operators, Oil and Gas	Energy
47-5013	Service Unit Operators, Oil, Gas, and Mining	Energy
47-5071	Roustabouts, Oil and Gas	Energy
49-9012	Control and valve installers and repairers, except mechanical door	Energy
49-9021	Heating, air conditioning, and refrigeration mechanics and installers	Energy
49-9081	Wind Turbine Service Technicians	Energy
49-9099.01	Geothermal Technicians	Energy
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Energy
51-8021	Stationary engineers and boiler operators	Energy
51-8092	Gas Plant Operators	Energy
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	Energy
51-9061	Inspectors, testers, sorters, samplers, and weighers	Energy
53-7073	Wellhead Pumpers	Energy
53-7071	Gas Compressor and Gas Pumping Station Operators	Energy
53-7072	Pump Operators, Except Wellhead Pumpers	Energy
17-3023	Electrical and electronics engineering technicians	Engineering Technicians
49-2094	Electrical and electronics repairers, commercial and industrial equipment	Engineering Technicians
49-9041	Industrial machinery mechanics	Engineering Technicians
17-3029.02	Electrical Engineering Technologists	Engineering Technologists
17-3029.03	Electromechanical Engineering Technologists	Engineering Technologists
17-3029.04	Electronics Engineering Technologists	Engineering Technologists
17-3029.05	Industrial Engineering Technologists	Engineering Technologists
17-3029.07	Mechanical Engineering Technologists	Engineering Technologists
15-1199.02	Computer Systems Engineers/Architects	Information and Communications Technology
15-1143	Computer Network Architects	Information and Communications Technology
15-1142	Network and Computer Systems Administrators	Information and Communications Technology
15-1143.01	Telecommunications Engineering Specialists	Information and Communications Technology
15-1121	Computer Systems Analysts	Information and Communications Technology
15-1122	Information Security Analysts	Information and Communications Technology
15-1133	Software Developers, Systems Software	Information and Communications Technology
11-1021	General and Operations Managers	Managers
11-3071.01	Transportation Managers	Managers
11-3071.02	Storage and Distribution Managers	Managers
11-3071.03	Logistics Managers	Managers
11-3051	Industrial production managers	Managers
11-3051.02	Geothermal Production Managers	Managers
11-3051.04	Biomass Power Plant Managers	Managers
11-3051.06	Hydroelectric Production Managers	Managers
11-9021.00	Construction Managers	Managers
11-9199.09	Wind Energy Operations Managers	Managers
11-9199.10	Wind Energy Project Managers	Managers
47-1011.03	Solar Energy Installation Managers	Managers

SOC / ONET Code(s)	Occupation	Occupational Cluster
49-1011	First-line supervisors/managers of mechanics, installers, and repairers	Managers
17-2051	Civil Engineers	Professional Engineers
17-2071	Electrical Engineers	Professional Engineers
17-2072	Electronics Engineers, Except Computer	Professional Engineers
17-2081	Environmental Engineers	Professional Engineers
17-2112	Industrial Engineers	Professional Engineers
17-2141	Mechanical Engineers	Professional Engineers
17-2141.01	Fuel Cell Engineers	Professional Engineers
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	Professional Engineers
17-2171	Petroleum Engineers	Professional Engineers
17-2199.03	Energy Engineers	Professional Engineers
17-2199.05	Mechatronics Engineers	Professional Engineers
17-2199.06	Microsystems Engineers	Professional Engineers
17-2199.10	Wind Energy Engineers	Professional Engineers
17-2199.11	Solar Energy Systems Engineers	Professional Engineers
11-2011.01	Green Marketers	Sales, Marketing, or Business
13-1161	Market Research Analysts and Marketing Specialists	Sales, Marketing, or Business
13-1199.01	Energy Auditors	Sales, Marketing, or Business
13-2011	Accountants and Auditors	Sales, Marketing, or Business
41-3099.00	Energy Brokers/Sales Representatives, Services, All Other	Sales, Marketing, or Business
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	Sales, Marketing, or Business
41-4011.07	Solar Sales Representatives and Assessors	Sales, Marketing, or Business
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	Sales, Marketing, or Business
43-4051	Customer Service Representatives	Sales, Marketing, or Business
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Utilities
49-9051	Electrical Power-Line Installers and Repairers	Utilities
49-9052	Telecommunications Line Installers and Repairers	Utilities
49-9071	Maintenance and repair workers, general	Utilities
51-8012	Power Distributors and Dispatchers	Utilities
51-8013	Power Plant Operators	Utilities
51-8099.01	Biofuels Processing Technicians	Utilities
51-8099.02	Methane/Landfill Gas Generation System Technicians	Utilities
51-8099.03	Biomass Plant Technicians	Utilities
51-8099.04	Hydroelectric Plant Technicians	Utilities

Source: Emsi and ICF

This Market Assessment report is divided into seven tasks. Tasks 1-3 were part of Phase 1 of the research and focused on understanding the baseline jobs and skills and how they are being affected by current California policies. Task 1 identifies the baseline number of jobs and energy related skills for the identified occupations. Task 2 is an assessment and literature review of how California state policies are affecting and will continue to affect demand for labor in the identified occupations. Task 3 identifies available training resources for each occupation. Tasks 4-7 were part of Phase 2 of the research. Tasks 4 & 5 discuss changes in technology in the clean energy economy and new and expanded skills needed by the workforce. Task 6 provides employment projections for the selected energy-related occupations through 2022. Task 7 is the occupational gap analysis comparing occupational demand to occupational supply.

III. Task 1: Related Skills Baseline Jobs and Energy

As part of the market demand analysis, ICF identified the number of jobs in California in 2018 across the 87 identified energy-related occupations and determined baseline energy-related skills specific to those occupations. ICF utilized the Emsi Developer labor market analytics tool to collect LMI and O*NET to examine the key tasks, required skills, knowledge, and abilities for energy-related occupations and summarized these results by occupational cluster, which is delineated in detail below.

We compiled the LMI data (in Appendix B) for energy-related occupations within the direct energy industry sectors (as defined for this report) and, separately, (in Appendix C) for all industry sectors. We focus the demand analysis below on the occupational data for all sectors because the literature and employer interviews indicate that the competition for these occupations is not limited to the energy sector and employers are recruiting employees with core skills sets from other sectors and conducting specialized on-the-job training as needed. The comprehensive occupational skills profiles per occupation can be found in Supplemental Attachment 1.

1. Baseline Jobs in California - All Industry Sectors

Using Emsi data, ICF analyzed 65 occupations[6] across all industry sectors in California. Analyzing the employment totals for these energy-related occupations across all sectors provides a more relevant representation of the California labor force for these occupations in terms of enumerating the current demand projections for 2018 and the future ones through 2028.

In 2018, there were almost 3.1 million jobs in the energy-related occupations across all industry sectors and it is projected that another 275,744 jobs will be created in these occupations over the next 10 years in California, a 9% growth rate. In the short-term through 2022, almost 160,000 jobs are projected, a 5.2% growth rate.

Exhibit 3 below displays the top energy-related occupations in all sectors with greater than 15% growth over the next decade. Five occupations show a greater than 20% growth rate over the next ten years. Wind Turbine Service Technicians (49-9081) and Solar Photovoltaic Installers (47-2231), occupations specific to clean energy, have the highest rates of projected growth over the next ten years at 52% and 78% respectively. In the short-term through 2022, these two occupations also have the highest projected growth; by 2022, Wind Turbine Service Technicians (49-9081) are expected to grow 25.5% adding 320 jobs and Solar Photovoltaic Installers (47-2231) are expected to grow 38%, adding almost 1,800 jobs. (See Appendix F for projections through 2022). These occupations also have a Location Quotient (LQ) greater than one, indicating that the concentration of these occupations in California is greater than in the rest of the United States. Solar Photovoltaic Installers (47-2231) has the largest location quotient of all 65 occupations at 2.62 so it is not only the occupation positioned to experience the highest relative growth by 2028, but this occupation also has over 2.5 times the concentration of workers than in the U.S. as a whole. This indicates that solar energy production is a very strong sector in California, likely due to locational advantages that the State's climate offers and technological advantages of its workforce. Solar Photovoltaic Installers (47-2231) is projected to have over 10,500 job openings from 2018–2028, roughly 1,050 job openings annually across the state. Job openings represent new job creation from growth and replacement jobs for attrition and retirements. Wind Turbine Service Technicians (49-9081) shows a high growth rate over the next ten years, but the volume of these jobs is relatively small compared to other occupations; the total projected openings from 2018-2028, is just over 2,100 jobs.

[6] As noted earlier, while 87 occupational SOC-O*Net codes were identified for this analysis, Emsi LMI data is available only by SOC, meaning that 22 of the more detailed O*Net codes are rolled up into their higher-level SOC codes. Thus, a total of 65 SOC codes are analyzed in this analysis.

Information Security Analysts (15-1122) has the third highest growth rate among the selected energy-related occupations, projected to grow by 31% (adding an additional 13,082 jobs to the labor market) by 2028. Other occupations with a greater than 20% projected increase in jobs are Roustabouts, Oil and Gas (47-5071) and Electrical Power-Line Installers and Repairers (49-9051). Heating, Air Conditioning, and Refrigeration Mechanics and Installers (49-9021), Market Research Analysts and Marketing Specialists (13-1161), and Plumbers, Pipefitters, and Steamfitters (47-2152), are all projected to grow between 18-19%, and have over 42,000, 145,000, and 80,000 job openings from 2018-2028, respectively.

Comparatively, energy-related occupations with the highest number of projected total job openings are more generic in nature like Customer Service Representatives (43-4051) or General and Operations Managers (11-1021) which have total projected openings of 342,200 and 263,490, respectively, over the next decade across all sectors. These occupations are very prevalent across a range of industry sectors and contain a far larger number of workers than the other selected energy-related occupations.

Exhibit 3: Summary Table for Top Energy-Related Occupations across All Sectors with Projected Growth above 15% from 2018-2028

SOC	Occupation Name	Employed (2018)	% Change (2018-2028)	2018 Location Quotient	Total Projected Openings (2018-2028)	Automation Index
47-2231	Solar Photovoltaic Installers	4,736	77.6%	2.62	10,544	119.7
49-9081	Wind Turbine Service Technicians	1,256	52.3%	1.14	2,178	106.3
15-1122	Information Security Analysts	9,960	31.3%	0.70	10,798	86.4
47-5071	Roustabouts, Oil and Gas	2,493	27.1%	0.31	4,086	123.5
49-9051	Electrical Power-Line Installers and Repairers	7,834	20.8%	0.55	8,526	114.0
47-5013	Service Unit Operators, Oil, Gas, and Mining	2,941	19.4%	0.43	4,450	106.1
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	34,468	19.0%	0.72	42,736	113.0
13-1161	Market Research Analysts and Marketing Specialists	120,101	17.9%	1.31	146,594	88.6
47-2152	Plumbers, Pipefitters, and Steamfitters	61,490	17.8%	0.91	80,664	116.3
47-5011	Derrick Operators, Oil and Gas	672	17.4%	0.44	981	106.6
17-1021	Cartographers and Photogrammetrists	1,783	16.8%	0.88	1,672	94.2
47-5012	Rotary Drill Operators, Oil and Gas	1,296	16.0%	0.50	1,864	110.9

Source: Emsi

Another essential metric to underscore in analyzing these occupations is the Automation Index, where occupations that have a value above 100 have an above average risk of being affected by automation. In Exhibit 3 above, the occupations Roustabouts, Oil and Gas (47-5071) and Solar Photovoltaic Installers (47-2231) have an Automation Index of 123.5 and 119.7, respectively. Of the highest-growth occupations in Exhibit 3, nine of the 12 have Automation Indexes greater than 100. Emsi's Automation Index is made up of a number of factors that project the risk of an occupation becoming automated. Tasks performed by workers in the occupation plays a major role. Occupations that have tasks that can be automated through the use of artificial intelligence or robotics will have higher Automation Indexes. Despite the high

Automation Indexes for occupations such as Solar Photovoltaic Installers (47-2231), Wind Turbine Service Technicians (49-9081), Roustabouts, Oil and Gas (47-5071), and Electrical Power-Line Installers and Repairers (49-9051), these occupations respresent primary functions in the energy sector and are projected to continue to be in high demand and grow significantly over the next 10 years. Given the tasks involved in these jobs, it is possible that over time these occupations may begin to acquire more automated functions, however, which may or may not impact employment. At this point, however, the data does not suggest a decline in employment from automation over the next 10 years but it is likely that these occupations will need to obtain new competencies and skills oriented towards managing, maintaining, and operating technologies or systems that control automation.

Exhibit 4 below details the educational, work, and on-the-job training (OJT) requirements for these occupations expected to experience more than 15% growth by 2028. In referencing the table below, 11 out of the 12 highest growth occupations do not require previous work experience. Regarding education level and typical OJT, these occupations have varied requirements due to the nature of their job responsibilities and duties. For instance, Market Research Analysts and Marketing Specialists (13-1161), which is expected to have a relatively significant amount of total job openings over the next ten years, requires a bachelor's degree. Information Security Analysts (15-1122) and Cartographers and Photogrammetrists (17-1021) also require a bachelor's degree. However, three of these high-growth occupations only require a high school diploma or equivalent, including Solar Photovoltaic Installers (47-2231), Electrical Power-Line Installers and Repairers (49-9051), and Plumbers, Pipefitters, and Steamfitters (47-2152). Of note, these three occupations are expected to add over 16,000 jobs in by 2028 and require moderate-term, long-term, and apprenticeship training, respectively. Furthermore, there are four high-growth occupations in Exhibit 4 (which in total are expected to add just over 1,500 jobs by 2028) that require no formal education credential but are supplemented by some form of OJT. Thus, given the amount of job creation expected over the next decade among these seven occupations, their lower educational requirements will allow for a larger portion of the general population to quickly be trained in the skills required for these occupations to satisfy future demand.

Exhibit 4: Education, Work, and On-the-Job Training Requirements for Top Energy-Related Occupations across All Sectors with Projected Growth above 15% from 2018-2028[7]

SOC	Occupation Name	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
47-2231	Solar Photovoltaic Installers	HSD	None	Moderate-term
49-9081	Wind Turbine Service Technicians	Postsecondary	None	Long-term
15-1122	Information Security Analysts	Bachelor's degree	Less than 5 years	None
47-5071	Roustabouts, Oil and Gas	No formal	None	Moderate-term
49-9051	Electrical Power-Line Installers and Repairers	HSD	None	Long-term
47-5013	Service Unit Operators, Oil, Gas, and Mining	No formal	None	Moderate-term
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Postsecondary	None	Long-term
13-1161	Market Research Analysts and Marketing Specialists	Bachelor's degree	None	None
47-2152	Plumbers, Pipefitters, and Steamfitters	HSD	None	Apprenticeship
47-5011	Derrick Operators, Oil and Gas	No formal	None	Short-term
17-1021	Cartographers and Photogrammetrists	Bachelor's degree	None	None

[7] "HSD" indicates a high school diploma or equivalent is required; "No formal" indicates no formal education credential required; "Postsecondary" indicates postsecondary nondegree award is required.

47-5012	Rotary Drill Operators, Oil and Gas	No formal	None	Moderate-term

Source: Emsi

While most energy-related occupations are projected to grow over the next ten years (85% of the 65 selected occupations), 10 occupations are projected to experience negative growth during this period. Most of the occupations that are projected to decline are related to the oil and gas industry, which are being impacted by the shift to renewable forms of energy in California, such as solar and wind. Exhibit 5 below shows these 10 occupations and selected occupational data. As listed in the table below, Gas Compressor and Gas Pumping Station Operators (53-7071) is projected to experience the largest percent decline in jobs by 2028, losing approximately 250 jobs (or decreasing by 21%). The occupation Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers (51-2028) is estimated to experience a loss of almost 6,000 jobs by 2028 (16% decline) and concurrently has an Automation Index value of 110.9. This suggests that market conditions are expected to negatively impact growth and it could be that instead of automation changing the nature of this occupation in terms of new skills or proficiencies needed to adapt to the presence and use of technology, automation could be one factor hindering the growth of this occupation. Furthermore, this occupation has the highest Automation Index of all the occupations projected to have negative growth. Fifty percent of the occupations listed in Exhibit 5 have Automation Indexes over 100. Focusing training initiatives and efforts on occupations defined by projected job losses and Automation Indexes over 100 might be counterproductive.

Exhibit 5: Summary Table for Energy-Related Occupations across All Sectors with Negative Projected Growth from 2018-2028

SOC	Occupation Name	Employed (2018)	% Change (2018-2028)	2018 Location Quotient	Total Projected Openings (2018-2028)	Automation Index
53-7071	Gas Compressor and Gas Pumping Station Operators	1,176	-21.3%	1.13	1,260	97.9
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	36,636	-16.3%	1.15	39,627	110.9
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	4,590	-8.6%	0.94	4,458	104.0
51-8092	Gas Plant Operators	1,240	-5.7%	0.66	1,308	101.1
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	64,735	-5.5%	0.90	76,861	106.1
19-4041	Geological and Petroleum Technicians	1,746	-2.1%	0.83	1,819	87.9
17-2072	Electronics Engineers, Except Computer	31,223	-1.3%	1.74	20,342	85.4
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	179,662	-0.8%	0.93	185,812	91.5
51-8099	Plant and System Operators, All Other	1,641	-0.8%	0.89	1,647	110.2
17-2171	Petroleum Engineers	2,521	-0.6%	0.55	1,760	82.0

Source: Emsi

In addition to examining growth rates, it is important to contextualize this information in terms of job volume to determine where training resources should be allocated and what occupations strategic initiatives should target to have the greatest impact in preparing the future workforce. Exhibit 6 below displays the top occupations across all sectors projected to experience a net increase in jobs of over

10,000 by 2028 and selected occupational data. As mentioned previously, energy-related occupations that are more broadly represented across a large number of industries have a larger net increase in jobs. In referencing the table below, the occupations Managers, All Other (11-9199), General and Operations Managers (11-1021), and Customer Service Representatives (43-4051) are positions that are represented across many industry sectors. In California, they are projected to contribute a combined 83,231 jobs to the economy by 2028 and these three occupations have Automation Indexes below 100 since these jobs tend to have people facing, soft-skill requirements. Conversely, there are three occupations listed in Exhibit 6 that also have Automation Indexes over 100: Maintenance and Repair Workers, General (49-9071), Electricians (47-211), and Plumbers, Pipefitters, and Steamfitters (47-2152). The latter has the highest relative Automation Index of 116.3. These occupations are expected to significantly expand in terms of job volume over the next decade and but also estimated to have an above average risk of being impacted by automation. Thus, these three occupations will probably have to develop and obtain new skills and knowledge that complement how automation will change their current occupational tasks to meet the expected labor demand and the transition to clean energy and the green economy.

Exhibit 6: Summary Table for Energy-Related Occupations across All Sectors with Largest Projected Job Change over 10,000 from 2018–2028

SOC	Occupation Name	Employed (2018)	Job Change (2018-2028)	% Change (2018-2028)	Total Projected Openings (2018-2028)	Automation Index
11-9199	Managers, All Other	262,696	31,933	12.2%	225,104	84.5
11-1021	General and Operations Managers	280,199	27,008	9.6%	263,490	82.2
43-4051	Customer Service Representatives	238,517	24,290	10.2%	342,200	96.4
13-1161	Market Research Analysts and Marketing Specialists	120,101	21,502	17.9%	146,594	88.6
41-3099	Sales Representatives, Services, All Other	164,891	17,596	10.7%	223,864	96.7
49-9071	Maintenance and Repair Workers, General	156,364	16,966	10.9%	176,299	109.6
13-2011	Accountants and Auditors	217,297	16,775	7.7%	214,548	93.1
13-1199	Business Operations Specialists, All Other	171,496	14,452	8.4%	174,077	86.8
47-2111	Electricians	81,242	12,112	14.9%	108,283	110.3
47-2152	Plumbers, Pipefitters, and Steamfitters	61,490	10,974	17.8%	80,664	116.3
15-1121	Computer Systems Analysts	87,125	10,155	11.7%	69,195	81.7

Source: Emsi

Exhibit 7 lists the non-professional engineering, energy-related occupations that have a 2018 hourly earnings over $40.00. The professional engineering occupations (excluded from the exhibit) had an average hourly wage range of $43.54 for Engineers, all other (17-2199) to $63.42 for Mining and Geological Engineers, Including Mining Safety Engineers (17-2151) in 2018 in California. The average hourly wage across all selected energy-related occupations was $32.53 in 2018. The high-wage jobs shown in Exhibit 7 are all expected to experience growth over the next ten years except for Gas Plant Operators (51-8092). Many of these high-wage occupations are in the “Information and Communications Technology (ICT)” and “Managerial” occupational clusters. ICT jobs are becoming increasing important in energy, as the sector continues to automate many systems. Electrical Power-Line Installers and Repairers (49-9051), Power Plant Operators (51-8013), and Electrical and Electronics Repairers, Powerhouse, Substation, and Relay (49-2095) are more traditional energy occupations that are also

relatively high paying and are also projected to grow over next 10 years. These occupations also only require a high school diploma or equivalent or a postsecondary nondegree award as an entry-level educational requirement, have no or less than 5 years of previous work experience required, and have moderate- or long-term OJT requirements for employees.

Exhibit 7: Summary Table for Non-Engineering, Energy-Related Occupations across All Sectors with 2018 Median Hourly Earnings over $40

SOC	Occupation Name	Employed (2018)	Job Change (2018-2028)	% Change (2018-2028)	2018 Median Hourly Earnings	Automation Index
15-1143	Computer Network Architects	18,712	2,222	11.9%	$58.50	87.1
15-1133	Software Developers, Systems Software	89,674	8,803	9.8%	$58.21	78.2
15-1122	Information Security Analysts	9,960	3,122	31.3%	$52.10	86.4
11-1021	General and Operations Managers	280,199	27,008	9.6%	$51.16	82.2
49-9051	Electrical Power-Line Installers and Repairers	7,834	1,629	20.8%	$50.71	114.0
51-8092	Gas Plant Operators	1,240	-71	-5.7%	$47.90	101.1
11-3051	Industrial Production Managers	21,891	480	2.2%	$47.73	80.9
51-8013	Power Plant Operators	3,394	448	13.2%	$46.22	108.8
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	2,787	66	2.4%	$46.15	99.9
15-1121	Computer Systems Analysts	87,125	10,155	11.7%	$44.12	81.7
15-1142	Network and Computer Systems Administrators	45,032	4,535	10.1%	$43.30	87.2
11-3071	Transportation, Storage, and Distribution Managers	21,363	2,231	10%	$41.93	88.2
15-1199	Computer Occupations, All Other	57,782	6,316	10.9%	$41.18	85.5

Source: Emsi

Due to the increasing prevalence and use of automation across all industries in the economy, it is necessary to focus on and isolate energy-related occupations expected to be most and least impacted by automation in California. The Emsi Automation Index captures an occupation's risk of being affected by automation derived from four measures: percent time spent on tasks at high-risk of automation; percent of time spent on tasks at low-risk of automation; number of high-risk jobs in compatible occupations; and the overall industry automation risk[8]. Overall, the average Automation Index across all 65 of these energy-related occupations for all sectors is 97.4. Exhibit 8 below lists the six occupations with the highest and lowest Automation Indexes. As mentioned previously, Roustabouts, Oil and Gas (47-5071) and Solar Photovoltaic Installers (47-2231) have the highest Automation Indexes of all 65 occupations but are also are expected to experience high growth. This indicates that despite automation being a disruptive force to the original work and responsibilities of these occupations, these occupations will continue to expand by 2028. Therefore, these occupations will most likely have to obtain additional competencies orientated towards operating, monitoring, and repairing systems and technologies that will leverage automation within their own job contexts. Furthermore, the Plumbers, Pipefitters, and Steamfitters (47-2152) occupation has a relatively high Automation Index (116.3) but is expected to contribute almost 11,000 jobs and will have over 80,000 total job openings over the next ten years across the state. This occupation will likely have to understand the operation of and learn how to repair plumbing and water heating systems that more predominantly rely on automation, which will require an enhanced skillset and additional training to fill these jobs. Conversely, the occupations with the lowest Automation

[8] Emsi. (n.d.). Retrieved May 22, 2019, from https://kb.economicmodeling.com/glossary/.

Indexes across the 65 occupations are largely engineering, information and communications technology, and managerial positions. These occupations are highly design and technically oriented or people-oriented and are less impacted by automation. Many of these engineers and ICT workers design the automation processes.

Exhibit 8: Summary Table for Energy-Related Occupations across All Sectors with Top 6 Highest and Lowest Automation Indexes

SOC	Occupation Name	Employed (2018)	Job Change (2018-2028)	% Change (2018-2028)	Total Projected Openings (2018-2028)	Automation Index
47-5071	Roustabouts, Oil and Gas	2,493	675	27.1%	4,086	123.5
47-2231	Solar Photovoltaic Installers	4,736	3,677	77.6%	10,544	119.7
47-4098	Miscellaneous Construction and Related Workers	4,036	597	14.8%	5,171	118.8
49-9052	Telecommunications Line Installers and Repairers	14,912	483	3.2%	15,709	116.9
47-2152	Plumbers, Pipefitters, and Steamfitters	61,490	10,974	17.8%	80,664	116.3
53-7073	Wellhead Pumpers	6,974	672	9.6%	9,714	115.1
17-2051	Civil Engineers	50,872	4,492	8.8%	42,540	81.7
15-1121	Computer Systems Analysts	87,125	10,155	11.7%	69,195	81.7
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	524	78	14.9%	495	81.1
11-3051	Industrial Production Managers	21,891	480	2.2%	16,778	80.9
15-1133	Software Developers, Systems Software	89,674	8,803	9.8%	68,872	78.2
17-2081	Environmental Engineers	8,453	417	4.9%	6,071	76.6

Source: Emsi

Beyond the information presented above, Appendix C includes additional metrics by energy-related occupation. These metrics include *Replacement Job*, which indicates the number of job openings resulting from attrition and retirements and *Regional Completions* data for each occupation and for each year between 2012 and 2017. The latter represents the number of degrees or certifications conferred by educational institutions in California associated to each occupation. This data indicates the available "supply" of workers who have earned appropriate credentials to potentially be employed in a given occupation; this is discussed further in the Gap Analysis section of this report. Appendix C also lists employment totals per occupation across all sectors by various demographic characteristics such as age group, gender, and race. Occupational requirement data is also provided in terms of typical entry-level education, work experience, and OJT by occupation. Lastly, Appendix C includes the average hourly and annual earnings and the hourly and annual earnings for the 10th, 25th, 50th, 75th, and 90th percentiles per occupation.

2. Energy-Related Skills

The following analysis summarizes energy-related skills and tasks performed by each occupational cluster to identify commonalities in skillsets that prospective workers need to achieve competency in to gain viable employment in the emerging energy sector in California. In Supplemental Attachment 1, there is comprehensive information delineating the following information per energy-related occupation:

- Tasks
- Technology skills and other skills

- Knowledge
- Abilities
- Work activities (both general and detailed)
- Work context
- Distribution of education and credentials among existing workforce

The content that follows will only underscore energy-related tasks and skills required by each occupational cluster to reveal commonalities and help identify the kind of skills workers need to obtain to secure employment for these energy-related occupations. All data is sourced from O*Net.

2.1 Professional Engineers

Energy-Related Skills and Tasks for Professional Engineers Occupational Cluster:

Design and develop systems and structures that use renewable energy

Track environmental patterns and conditions

Consult stakeholders on environmental impacts and hazards

The "Professional Engineers" occupational cluster is comprised of traditional engineering occupations such as Civil Engineers (17-2015), Mechanical Engineers (17-2141), Wind Energy Engineers (17-2199.10), and Energy Engineers (17-2199.03). While all these occupations to some extent design and develop new products and structures using advanced computer software, there are several energy-specific skills in this occupational cluster that workers will need to adopt. For instance, these occupations need to have skills related to designing and developing systems and structures that largely utilize renewable energy sources and minimize the environmental impact in terms of carbon emissions. They also focus on researching and developing green technologies that can be leveraged by commercial and residential entities that are less invasive on the surrounding environment and are simultaneously cost-effective. To do this type of work, occupations in this cluster need to be able to collect and interpret data to identify environmental risks and track environmental conditions to corroborate the development of the best technical solution that will resolve societal, consumer, and environmental needs. These occupations also have to monitor, test, and maintain systems that leverage non-traditional energy sources such as wind and solar. Lastly, these occupations play an influential role when it comes to consulting with private entities and government agencies on appropriate strategies, policies, and procedures to employ that can most effectively serve a desired functional goal but also protect the local population and environment from unwarranted harm. Therefore, not only are occupations in this cluster at the forefront of developing and creating these energy-efficient technologies and systems but they will concurrently serve as subject matter experts—and will collaborate with other relevant stakeholders like scientists, environmental planners, and those in environmental law—to influence policy, create plans, and serve as liaisons on issues pertaining to environmental impact or potential hazards. Professionally engineering degrees almost exclusively require four-year college degrees at a minimum.

2.2 Engineering Technologists

Occupations such as Electrical Engineering Technologist (17-3029.02) and Industrial Engineering Technologist (17-3029.07) constitute the "Engineering Technologist" occupational cluster, which consists of occupations devoted to the implementation of existing technology within a specific field of engineering. However, specific to the clean economy and energy sector, these occupations assemble and test power-saving devices, energy-efficient power charges, thermodynamic systems, solar photovoltaic devices, electromechanical components, and other green technologies initially designed by those in the "Professional Engineers" occupational cluster. Furthermore, these occupations need to be able to determine whether these systems and products comply with environmental standards and regulations and whether their sustainable design are cost-effective. Being able to modify and create products to use in renewable energy generation and develop energy-conserving production or fabrication methods are also essential to how these occupations will support the evolving energy sector. Beyond assisting engineers with the development and implementation of products for sustainable applications, these occupations continually evaluate whether the function of these products is environmentally viable and make enhancements when needed to maximize energy production or mitigate adverse environmental effects. These occupations employ a mix of four-year degree and associate's degree and post-secondary certificate holders. Within the "Engineering Technologists" cluster, Industrial Engineering Technologists (17-3029.07) is the occupation with the highest proportion of four-year holders (68%) and Electronics Engineering Technologists (17-3029.04) is the lowest at 22%.

Energy-Related Skills and Tasks for Engineering Technologists Occupational Cluster:

Test power-saving and clean energy devices

Support development of sustainable products

Ensure products comply with environmental standards

2.3 Managers

The "Managers" occupational cluster includes all managerial and energy-related manager occupations. This group is comprised of occupations as universal as General and Operations Managers (11-1021) and occupations as specific as Solar Energy Installation Managers (47-1011.03) and Wind Energy Operations Mangers (11-9199.09). While the content knowledge required across these managerial positions vary greatly in terms of topic area, all these occupations require energy-specific skills. Specifically, from a coordination and planning standpoint, these occupations need to develop the scope of work for and then later direct and manage green engineering or construction activities to ensure sustainability objectives are met across projects. Managers need to have substantial knowledge of how to complete applications for environmental permits and documentation for environmental audits to ensure compliance with numerous environmental standards and regulations. They need to employ strategies in project workflows that conserve energy and predominantly leverage natural resources and to provide technical support and expertise to employees and subcontractors specific to energy production and sustainability. The occupations in this cluster need to take measures to ensure efficiency, effectiveness, or sustainability of operations (including supply chain and logistical enhancements) and need to train employees in environmental issues and policies. Lastly, managers need to take initiative in applying green and energy-conserving strategies to reduce costs and minimize carbon output and in developing budgets that compare green and non-green alternatives in terms of short-term costs, long-term costs, and environmental impacts. Occupations in this cluster employ a range of terminal qualifications from bachelor's and master's degrees to high school diplomas and post-secondary certificate holders. Solar Energy Installation Managers (47-1011.03) and First-line supervisors/mangers of mechanics, installers, and repairers (49-1011) do not require four-year degrees and the data shows that those with high school diplomas, post-secondary certificates, or associate's degrees make up the majority of those employed in these occupations. On the other hand, over 70% of those employed as Wind Energy Project Managers (11-9199.10), Wind Energy Operations Managers (11-9199.09), Construction Managers (11-9021.00) and Logistics Managers (11-3071.03) hold at least a bachelor's degree.

Energy-Related Skills and Tasks for Managers Occupational Cluster:

Manage green engineering and construction activities

Understand environmental permit and auditing processes

Train employees in environmental issues and policies

2.4 Information and Communications Technology (ICT)

The "Information and Communications Technology" occupational cluster is comprised of occupations such as Computer Systems Engineers/Architects (15-1199.02), Information Security Analysts (15-1122), and Software Developers, Systems Software (15-1133), among others. While these occupations are not limited to the energy sector, evidence suggests they are becoming increasingly important in the expansion of the clean energy economy particularly through the rise of automation, digitization, and digitalization[9]. As the demand for jobs in this area continues to increase, the occupations in this cluster are essential for supporting, developing, and securing the technology required to perform these clean energy activities. Specifically, these occupations create, operate, and maintain the comprehensive computer systems that smart grids, smart meters, and other renewable energy and green technologies use. Therefore, having a sound understanding of these newly developed technologies and their sustainable impact is vital to providing support and ensuring protection of these products and their associated data. Moreover, these occupations will have to obtain the knowledge to design, use, and dispose of computing systems and their components (networks, printers, monitors, etc.) in a way that decreases environmental impact and conserves energy. Lastly, developing and then managing software compatible to clean energy technological products will help facilitate a smoother implementation and integration of environmentally friendly systems into new or existing digital or virtual infrastructure. While some occupations (e.g., Software Developers) are predominantly held by those with four-year college degrees, for others such as Network and Computer Systems Administrators, Information Security Analysts, and Computer Systems Analysts the data show about only about 50% of those employed holding a bachelor's degree or higher. See Supplemental Attachment 1 – Occupational Profiles.

Energy-Related Skills and Tasks for ICT Occupational Cluster:

Maintain computer systems that support renewable energy

Design technology that conserves energy

Understand environmental impact of emerging and green technologies

2.5 Energy

Occupations in the "Energy" occupational cluster vary by function, for instance, this cluster includes diverse occupations such as Electricians (47-2111), Gas Plant Operators (51-8021), Wind Turbine Service Technicians (49-9081), and Derrick Operators, Oil and Gas (47-5011). Some of the energy-specific skills and tasks across these occupations include conducting activities related to the manufacturing, management, assembly, or installation of green technology as well as energy efficient processes. These occupations are also be positioned to integrate different types of renewable energy (such as solar, wind, and geothermal) into comprehensive energy efficiency systems and existing infrastructure to simultaneously conserve energy but maximize energy production. Compiling or maintaining records of these systems and products that leverage non-traditional energy sources is also important so their operation, performance, and maintenance can be effectively tracked and improved. These occupations will need to obtain a broad understanding of what materials, equipment, and

[9] DNV-GL. (n.d.). Digitalization and the Future of Energy: Beyond the Hype. Retrieved May 11, 2019, from https://www.dnvgl.com/power-renewables/themes/digitalization/index.html.

installation or implementation sequences are necessary to maximize efficiency and lessen adverse environmental impacts. Also, these types of occupations select designs, equipment, and plans that conform to and comply with environmental, architectural, structure, site, and code requirements while concurrently identifying electrical, environmental, or safety hazards associated with their work. Generally, these occupations apply and implement green technology or techniques to increase energy efficiency as well as collect and interpret data to address environmental issues and carry out various forms of preventative maintenance. For more specific energy-related skills and tasks for each of the disparate occupations that constitute this occupational cluster, please reference Supplemental Attachment 1.

Energy-Related Skills and Tasks for Energy Occupational Cluster:

- Integrate renewable energy into existing energy systems
- Understand what materials and equipment optimize energy production
- Ensure plans comply with environmental requirements

2.6 Utilities

Energy-Related Skills and Tasks for Utilities Occupational Cluster:

- Deliver and generate electricity from renewable energy sources
- Track energy performance of system operations
- Understand technical operation of wind, solar, geothermal, and biomass energy sources

The “Utilities” occupational cluster is made up of several occupations tasked with managing power distribution and other energy-specific processes. Some of the occupations that form this occupational cluster include Electrical Power-Line Installers and Repairers (49-9051), Biofuels Processing Technicians (51-8099.01), and Power Plant Operators (51-8013). While these occupations possess energy-specific skills tailored to their topical area of expertise, these occupations also share some commonalities in tasks performed. For instance, these occupations need to know mechanically how to deliver electricity from different sources of power generation, including renewable energy sources, by leveraging knowledge specific to interstate power grids and other forms of non-traditional energy. While they generally conduct activities related to developing and using energy sources such as solar, wind, geothermal, and biomass, they also help facilitate the technological changes from traditional, non-renewable sources of energy to clean energy. In the context of plant technicians, these occupations spearhead efforts to coordinate, regulate, or distribute electricity from the power plants over transmission lines to industrial plants, substations, and other commercial or residential users. These occupations also operate or maintain distributed power generation equipment, such as fuel cells or microturbines, to produce energy on-site for manufacturing, future distribution, or other commercial purposes. Furthermore, these occupations must be able to take readings and record data such as water levels, electricity voltage, or other metrics specific to their line of work and track energy performance of all operating systems and equipment. Lastly, they need to perform routine maintenance on equipment in the form of replacing parts, installing energy-efficient components, or reinforcing structural weaknesses to ensure optimal efficiency and that energy is not being lost. While the above skills and tasks broadly cover the occupations in this cluster, more specific energy-related information for these distinct occupations including their educational profiles can be found in Supplemental Attachment 1.

2.7 Sales, Marketing, and Business

The types of occupations that constitute the "Sales, Marketing, and Business" occupational cluster span various business operational and support roles such as Sales Representative, Wholesale and Manufacturing, Technical and Scientific Productions (41-4011), Green Marketers (11-2011.01), and Accountants and Auditors (13-2011). While the job functions and responsibilities between a sales representative, a market research analyst, and an accountant or auditor greatly differ, these occupations do embody similar energy-related skills and would need to perform specific tasks to support the evolution and expansion of the energy sector and the clean energy economy. For instance, some of these occupations in this cluster analyze regional energy markets, energy generation competition, energy transmission constraints, normative energy usage, or trends in green products or techniques to equip themselves with the knowledge to effectively sell and market to prospective customers or to make recommendations to clients in how to save energy costs. They attend or participate in conferences, community events, and promotional events related to green products or technologies, conduct research on target audiences for green products and services, or develop sales and marketing strategies to effectively serve and cater to the needs of the stakeholders in this expanding sector. More broadly, these occupations need to develop an understanding of the type of green or energy-technology they are providing to the market or suggesting to clients, how that type of equipment works so they can demonstrate its use to potential customers and dealers, and give technical information to convince prospective buyers of their expertise to corroborate their recommendations. Lastly, these occupations must be able to research and convey information to potential clientele about how their products are technically sound and environmentally friendly while also speaking to broader trends in topics like sustainability efforts, environmental remediation, or carbon reduction practices.

Energy-Related Skills and Tasks for Sales, Marketing, and Business Occupational Cluster:

Research and analyze energy markets, trends, and usage

Develop a sound understanding of green technologies

Participate in conferences or events related to clean energy

2.8 Engineering Technicians

Energy-Related Skills and Tasks for Engineering Technicians Occupational Cluster:

Manufacture green technology and energy efficient processes

Assemble and test components for renewable energy generation

The "Engineering Technicians" occupational cluster includes three unique occupations: Industrial Machinery Mechanics (49-9041), Electrical and Electronic Repairers, Commercial and Industrial Equipment (49-2094), and Electrical and Electronics Engineering Technicians (17-3023). These occupations conduct activities related to the manufacturing of green technology as well as energy efficient manufacturing processes. These occupations potentially test or assemble solar photovoltaic products or electrical components to be used in renewable energy generation or for consumer electronics applications. Additionally, they participate in the development or testing of electrical and manufacturing aspects of new green technologies or energy management systems. These occupations usually possess a post-secondary degree certificate or an associate's

degree. More detailed information specific to these occupations can be found in Supplemental Attachment 1.

2.9 Drafters

In the "Drafters" occupational cluster, the following four occupations are included: Cartographers and Photogrammetrists (17-1021), Electrical and Electronics Drafters (17-3012), Mechanical Drafters (17-3013), and Architectural and Civil Drafters (17-3011). The energy-related skills and tasks associated with these occupations are predominantly comprised of supporting engineers and other stakeholders tasked with designing, developing, and constructing green and clean energy technologies and systems. Specifically, these occupations consult with environmental, wind energy, and other engineers to discuss or interpret design concepts, or determine requirements of detailed working drawings, for green technology or clean energy projects. Additionally, they draft detail and assembly drawings of design components for products and systems that leverage renewable energy sources, specifically drawing circuitry or printed circuit boards, using computer-assisted equipment (such as CAD software) or standard drafting techniques and devices. Conducting other supportive activities related to constructing new green buildings, retrofitting residential and commercial buildings, and installing other green construction technology are also part of these occupations' responsibilities. Many of these workers will utilize Building Information Modeling (BMI) technology, a 3-D model based process that provides architecture, engineering, and construction professional the tools to efficiently design, construct, and manage buildings and infrastructure. Lastly, the occupations in this occupational cluster also focus on modifying and revising designs to correct operating deficiencies, conserve energy, mitigate overall environmental impact, and reduce other production problems.

Energy-Related Skills and Tasks for Drafters Occupational Cluster:

Create work and assembly drawings for clean energy projects

Collaborate with engineers to develop green technologies

Modify designs to conserve energy and reduce environmental impacts

2.10 Construction

There is only one occupation categorized under the "Construction" cluster in this analysis[10]. This occupation is Plumbers, Pipefitters, and Steamfitters (47-2152). Given the transition to and the growing dependence on clean energy and other renewable energy sources, workers in this occupation will not only have to enhance their current skillset and on-the-job knowledge to adapt to the changes in this industry, but also adopt new ones to better anticipate and support consumer needs. Specifically, this occupation need to know how to install fixtures, pipe systems, appliances, and other equipment designed to reduce energy consumption and water usage. Additionally, this occupation will need to develop an expertise related to information on governmental incentive programs and general industry trends related to the installation and use of energy or water saving devices to effectively assist and guide prospective clients in the buying process. With this, this occupation will need to be able to perform plumbing audits to identify ways in which consumers can reduce energy consumption in their household or commercial building and to recommend energy or water saving products that are highly efficient and cost-effective. Installing alternative water sources, green plumbing equipment, and solar thermal or solar photovoltaic water heating systems is another aspect of this occupation that will become more prominent given the changes in the energy industry. Lastly, this occupation needs to be able to calculate and project potential cost savings for selected clients if they decide to install energy-efficient systems or appliances.

Energy-Related Skills and Tasks for Construction Occupational Cluster:

Install energy- or water-saving systems or appliances

Understand governmental incentive programs

Recommend ways consumers can save energy and water

IV. Task 2: How California Policies affect Demand for Energy Related Occupations

California is a global leader in aggressively implementing policies and legislation to combat climate change and to de-carbonize its economy, particularly in the energy, construction, and transportation sectors. Climate policies have been implemented variably through Executive Orders, legislation, and regulation – commonly, an Executive Order is issued, which the legislature codifies and directs agencies (Public Utility Commission, Energy Commission) to act on by implementing regulations. This section of the report summarizes key findings from a broad survey of academic and industry literature, reinforced by a series of employer interviews. Complete findings are in Appendix D.

Current legislation calls for the state to power 100% of its electricity grid through renewable sources by 2045, a reduction of Greenhouse Gases (GHG) emissions to 40% below 1990 levels by 2030, and a doubling of energy efficiency by 2030. Former Governor Brown expanded the GHG goal through Executive Order to be completely carbon neutral by 2045. The 2019 Update to Title 24 requires all new low-rise residential buildings to install solar power beginning in 2020. Beginning with the 2002 passage of

[10] Other occupations that might be considered in a "Construction" occupational cluster such as Electricians and HVAC Mechanics and Installers were grouped under other occupational clusters for the purposes of this analysis, based on the Center of Excellence, California Community Colleges Energy Construction & Utilities Sector occupational clusters. Additionally, there may be other Construction occupations such as Construction Carpenters or Framers that were not included as part of the Energy Industries in this analysis.

California's first Renewables Portfolio Standard (RPS), evidence shows positive economic and workforce impacts from climate legislation.

From 2002-2018, California's legislature passed dozens of key pieces of legislation addressing climate in three primary ways: 1) Renewable Energy; 2) GHG Reduction; and 3) Energy Efficiency. In addition, the Transportation sector gets much specific attention in the legislation because it accounts for 40% of GHG emissions. Approximately half of the bills funded, authorized, or encouraged workforce training and job creation explicitly. A table of the key legislation can be found in the complete memo in Appendix D.

By 2017, California had achieved 29% of its total electricity consumption from renewable sources, including 30% of in-state generation. Evidence of the impact of this and other climate-related actions on the California economy and workforce is weighted fairly positively as presented in three studies:

- A 2016 San Joaquin Valley study found that RPS, Cap-and-Trade, and Energy Efficiency measures had generated $13.6 billion in net economic benefit and was responsible for the creation of over 38,000 direct and 67,000 indirect jobs.[11]
- A similar study in the Inland Empire for the same period found net economic benefits of $9.1 billion and net jobs gained of 41,000.[12]
- A statewide 2016 study estimates that California's RPS during a 5-year study period created 25,500 blue-collar job-years and 7,200 white-collar construction job-years. Solar photovoltaic (Solar PV) projects were responsible for two-thirds of the jobs, with Wind projects making up 9%.[13]

A review of the academic and industry literature focused on workforce impacts for blue collar and white collar "trades" jobs (versus scientific and engineering jobs). As should be expected with tectonic policy shifts away from conventional energy to production from renewable energy sources, the literature finds significant impact on general construction occupations, followed by a need for up-skilling of O&M occupations to deal with new technologies – up-skilling is a far more common finding than new classes of occupations. Studies found that renewables created more construction and O&M jobs per megawatt (MW) than conventional sources.

Solar power will be provided through utility-scale solar plants and large commercial and industrial behind-the-meter (BTM) installations, built and operated by a unionized workforce, and distributed residential BTM solar, built largely through non-union contract labor. While the energy costs per MW of the latter are shown to be double the former, policy has supported both through legislation and through regulations. O&M labor at utility-scale plants will require up-skilling, and while contractors are reporting a hard time filling openings, they are showing preference for basic construction skills over specific solar technology skills, and prefer on-the-job training.

Wind has the potential to produce up to 40% of California's power needs, but will continue to lag solar. Wind has an interesting characteristic in that, unlike BTM (commercial or residential) solar, wind plants are virtually all rurally sited. This has an added benefit of bringing quality jobs throughout its supply chain and life cycle to communities with otherwise limited economic opportunities.

Transportation is the single largest contributor to GHG emissions, at 41% - almost double industrial at 23% and more than four times electrical generation at 10%. Net workforce impacts of electrification of this

[11] Jones, B. (2017, February 06). California's Climate Policies Bring Good Jobs to the San Joaquin Valley. Retrieved May 10, 2019, from http://laborcenter.berkeley.edu/californias-climate-policies-bring-good-jobs-to-the-san-joaquin-valley/.
[12] Ibid.
[13] Jones, B., Philips, P., & Zabin, C. (2016, July). The Link Between Good Jobs and a Low Carbon Future. Retrieved May 11, 2019, from http://laborcenter.berkeley.edu/pdf/2016/Link-Between-Good-Jobs-and-a-Low-Carbon-Future.pdf.

sector are largely in the construction sector, building electric vehicle (EV) charging infrastructure, with accompanying electrical grid infrastructure impacts. California will not achieve the GHG emission goals of the legislation without significant inroads in electrifying this sector.

Automation, and specifically Building Automation Systems, plays a key role in achieving the legislated doubling of energy efficiency mandate through lighting and HVAC controls. “Smart Buildings” will control their energy usage through connected sensors, assessing the environment inside and outside the building, and automatically adjusting systems for optimum comfort and maximum efficiency. Connected sensors are foundational to automation, collecting and processing massive amounts of data in smart buildings. A skilled workforce will be required to ensure that these systems are properly installed and maintained to achieve the desired savings and comfort, and be more pro-active in the efficient and smooth operation of a building's systems. Competence in basic ICT concepts is important in Building Automation occupations in addition to traditional maintenance skills.

Core technologies involved in the automation of buildings and cities are being applied to the energy sector and utilities in general. Sensors and smart meters are being deployed to monitor, adjust, and change the billing structure of the energy grid to make it more responsive and efficient. Massive amounts of data are being collected on real-time grid performance; these data must be communicated to a central processing center, interpreted, and acted upon, invoking elements of machine learning and artificial intelligence. ICT skills will be increasingly in demand in this sector. In addition, this non-traditional interconnectedness exposes the grid to a non-traditional vulnerability: cyberthreats. Cybersecurity will become a skillset of increasing importance as the grid becomes smarter and more adaptive.[14]

Interviews were conducted with seven employers to validate/invalidate general and specific themes in the literature. Respondents included executives, training managers, operations managers, and contractors from automation controls, HVAC, refrigeration, and manufacturing companies. All questions and answers are presented in Appendix E but summarized here.

All respondents agreed to the premise in the literature that more conventional construction jobs would be created and that O&M jobs would be upskilled to support new technologies like automation. Several respondents reiterated that core electrical and mechanical skills would continue to be foundational, but that ICT skills would be layered onto traditional jobs. One respondent noted particularly the challenges of achieving energy efficiency goals in existing building stock that reinforced the need for traditional skill sets; new HVAC equipment pushing air through existing, inefficiently designed ducts do not achieve the energy efficiency savings potential of the system.

Most respondents indicated ICT and networking skills as growing in importance, particularly the interconnection of disparate types of equipment from different vendors in the absence of standardized interfaces. Most emphasized that the traditional electrical and mechanical skills for installing and maintaining equipment were foundational and necessary; computer skills were important in addition to those skills. Several respondents indicated their dependence on vendors for training and troubleshooting and saw a need for more efficient (e.g., digitized, online, real-time) training for their workforce.

All respondents agreed with an increasing demand for improved soft skills. Soft skills are as a bottom line issue for their companies. Technicians are a customer-facing front line in their business and the inability to be responsive and communicate effectively are seen as threatening future revenue streams.

In summary, all respondents agreed that staffing of skilled positions is difficult. Most respondents look outside their industry for applicants with a core set of technical skills who can be trained for company- and

[14] DNV-GL. (n.d.). Digitalization and the Future of Energy: Beyond the Hype. Retrieved May 11, 2019, from https://www.dnvgl.com/power-renewables/themes/digitalization/index.html.

industry-specific job functions. Several indicated that recruiting for “trades” (e.g., HVAC Technicians) is impacted by public perceptions of blue-collar work, when the reality is that many of these jobs are highly skilled and highly paid. Another bottleneck indicated by respondents is the increasing merging of “wrench-turning” and computer skills; it is easier to find candidates strong in one or the other, but not both. The lack of qualified applicants was their number one pain point in hiring workers. A second frequent pain point was applicants' work-readiness, i.e., desire to work, soft skills, professionalism. A third common pain point was lack of hard skills in applicants, with competition for skilled applicants between a proliferation of small vendors cited as a primary cause. A common lament in the contracting industry is that workers tend to be trained and then set themselves up in business. There was general agreement that this happens too easily and frequently, and leads to lower quality work in the industry.

Due to the lack of qualified candidates and difficulty in staffing, virtually all respondents indicated that they conduct a high level of internal training with significant company investment and on-the-job training/mentoring. Employers mentioned Community Colleges and Technical Trade Schools next as sources of training and while they considered them to be of good quality, employers saw them as often lagging behind current industry trends and technologies. Respondents mentioned union training centers frequently and held them in high regard. A frequently mentioned training gap was the need for vendor-specific training, driven by a lack of standardized equipment interfaces in the industry.

Evidence from recent studies regionally and statewide supports the assertion that GHG reduction, renewable energy, and energy efficiency mandates of California's climate legislation will have positive net economic and employment impacts. Employers support the general findings and note a layering of new ICT skills in non-ICT occupations. While academic literature does not predict changes to specific jobs, several general conclusions can be drawn:

- Technology will continue to have a profound impact on labor, both directly and indirectly. Directly, there will be a growing demand for white-collar science, technology, engineering, and math jobs to support the technological improvements and cost reductions anticipated in meeting the climate mandates.
- Indirectly, technology and technological improvements will continue to be a growing component of blue-collar work. Energy efficiency is as key to ensuring enough power is available in coming years as rationing was to ensure sufficient water during the drought. Up-skilling the building trades for ever-tightening codes, standards, and the impacts of automation is essential.
- While the literature does not specify new types of workers, elements of energy skills are appearing in diverse occupations, some traditional, some emerging. For example, energy auditing is a desirable skill in occupations like facility management, which used to be about floorspace allocation and basic maintenance, but now manages whole-building health and is expected to deliver financial savings through energy management.
- Mandates for reduction in GHGs and deployment of renewables will initially impact the traditional construction trades; relatively more construction workers are required per MW in construction of wind and solar plants than in natural gas plants.
- Deployment of renewable energy will require more operations and maintenance personnel per MW generated than conventional power plants.
- California has maintained a favorable environment for distributed solar through consumer-friendly net metering policies that, while reduced, are still economically favorable to the consumer.

- Achieving GHG reduction goals cannot be accomplished without electrification of the transportation sector; this will impact construction trades for build-out of charging infrastructure and utilities for adapting the electrical grid to support this growing load.
- Automation will continue to grow in its impact on many occupations, requiring new generations of workers to have basic understanding of Information and Communications Technology (ICT) concepts and their application in performing tasks that were traditionally the realm of blue-collar workers, like building maintenance. Automation is creating a paradigm shift in work not unlike in scope the shift from agriculture to industrialization.
- Building Automation Systems (BAS) play a key role in achieving the doubling of energy efficiency mandate in SB 350 through lighting and HVAC controls, and will require workers comfortable with both a wrench and a computer. "Smart Buildings" will control their energy usage through automated lighting and HVAC systems, assessing the environment inside and outside the building, and automatically adjusting systems for optimum comfort and maximum efficiency – in theory. Connected sensors – the Internet of Things (IoT) – are foundational to automation, collecting and processing massive amounts of data in smart buildings. A skilled workforce that can understand and manipulate those data will be required to ensure that these systems are properly installed and maintained to achieve the desired savings and comfort, and be more proactive in the efficient and smooth operation of a building's systems.[15] Below is a representative list of BAS occupation titles:[16]
  - Commercial Building Controls Installer
  - Building Lighting Systems Programmer
  - Commercial HVAC Control System Programmer
  - Commercial Building Control Systems Service Technician
  - Building Commissioning Technician
  - Energy Conservation Measure Technician
  - Systems Integration Technician
  - Facilities Management Technician
  - Physical Plant Operations Technician
  - Physical Plant Maintenance Technician

  Several sources cite core competencies for BAS professionals, a composite subset of which is listed here:[17]
  - Controls Fundamentals
  - Mechanical Fundamentals
  - Bldg. Mechanical Systems
    - HVAC
    - Potable Water
    - Fire Suppression
    - Irrigation
    - Escalators and Elevators

[15] Rotello, F. (2014, November 3). Integration Intel: Determining the Costs and ROI of a Smart Building. Retrieved May 12, 2019, from https://www.hpac.com/building-controls/integration-intel-determining-costs-and-roi-smart-building.
[16] Delaware Technical Community College. (2018, June 13). Building Automation Systems Option. Retrieved May 15, 2019, from https://www.dtcc.edu/academics/programs-study/building-automation-systems-option.
[17] Delaware Technical Community College. (2018, June 13). Building Automation Systems Option. Retrieved May 15, 2019, from https://www.dtcc.edu/academics/programs-study/building-automation-systems-option; Building Automation. (n.d.). Retrieved May 12, 2019, from https://en.wikiversity.org/wiki/Building_Automation#ESSENTIALS; Rancho Santiago Community College District. (2019, March 25). Rancho Santiago Community College District (RSCCD) Board of Trustees (Regular meeting). Retrieved May 11, 2019, from https://www.rsccd.edu/Trustees/Documents/Dockets/2019 Dockets/03-25-19 DOCKET.pdf.

- Electronics Fundamentals (AC and DC)
- Controls Programming (PLCs)
- Data Communication
- Systems Integration
- Energy Efficiency
  - Codes and standards
  - Performance monitoring
  - Performance predictive controls
  - Occupants behavior
  - Design point vs. part load
  - Heat transfer vs. heat generation/rejection
- Variable speed
- Energy storage
- Renewables

The Association of Controls Professionals (ACP) was commissioned to conduct a study of Building Automation and related occupations for the Los Angeles-Orange County Region of the California Community Colleges.[18] Employer responses to select interview questions about skills, hiring, and training needs in a draft release of the report can be summarized as follows:

- Education: a two-year or technical college degree or equivalent is preferred. Experience is preferred, but given the number of vacancies, employers would hire for entry-level positions without prior experience.
- Training: short-term internships (1-2 month) were considered inadequate for these positions due to the amount of training required (6 months to 2 years).
- Knowledge, Skills, and Abilities (KSAs): a background in basic computer science, IT, networking, and some programming courses. Other skills mentioned were good verbal communication skills, logical mindset, ability to apply knowledge in an independent setting, problem solving, grit ("not an office job"), be able to read and properly interpret documents, and time management.

- Employers considered hands-on learning and the ability to apply knowledge as more valuable than certifications for entry-level positions.
- Among general ICT skills, cybersecurity is of particular importance in the utility sector as connected sensors and smart meters provide an entry path for malefactors into the utility grids.
- Employer interviews largely reinforced these themes, particularly with regard to the up-skilling of conventional trades to support the increasing digitization of equipment and deployment of Building Automation Systems. Conventional electrical and mechanical skills will continue to be foundational as new ICT skills are layered onto traditional trade occupations. Strong soft skills are also in high demand.

The complete literature review is presented as Appendix D.

V. Task 3: Resources to Inform Education and Training

Across the 87 occupations selected for this analysis, there are a variety of training, educational, and apprenticeship programs located across California to instruct and equip prospective workers with the skills and knowledge required to obtain employment in energy-related sectors. ICF identified current

[18] Lovell, B., & Vyapari, S. (2018). Assessment of Automation Employment Opportunities: Preparing 21st Century Automation Professionals (Draft) (Rep.). Association of Controls Professionals.

training, education, and apprenticeship resources and providers in California and national certifications that CalCEF/TESC can leverage to support workforce development initiatives. The methodology for this task involved using each respective occupation's O*NET profile to search for active training or education programs in California that would adequately prepare prospective workers to fulfill the job requirements for a given occupation. Additionally, information was also gathered by searching an occupation's O*NET occupational profile including national-level certification programs. O*NET will not necessarily capture all training resources. Smaller training providers and union and employer based training programs are largely excluded. Most of the education and training resources found in O*NET are colleges and universities, community colleges, and trade and technical schools. Apprenticeship program information is supplemented in this analysis using information provided by the State of California Department of Industrial Relations (CA DIR).[19]

Overall, this occupation-specific program and certification information can help CalCEF/TESC address the shortage of workers and skill gaps by identifying potential partnerships and providers who are already providing training resources. The full list of training and education programs, occupational certifications, and apprenticeship program information by individual occupation (SOC code) can be found in Supplemental Attachment 2. This list denotes the provider's name, location and contact information, and program length and type for each training program, certification program, or apprenticeship program. High-level findings and trends are summarized below by occupational cluster to give some insight into the availability, required time commitment, and the other essential characteristics of these programs.

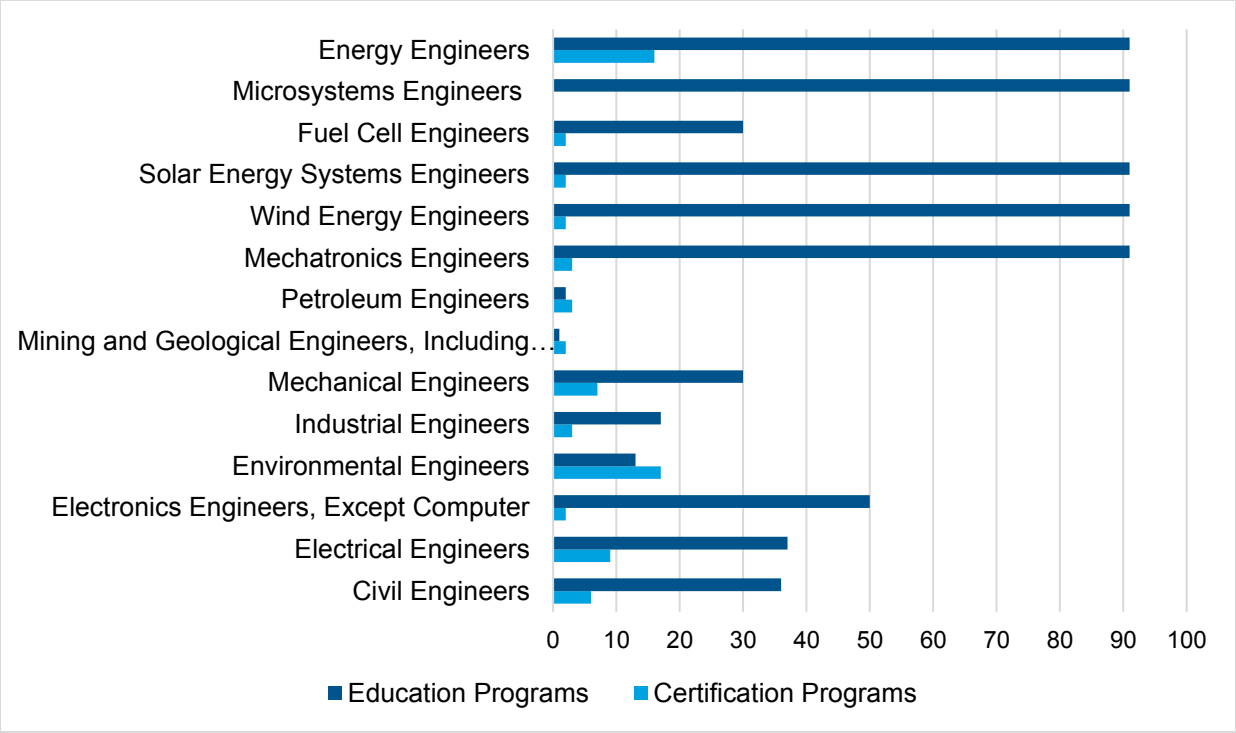
1. Professional Engineers

Fourteen of the occupations examined in this report are classified as part of the "Professional Engineers" occupational cluster. Educational programs across these occupations are predominantly provided by four-year universities in California and these are typically four-year or longer degree programs specific to the type engineering occupation. For example, programs linked to the Industrial Engineers occupation (17-2112) are typically listed as *Industrial Engineering* or *Manufacturing Engineering* programs while educational programs associated with the Electrical Engineers (17-2071) are listed as *Electrical and Electronics Engineering* or *Electrical, Electronics and Communications Engineering, Other* programs. There are 671 total engineering programs identified in O*NET for the "Professional Engineers" occupational cluster. Because occupations in this occupational cluster are closely related, some programs listed for specific providers may be duplicative. Across the identified engineering occupations, the number of educational programs range from 1-91; there is only one program for Mining and Geological Engineers, Including Mining Safety Engineers (17-2151). Referencing the exhibit below, which shows the count of educational programs and certifications available per occupation from this occupational cluster, there are several engineering occupations with 91 educational programs available in California. This is because these specific occupations roll up into the same SOC code-level (i.e., 17-2199) which is the level that O*NET disseminates training and education programs information. These occupations may receive education from the same programs initially, only to develop specialization later in their career. Furthermore, in this cluster, there are 74 certifications available—advanced, specialty, and core certifications—provided by a handful of organizations such as the National Association of Radio and Telecommunications Engineers, Inc., the American Academy of Environmental Engineers and Scientists, and the Association of Energy Engineers to indicate worker competencies needed for these engineering-based job types. O*Net denotes three certifications as "in demand" for Professional Engineers indicating that online job postings frequently mention these certifications as needed. An example of an "in demand"

[19] Division of Apprenticeship Standards. (n.d.). Find an apprenticeship program. Retrieved June 18, 2019, from https://www.dir.ca.gov/databases/das/aigstart.asp.

certification is the *Certified Carbon Reduction Manager* offered by the Association of Energy Engineers for the "Environmental Engineers" (17-2081) occupation. Additionally, for Environmental Engineers (17-2081) and Solar Energy Systems Engineers (17-2199.11) occupations, variations of the *Leadership in Energy and Environmental Design Accredited Professionals (LEED AP)* certification are offered by Green Business Certification Inc. These credentials denote competency in sustainable design, construction, and operations standards and demonstrate credibility in the green building marketplace. This cluster has projected growth of just over 6% over the next ten years (adding a net of just over 12,000 jobs). While professional engineering jobs typically require a bachelor's degree or higher, in California, the California Community College System can serve as a feeder into the California State University (CSU) and University of California (UC) systems for students wanting to pursue a bachelor's degree. In 2017, more than 92% of transfers into the UC system came from California Community Colleges[20]. Every year more the 80,000 students transfer from California Community Colleges to the CSU and UC systems including through programs that guarantee admission after completion of an associate's degree[21].

Exhibit 9: Count of Training and Certification Programs for the Professional Engineering Occupational Cluster by Occupation



Source: O*NET

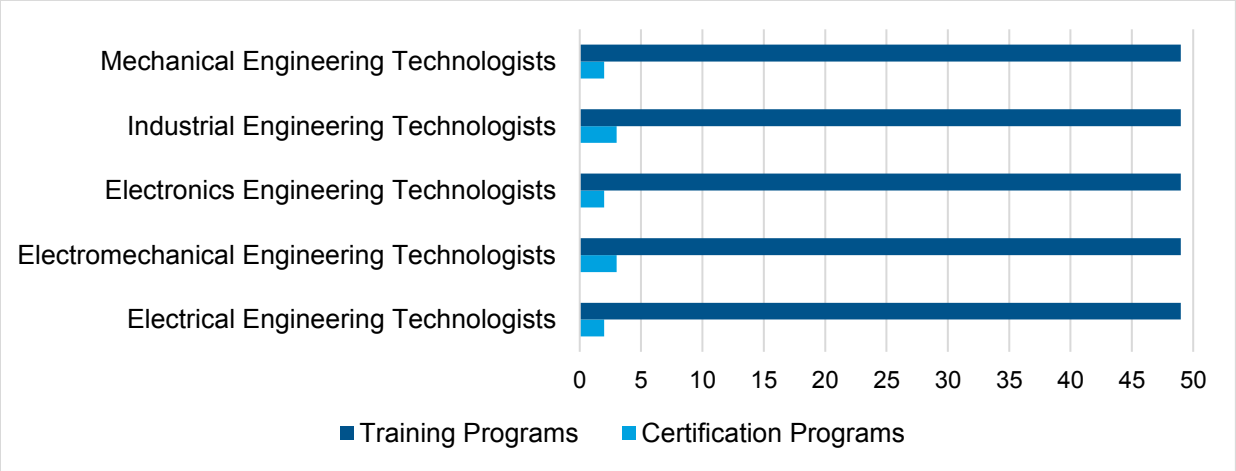
2. Engineering Technologists

The "Engineering Technologists" cluster includes occupations such as Electrical Engineering Technologists (17-3029.02) and Mechanical Engineering Technologist (17-3029.07). Across the five occupations under this cluster, O*NET reports 49 unique training programs in California and 12 unique

[20] University of California. (Summer 2017). University Opens Doors to Community College Systems. Retrieved from: http://www.universityofcalifornia.edu/sites/default/files/uc-transfer-onesheet-8-2017.pdf
[21] California Community Colleges Chancellors Office. (n.d.). A Degree with a Guarantee. Retrieved from: https://www.cccco.edu/Students/Transfer.

certifications. All occupations in this cluster are categorized under the same SOC code-level (17-3029) and therefore the training programs listed for each sub-occupation are the same. Technical colleges (e.g., Los Angeles Trade Technical College) and community colleges (e.g., San Bernardino Valley College and Diablo Valley College) predominantly provide training programs for this cluster. Given this, most program lengths are either less than one year or at least one but less than two years. Both advanced and core certifications are currently offered for these occupations. However, there are no certifications labeled as "in demand" and there are no identified apprenticeships in California for these occupations. These occupations are expected to grow by 2.5% over the next ten years (adding 288 jobs by 2022). Yet, while there are ample training programs available across the state for these occupations, projections indicate there will be a labor gap of over 660 jobs in the state annually where the demand for these occupations will surpass the projected supply (this is examined in detail in Task 7). Additionally, these occupations require no previous work experience, require an associate's degree, and do not typically need OJT for employees.

Exhibit 10: Count of Training and Certification Programs for the Engineering Technologists Occupational Cluster by Occupation



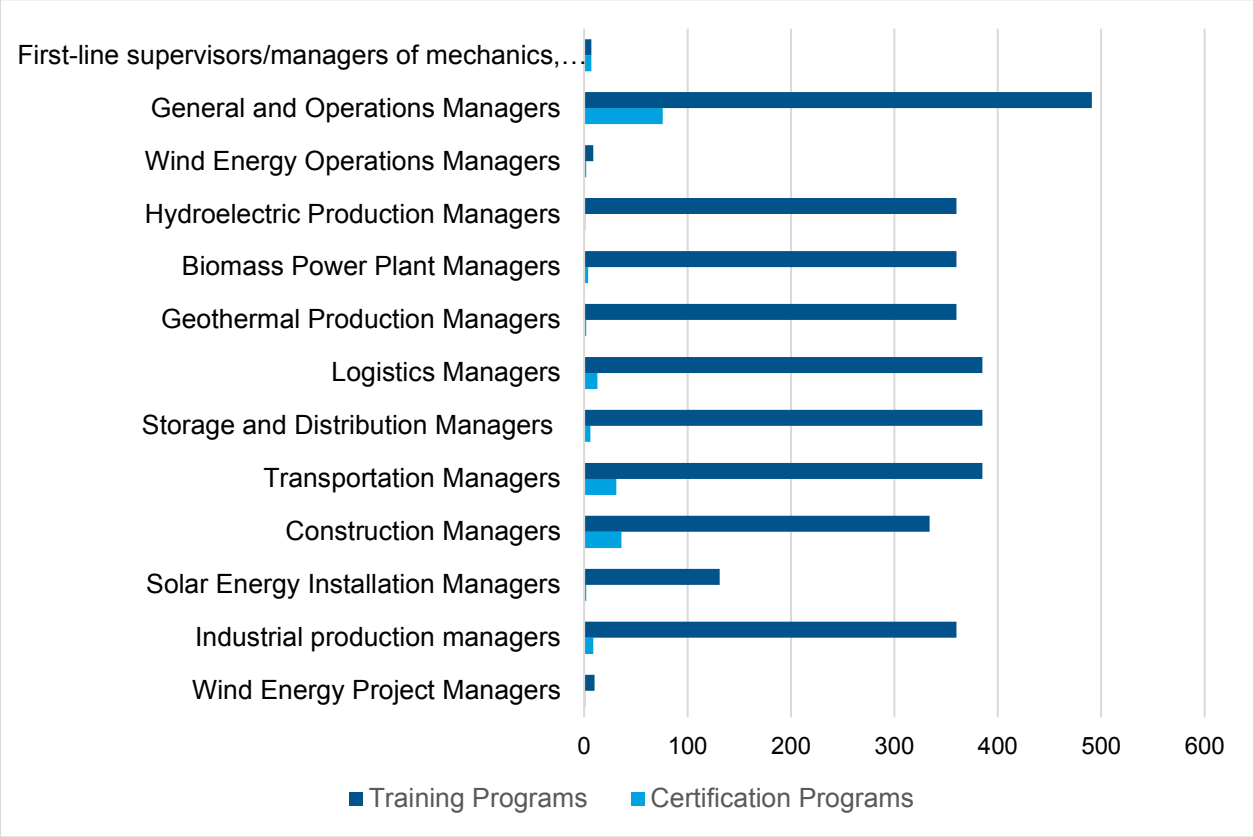
Source: O*NET

3. Managers

This occupational cluster includes an array of managerial positions from General and Operations Mangers (11-1021) who can serve in numerous industries or companies to more energy-specific managerial positions such as Hydroelectric Production Manager (11-3051.06) or Wind Energy Project Managers (11-9199.10). Occupations in this cluster have a total of 3,577 training programs and 190 associated certifications across all 13 occupations. Some of these training programs and certifications may be the same for several of the occupations in this cluster. On average, each occupation has roughly 275 training programs available in California and almost 15 unique certifications available. The certification types offered include advanced, product/equipment, specialty, and core and 15 certifications are denoted as "in demand" by employers. Some of these "in demand" certifications include *Project Management Professional* offered by the Project Management Institute, *Certified in Production and Inventory Management* offered by the American Production and Inventory Control Society, and *Certified Facility Manager* offered by the International Facility Management Association. A mix of four-year college institutions and community colleges provide training programs for this occupational cluster. While four-year colleges offer most general and business management degrees, specializations in a management

field can be obtained through associate's degrees, minors, or in study concentrations. For example, the occupation Wind Energy Project Manager (11-9199.10) provides proficiencies in management skills and content knowledge specific to wind energy operations. For this occupation, Cal Maritime Academy provides a *Power Generation Minor* that provides proficiency and Rio Hondo College has training through its *Alternative Energy Technology Program*. Additionally, CA DIR does not list any current apprenticeship opportunities in California offered for any of these occupations. Lastly, projected demand for this occupational cluster is estimated to grow by 5.8% by 2022 (adding almost 45,000 jobs).

Exhibit 11: Count of Training and Certification Programs for the Managers Occupational Cluster by Occupation



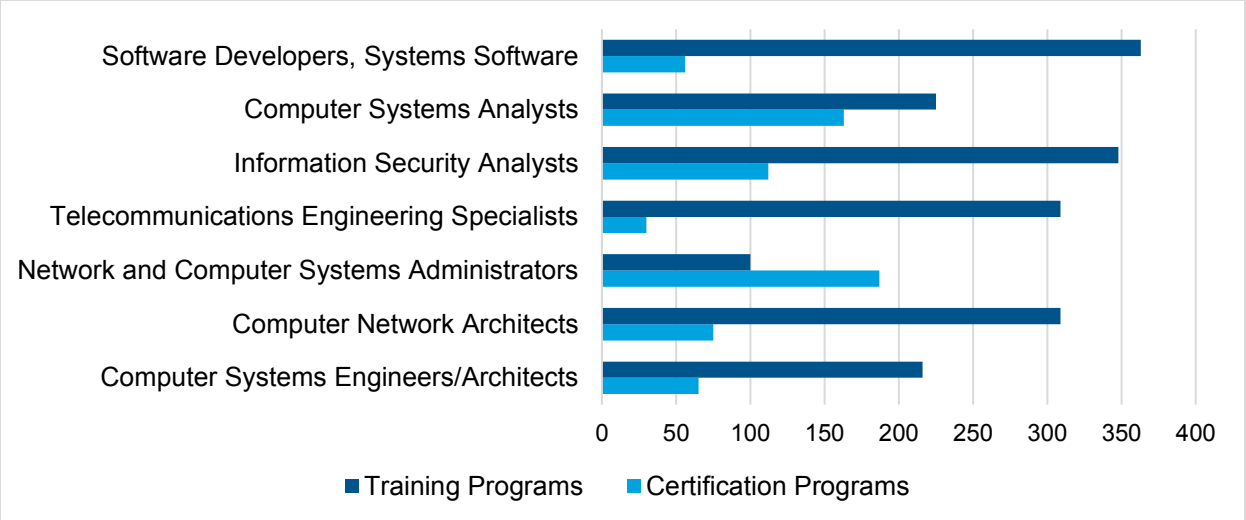
Source: O*NET

4. Information and Communications Technology (ICT)

The "Information and Communications Technology" (ICT) occupational cluster has seven occupations and includes occupations like Computer Network Architects (15-1143), Software Developers, Systems Software (15-1133), and Information Security Analysts (15-1122). Among these seven occupations, there are a total of 1,870 training programs in California and 688 certifications available. Again, because occupations in this cluster are highly related, some of the training programs identified are duplicative. The average number of training programs per occupation is just over 267 while the average certifications per occupation is nearly 100. ICT is an occupational cluster with a particularly high number of certifications due to the many areas of specialization and the rapidly evolving nature of ICT. The ICT skillset, which emphasizes unified communication and advanced information processing, storage, transmission, and manipulation, is in demand across many industries. Thus, certificates indicate to employers prospective

workers' specific areas of knowledge and competency in a field that is highly dynamic. For example, the "Computer Systems Engineers/Architects" occupation (15-1199.02) offers a certificate called *Information Systems Security Engineering Professional, which* conveys that a prospective worker has competency in applying security engineering principles to business processes. Furthermore, each occupation has at least one and up to 28 certifications denoted as "in demand," further indicating the increasingly high demand for these workers. Specifically, the "Information Security Analysts" occupation (15-1122) has 28 unique "in demand" certifications. Some of the "in demand" certifications for this occupation include *GIAC Certified Forensics Analyst* offered by Global Information Assurance Certification (GIAC), *Associate of International Information Systems Security Certification Consortium* offered by International Information Systems Security Certification Consortium, Inc., and *Cisco Certified Internetwork Expert Security* offered by Cisco Systems, Inc. Numerous national organizations offer certifications across these seven occupations including advanced, product/equipment, specialty, and core certifications. Four-year universities (e.g., San Francisco State University) and community colleges (e.g., Santa Barbara City College) provide the majority of training options for this cluster. Educational and training offerings in the area of ICT range from four-year degrees in Computer Science to two-year degree programs from community colleges to faster track programs that are less than one year in length. Examples include, an *Information Technology* program at Santa Clara University (i.e., four-year degree), a *Computer Science* program offered by Foothill College (i.e., two-year degree), and a *Computer Systems Networking and Telecommunications* program offered by City College of San Francisco (i.e., fast track program). Additionally, the State of California Department of Industrial Relations, Division of Apprenticeship Standards (DAS) identifies four apprenticeship programs currently offered in California for Network and Computer Systems Administrators (15-1142.00) and Information Security Analysts (15-1122.00), three of which focus on information security and cybersecurity. As discussed in the Gap Analysis, there is projected to be a significant shortage of workers in two CIT related occupations, Computer Systems Analysts (15-1121.00) and Network and Computer Systems Administrators (15-1142.00). These occupations will become increasingly important in the energy sector, as automation and digitalization proliferate. It will be critical to have an adequate training capacity in these programs to fill the projected gap.

Exhibit 12: Count of Training and Certification Programs for the Information and Communications Technology Occupational Cluster by Occupation



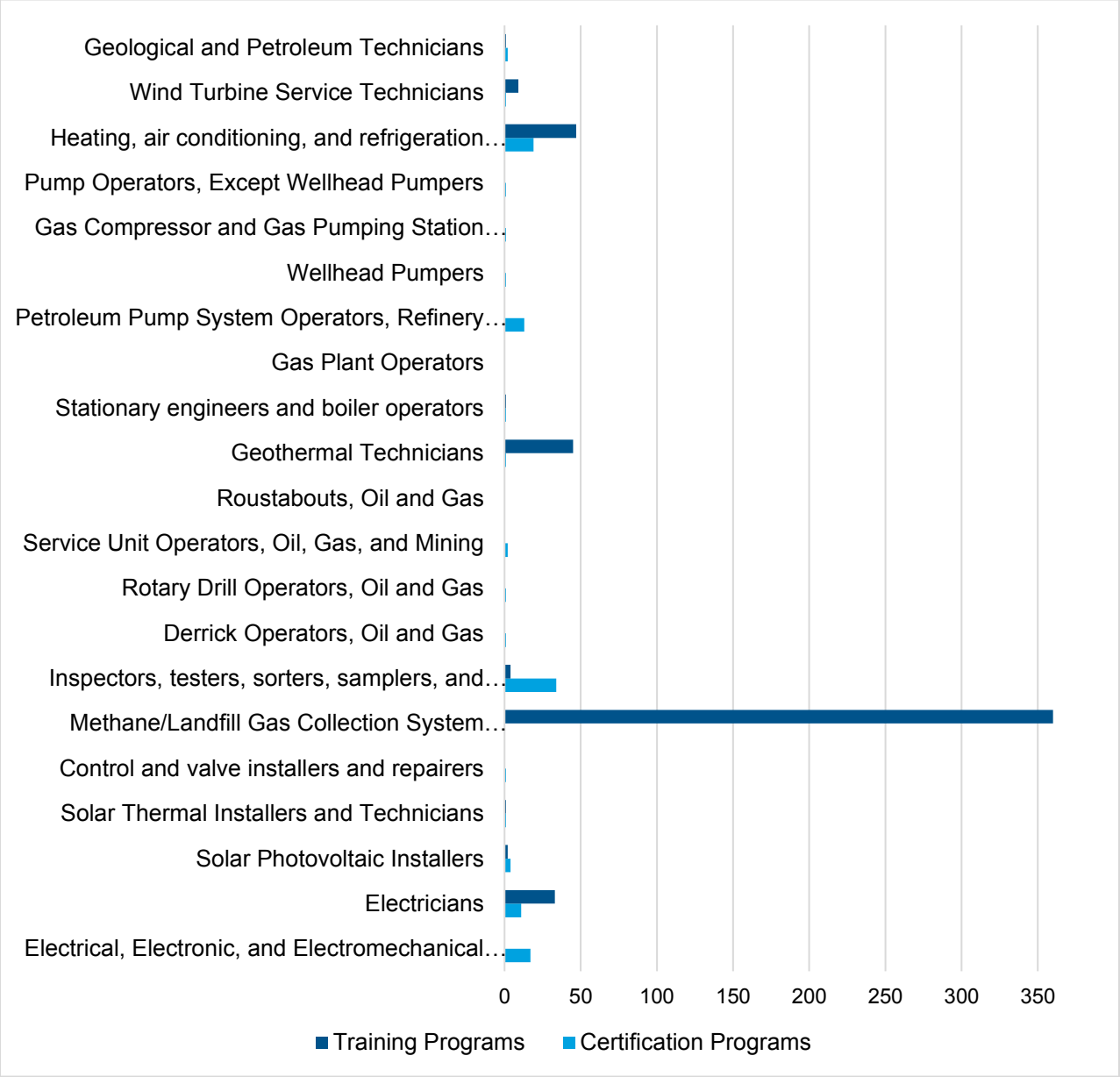
Source: O*NET

5. Energy

There are 21 occupations categorized under the "Energy" occupational cluster, ten of these do not have any training programs listed, one does not have any certification provided (Methane/Landfill Gas Collection System Operations 11-3051.05), and two occupations have neither training programs nor certifications currently listed. For the latter, these occupations--Roustabouts, Oil and Gas (47-5071) and Gas Plant Operators (51-8092)--have minimal education requirements and require extensive OJT, which substantiates the lack of training programs and certifications. Across the 19 occupations with educational and training resources available, there are 502 training programs in California in total and 112 certifications (some may be duplicative given how some of these occupations are closely related). On average, there are just over 26 training programs available for these 19 occupations and almost 6 certifications available per occupation. For the occupations that have certifications listed, the types of certifications offered include advanced, specialty, and core with ten certifications listed as having the "in demand" denotation. Some examples of these "in demand" certifications include the *ISA Certified Control Systems Technician - Level I* for the Control and Valve Installers and Repairers, Except Mechanical Door (49-9012) and the *Certified Welding Inspector* for the Inspectors, Testers, Sorters, Samplers, and Weighers (51-9061). These occupations are collectively projected to add over 15,000 jobs by 2022. However, six of these occupations are expected to lose jobs by 2022. Thus, these jobs will need to adopt and incorporate energy-specific and automation-management skills (in addition to their baseline responsibilities and job duties) to meet the changes persisting in both the occupational, technological, and regulatory landscape in California and to satisfy the overall projected increase in labor demand. Available training programs are predominantly offered by technical (e.g., CET – Sacramento) and community colleges (e.g., Summit College). The program length for these types of programs are mostly less than one year, at least one but less than two years, or two years which coincides with the structure of the most prominent training providers.

As will be discussed in the Gap Analysis section, many of the occupations in the energy occupational cluster are projected to have significant shortages in workers over the next four years, led by electricians and HVAC installers and repairers. These occupations are critically important to energy efficiency efforts in buildings and the automation of building systems. As with the CIT occupations, it will be essential that there is adequate training capacity in California to close this gap. Many of these occupations only require a high school diploma and post-secondary certifications and/or apprenticeships.

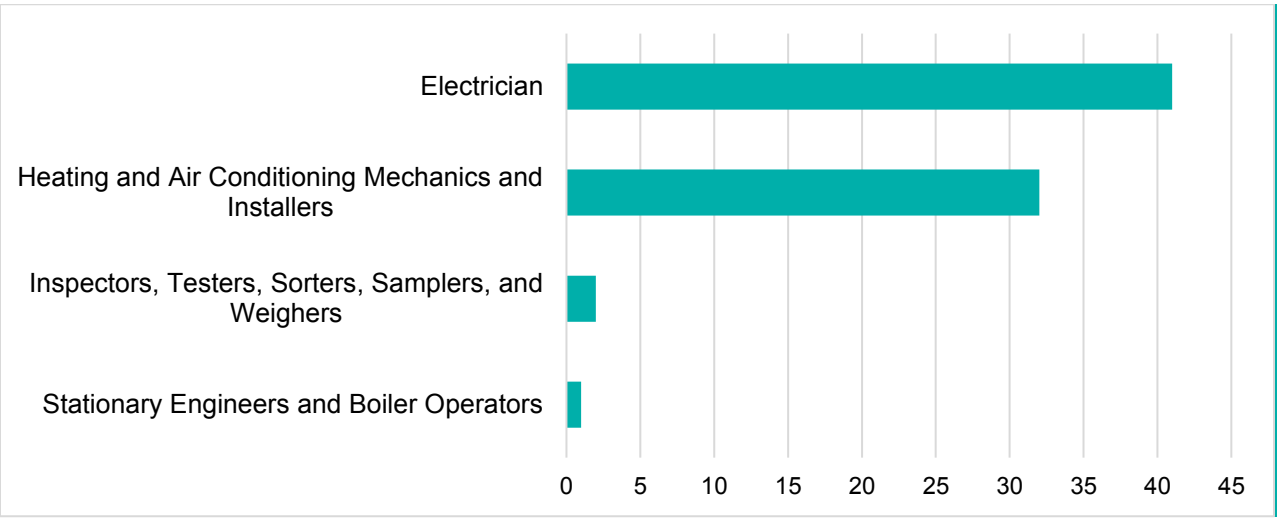
Exhibit 13: Count of Training and Certification Programs for the Energy Occupational Cluster by Occupation



Source: O*NET

Lastly, CA DIR identified four occupations in this cluster that have apprenticeship opportunities in California. There are 40 apprenticeship opportunities for electricians and over 30 for HVAC mechanic and installers.

Exhibit 14: Count of Apprenticeships for the Energy Occupational Cluster by Occupation



Source: State of California Department of Industrial Relations

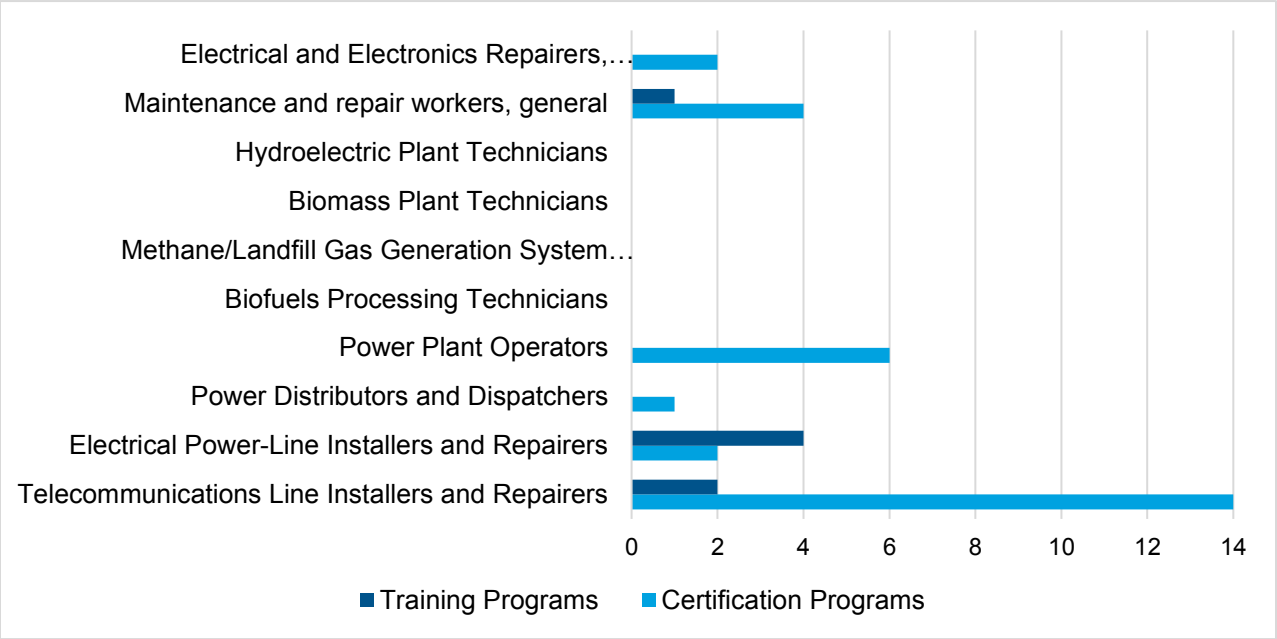
6. Utilities

For this occupational cluster, there are ten occupations that focus on carrying out work related to power distribution, maintenance, and repair. Some examples are Telecommunications Line Installers and Repairers (49-9052) and Power Plant Operators (51-8013). Six of these occupations have current certification programs available, three have no training programs currently available in California, and four have neither certification nor training programs available. The occupations with no training programs available are Power Distributors and Dispatchers (51-8012), Power Plant Operators (51-8013), and Electrical and Electronics Repairers, Powerhouse, Substation, and Relay (49-2095). Based on analysis completed in Task 1, these three occupations all require extensive OJT, have minimal educational requirements, and little to no work experience required. Training for these occupations are largely provided by employers versus third-party training providers or colleges and technical schools. Across occupations that have training programs available, there are a total of only 7 training programs currently offered and among all these occupations in this cluster, there are 29 certifications prospective workers can receive. On average, there is just one training program and five certifications available per occupation. As shown in the chart below, the range for training programs and certifications per occupation listed is from 0-4 and 0-14, respectively, which underscores the lack of post-secondary requirements for many of these occupations. Additionally, in the chart below, four occupations have neither training programs nor certifications, all categorized under Plant and System Operators, All Other (51-8099), which is projected to stagnate in growth by 2022 and decline slightly in employment after that. Conversely, all other occupations included in this cluster are expected to experience growth ranging from 1.3%-11.2% by 2022 and combined these occupations are projected to add over 11,000 jobs over the next few years.

A number of occupations in this cluster are also projected to have shortages in employment over the next four years, led by maintenance and repair workers, general, and telecommunications line and electrical power-line installers and repairers. Certifications offered for telecommunications line installers and repairers, *BICSI Technician* and *BICSI Installer 1*, are noted in O*NET as being “in demand,” the only two of the 29 certifications identified that are categorized as such. For the occupations that have associated training programs, they are largely offered by either technical colleges or community colleges (e.g., College of the Canyons) and a private postsecondary institution (RWM Fiber Optics). The program

lengths of currently operating training programs range from less than one year to two years and CA DIR did not identify any active California-based apprenticeships for any of the occupations in this cluster.

Exhibit 15: Count of Training and Certification Programs for the Utilities Occupational Cluster by Occupation

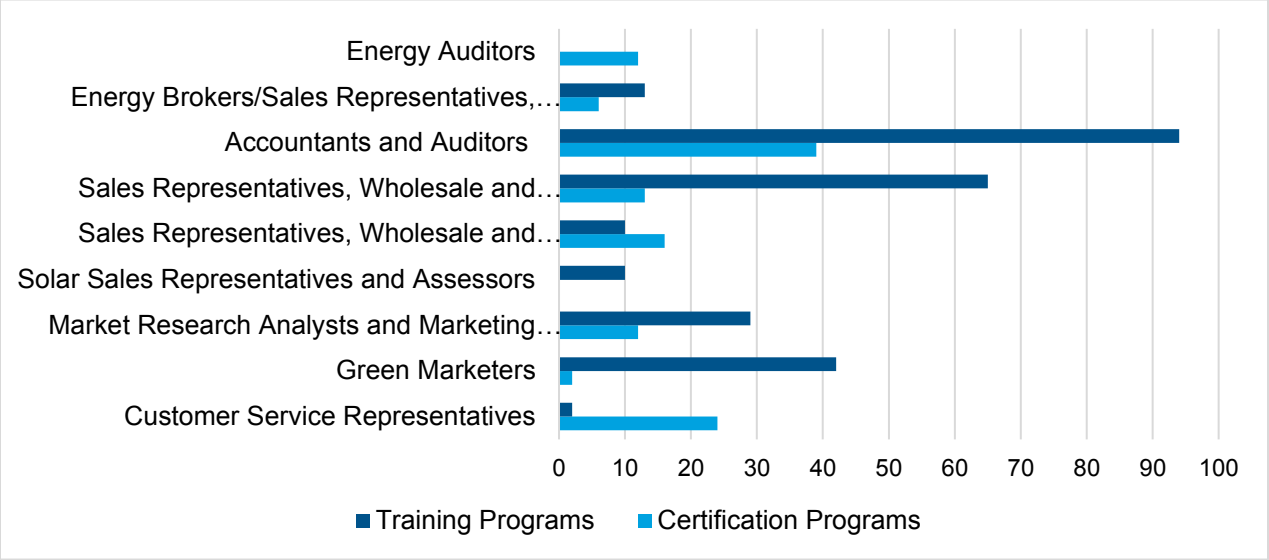


Source: O*NET

7. Sales, Marketing, or Business

There are nine occupations analyzed under the “Sales, Marketing, or Business” occupational cluster and this cluster includes occupations such as Customer Service Representatives (43-4051), Energy Auditors (13-1199.01), and Market Research Analysts and Marketing Specialists (13-1161). Across these occupations, there are 265 training programs available in California and 124 listed certifications. Given how some of these occupations are closely related in skillset and function, some of the training programs and certifications may be duplicative. On average, there are just over 29 training programs available per occupation and almost 14 certifications available per occupation. In reference to the chart below, the occupation Accountants and Auditors (13-2011) has the highest amount of training programs available (94) and the highest number of certification (39) in this occupational cluster. O*Net denotes nine of the 124 certifications a as “in demand” including *Certified Treasury Professional* offered by the Association for Financial Professionals and *HDI Certified Customer Service Representative* offered by HDI. Community colleges (e.g., Fremont College) and four-year college institutions (e.g., University of Redlands) predominantly provide training programs for these occupations. The program length for these training offerings greatly vary depending on the occupation. For example, the program lengths for the Customer Service Representatives (43-4051) or other forms of energy brokers or sales representatives is usually less than one year. Conversely, the training program length for accounting-based occupations is unilaterally concentrated at four-year colleges. CA DIR did not identify any apprenticeships offered in California for these occupations.

Exhibit 16: Count of Training and Certification Programs for the Sales, Marketing, and Business Occupational Cluster by Occupation

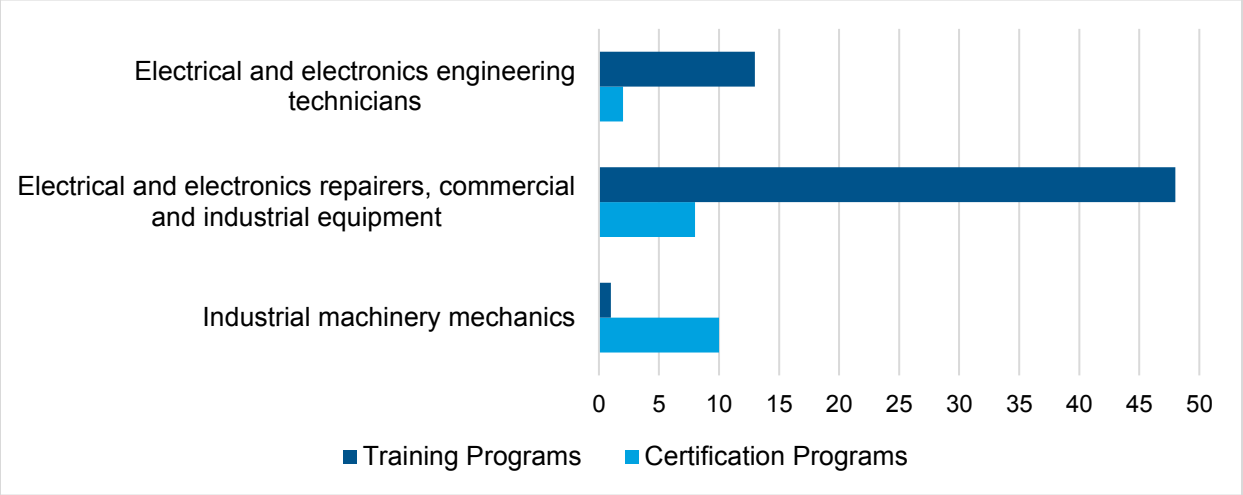


Source: O*NET

8. Engineering Technicians

There are three occupations categorized under the “Engineering Technicians” cluster and each occupation has both training programs and certifications available. This cluster includes the following occupations: Industrial Machinery Mechanics (49-9041), Electrical and Electronics Repairers, Commercial and Industrial Equipment (49-2094), and Electrical and Electronic Engineering Technicians (17-3023). Across these occupations, there are a total of 62 training programs and 20 certifications. Again, given how some of these occupations are closely related, some training programs may be duplicative. On average, there are almost 21 training programs in California and almost seven national certifications available per occupation. As shown in the Gap Analysis section of this report, Industrial Machinery Mechanics (49-9041) and Electrical and Electronics Engineering Technicians (17-3023) are projected to have significant shortages of workers in California over the next four years, 2,906 and 1,273 worker per year, respectively. Providers of applicable training programs in California include four-year universities (e.g., California State University – Long Beach), technical colleges (e.g., United Education Institute - Anaheim), and community colleges (e.g., San Diego City College) with program lengths primarily ranging from less than one year to two years. Currently CA DIR does not identify any California-based apprenticeship opportunities available for these occupations.

Exhibit 17: Count of Training and Certification Programs for the Engineering Technicians Occupational Cluster by Occupation

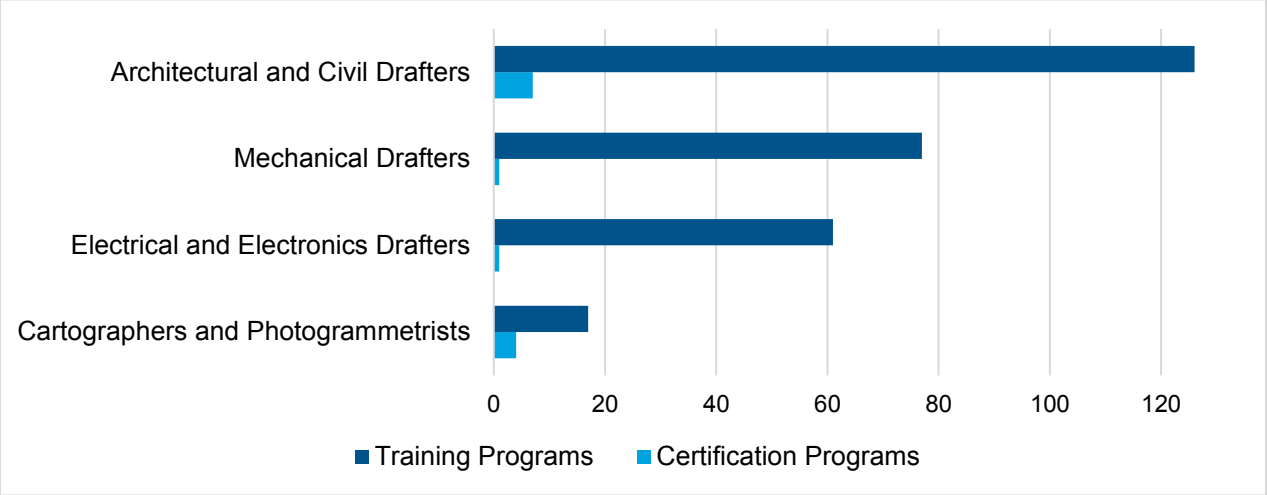


Source: O*NET

9. Drafters

For this occupational cluster, there are four unique occupations analyzed whose work revolves around leveraging tools and software programming to convert the work of engineers and architects into technical drawings. These occupations are Cartographers and Photogrammetrists (17-1021), Electrical and Electronics Drafters (17-3012), Mechanical Drafters (17-3013), and Architectural and Civil Drafters (17-3011). Among these four occupations, there are a total of 281 training programs in California and 13 national certifications available. Because the occupations in this cluster are highly related in terms of job responsibilities and function, some of the programs or certifications offered may be duplicative. On average, there are just over 70 active training programs per occupation. Other than Cartographers and Photogrammetrists (17-1021), which usually requires a bachelor's degree, most of the jobs in this occupational cluster require either an associate's degree or post-secondary certificates. As such, these training programs are largely provided by community colleges and program lengths are concentrated in the less than one year to the two-year time range. For example, Palomar College offers a two-year *Architectural Technology/Technician* program for the Architectural and Civil Drafters (17-3011) occupation and College of the Desert offers a less than two-year *Drafting and Design Technology/Technician* program for the Electrical and Electronics Drafters (17-3012.01) occupation. Advanced, product/equipment, and core certifications are offered by organizations with none currently denoted as "in demand." Additionally, CA DIR does not identify any active apprenticeships for these occupations in California. This occupational cluster is predicted to add over 1,400 jobs by 2022 (4.8% growth rate) and is projected to have a labor gap of roughly 1,300 jobs annually.

Exhibit 18: Count of Training and Certification Programs for the Drafters Occupational Cluster by Occupation

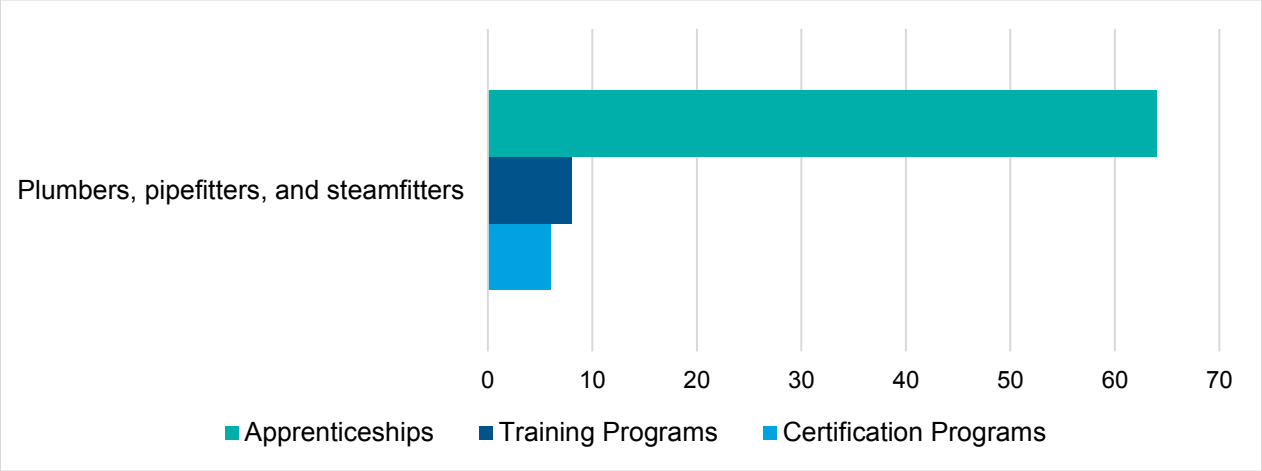


Source: O*NET

10. Construction

The only occupation categorized under the "Construction" occupational cluster in this analysis is the Plumbers, Pipefitters, and Steamfitters (47-2152) occupation. As shown in the chart below, this occupation has an abundance of apprenticeship resources available in California (64) relative to training programs and national certifications. Technical colleges (e.g., Baldy View Regional Occupational Program) and community colleges (e.g., College of San Mateo) provide Plumbing Technology/Plumber training programs. Training program length ranges from less than one year to two years. Three unique organizations offer core certifcations. The one "in demand" certification is the *National Center for Construction Education & Research* (*NCCER) Certification*, offered by the National Center for Construction Education and Research. With over 60 apprenticeships offered by 31 unique committees, the labor market highly relies on these apprenticeships to train and equip prospective workers. Additionally, no previous work experience and only a high school diploma or equivalent is required prior to employment. This occupation is expected to grow 9.7% (almost 6,000 jobs) by 2022 and have a shortage of over 7,000 workers per year over the next four years. It will be critical to the energy sector that the apprenticeship opportunities and technical and community colleges offering plumbing credentials have the capacity to address the large projected gap in workers.

Exhibit 19: Count of Training and Certification Programs for the Construction Occupational Cluster by Occupation



Source: O*NET and State of California Department of Industrial Relations

Per the request of CalCEF/TESC, apprenticeship opportunities were identified for the occupation of Operating Engineer. Though this occupation was not included in the original analysis, 19 unique apprenticeship programs were found in California offered by three unique committees for this occupation. These specific apprenticeship programs are listed in detail in Supplemental Attachment 2.

VI. Tasks 4 and 5: New Skills Required by New Technologies

In this section, we identify the emerging hard skills and qualifications that are currently in demand among energy sector employers. We take two approaches to identifying these emerging skills and qualifications. First, we utilize Emsi job posting analytics, which provides information on the skills and qualifications employers are indicating in current job postings. These skills are organized by occupation, which we categorized into occupational clusters (see Exhibit 2 for the energy related occupations that make up each occupational cluster). This information differs from the O*NET data provided in Task 1, in that it represents real-time information that includes only employers that are currently hiring. Our second approach in identifying emerging skills and qualifications for energy sector related jobs is a literature review of industry sector studies and reports focusing on emerging workforce skills that are currently in demand driven by new technology and changes in the economic landscape.

Exhibit 20 shows the emerging skills and qualifications by occupational job cluster identified from Emsi real-time job postings analytics. We compare the real time information to those in the O*NET data on skills and qualifications to identify those skills and qualifications that may be emerging. The job postings from which this information is extracted include employers in the energy sectors only, except for the construction cluster, which includes employers in the energy and construction sectors that are currently hiring workers for the selected energy related occupations. We focus on the just the energy sector here to examine the specific skills, qualifications, and technology most important to employers in that industry, since they can differ from other sectors. In the case of the construction occupational cluster, we include employers in the construction sector since the skills, qualifications, and technology are likely to be similar and transferable to the energy industry.

Of note in the “Professional Engineers” cluster is the demand for Leadership in Energy and Environmental Design (LEED) accredited professionals and engineers that are Certified Wireless Security

Professionals. This indicates the increasing importance of knowledge and skills in designing energy efficient systems in buildings, the trend towards automation, and the need to secure those systems from outside intrusion or interruptions. The ability to construct LEED certified buildings is becoming more important as local government authorities that regulate building construction are requiring some level of LEED certification and building owners and tenants are seeking LEED certified buildings that are more cost effective to maintain. LEED certification requires a set of standards that encourages buildings to be environmentally friendly. All aspects of a building's design, construction, operation and maintenance are taken into account and are certified at different levels and the most recent versions of LEED Certification standards have placed even more emphasis on energy efficiency.[22] According to the U.S. Green Building Council, green buildings have higher occupancy rates (4 to 8 percent above non-green buildings) and approximately 44 percent of tenants in a 2011 survey said that environmental considerations were important to their companies and 25 percent said that green building practices were important in their space search.[23] California has also enacted its own green building certification policy, Title 24 (CALGreen) certification,[24] which requires that all new buildings over 10,000 square feet meet energy efficiency guidelines.

The demand for Certified Wireless Security professionals is likely related to the increasing trend towards building and systems automation. Energy digitalization, the interaction and convergence between the digital and physical worlds, is an increasingly important function in the design of smart buildings and cities and the need to secure those systems will lead to demand for engineers in the energy sector with appropriate knowledge and skills.

LEED Accreditation is also an emerging qualification for occupations in the "Managers" occupational cluster. Also of note is the requirement for two ICT security related certifications, *Information Technology Infrastructure Library (ITIL)* and *Global Information Assurance Certification (GIAC)*, indicating the importance of ICT knowledge for managers in the energy sector. *Systems Operator Certification* is an energy sector specific credential offered by the North American Electric Reliability Corporation (NERC) that promotes reliability of the North American bulk power system.[25] Most of the remaining qualifications for managers in the energy sector include various degrees and certifications that are common across many sectors, such as Masters of Business Administration (MBAs) and Certified Public Accountants (CPAs).

In the "ICT" occupational cluster, an emerging skills requirement is automation. As noted earlier, systems and building automation is driving demand for ICT workers in the energy sector. Based on the data shown here, much of that demand is stemming from the need for information security as systems become automated and need to be protected. Virtually all of the ICT qualifications and certifications are related to information security, further indicating the strong demand for ICT security professionals and the emerging importance of information security in the energy sector.

Job postings for occupations in the "Energy" and "Utilities" clusters included a wide range of skills, qualifications, and certifications. A number of job postings indicated that employers required certifications in systems operation, ISA certified control systems, BICSI technician and installer, coding and internal auditing, and in trades such as electricians, and HVAC. Employers are demanding skills in computer control systems and building automation systems.

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[22] U.S. Green Building Council. (n.d.). Retrieved June 21, 2019, from https://new.usgbc.org/.
[23] Widener, D. (2011, May 20). Existing Buildings Seeing New Tenant Interest and Increased Savings with LEED. Retrieved June 21, 2019, from https://www.usgbc.org/articles/existing-buildings-seeing-new-tenant-interest-and-increased-savings-leed.
[24] 2016 California Green Building Standards Code, Part 11. (July 2016). Retrieved June 21, 2019, from, https://codes.iccsafe.org/content/document/657?site_type=public.
[25] NERC: System Operator Certification. (n.d.). Retrieved June 21, 2019, from https://www.nerc.com/pa/Train/SysOpCert/Pages/default.aspx.

Job postings for the "Construction" occupational cluster included a wide range of skills and certifications. Certifications include certified welder, operating engineers certification (OECP), plumbers license, certified coding specialist, certified senior lighting technician, residential electrical inspector, certified crane operator, and certification from NCCER. Skills that hiring construction employers indicated a need for include passive solar building design, photo voltaic systems, solar panel, systems monitoring, wind power, computer control systems, lighting control console, renewable energy, automation, enterprise application platform, network architecture, energy conservation, auditing, and energy policy. The diverse types of skills and certifications being required in the construction sector, particularly those specific to energy, further indicates the emerging need for construction workers to poses both traditional hard skills and new skills in ICT and the automation of energy systems.

The "Sales, Marketing, and Business" occupational cluster included a number of job postings that required certifications such as Certified Information Systems Auditor (CISA), certified internal auditor, certified power quality professional, and system operator certification.

The "Engineering Technicians" occupational cluster required a number of ICT credentials such as CompTIA A+, CompTIA Security+, Cisco Certified Network Associates and Professionals, and Information Assurance Technical (IAT) Certification. Other certifications required by engineering technician employers include certified control systems technician, certified internal auditor, certified quality auditor, and LEED accredited professionals.

Finally, employers hiring workers in the "Drafting" occupational cluster required certifications and skills in Computer Aided Design and Drafting (CADD), AutoCAD, SolidWorks, 3D modeling, Autodesk Revit, MicroStation, Management in Building Information Modeling (CM-BIM) certification, Advanced Certified Interconnector Designer, and LEED accreditation.

Exhibit 20: Emerging Skills and Qualification in the Energy Sector by Occupational Cluster

Occupational Cluster	Emerging Skills/Qualifications/Certifications
Professional Engineers	▪ Certified Professional in Erosion and Sediment Control ▪ Project Management Professional Certification ▪ Certified Wireless Security Professional ▪ LEED Accredited Professional (AP) ▪ Licensed Professional Engineer ▪ Certified Carbon Reduction Manager
Engineering Technologists	▪ C++ Programming Language ▪ C (Programming Language) ▪ Python (Programming Language) ▪ Unix ▪ ASNT Non-Destructive Tester
Managers	▪ Certified Internal Auditor ▪ Project Management Professional ▪ Certified in Production and Inventory Management ▪ Master of Business Administration (MBA) ▪ LEED Accredited Professional (AP) ▪ Six Sigma Green Belt Certification ▪ Chartered Financial Analyst ▪ Certified Public Accountant ▪ Certified Fraud Specialist ▪ ITIL Certifications ▪ System Operator Certification ▪ GIAC Certifications

Occupational Cluster	Emerging Skills/Qualifications/Certifications
Information and Communications Technology	▪ Automation ▪ Information Systems Security Engineering Professional ▪ GIAC Certified Forensic Analyst ▪ Associate of International Information Systems Security Certification ▪ Cisco Certified Internetwork Expert Security ▪ Certified Computer Forensics Examiner ▪ Certified Ethical Hacker ▪ Certified Information Security Manager ▪ Certified Information System Auditor (CISA) ▪ Certified Information Systems Security Professional ▪ Certified in Risk and Information Systems Control ▪ CompTIA Security+
Energy	▪ Control Systems ▪ Computer Control Systems ▪ Network Switches ▪ Building Automation Systems ▪ Master of Business Administration (MBA) ▪ Certified Coding Specialist ▪ Certified Internal Auditor ▪ Electrician License ▪ HVAC Certification ▪ Systems Operator Certification ▪ Master Craftsman ▪ ISA Certified Control Systems Technician ▪ Certified Welding Inspector
Utilities	▪ Master of Business Administration (MBA) ▪ Project Management Professional Certification ▪ Certified Control Systems Technician ▪ Computer Control Systems ▪ BICSI Technician ▪ BICSI Installer I
Construction	▪ Interconnection ▪ Passive Solar Building Design ▪ Photo Voltaic Systems ▪ Solar Panel ▪ C++ Programming Language ▪ Systems Monitoring ▪ Wind Power ▪ Transformers ▪ Control Systems ▪ Lighting Control Console ▪ HVAC ▪ Project Commissioning ▪ Renewable Energy ▪ Automation ▪ Enterprise Application Platform ▪ Energy Conservation ▪ Optical Fiber Cable ▪ Network Architecture ▪ Computer Control Systems ▪ Auditing ▪ Energy Policy ▪ Certified Welder

Occupational Cluster	Emerging Skills/Qualifications/Certifications
	▪ Operating Engineers Certification (OECP) ▪ Plumbers License ▪ Certified Coding Specialist ▪ Certified Senior Lighting Technician ▪ Residential Electrical Inspector ▪ Heating Specialist ▪ Certified Crane Operator ▪ NCCER Certification
Sales, Marketing, or Business	▪ Master of Business Administration (MBA) ▪ Project Management Professional Certification ▪ Certified Information System Auditor (CISA) ▪ Certified Internal Auditor ▪ Certified Power Quality Professional ▪ System Operator Certification ▪ Operator Certification ▪ Certified Treasury Professional ▪ HDI Certified Customer Service Representative
Engineering Technicians	▪ Automation ▪ Control Systems ▪ Computer Control Systems ▪ Auditing ▪ Data Acquisition ▪ ASQ Certified ▪ Certified Control Systems Technician ▪ Certified Internal Auditor ▪ Certified Quality Auditor ▪ CompTIA A+ ▪ CompTIA Security+ ▪ IAT Level I Certification ▪ LEED Accredited Professional ▪ Cisco Certified Network Associate ▪ Cisco Certified Network Professional
Drafters	▪ CADD Certification ▪ AutoCAD ▪ SolidWorks (CAD) ▪ 3D Modeling ▪ Autodesk Revit ▪ MicroStation ▪ Automation ▪ Advanced Certified Interconnect Designer ▪ LEED Accredited Professional (AP) ▪ LEED Green Associate ▪ CM-BIM Certification

Source: Emsi Job Posting Analytics and ICF

Much of the literature on the emerging skills needed in the energy sectors focuses on ICT skills and the increasing importance of these skills to employers as systems and building automation become more common and widespread in energy distribution and use. For example, in a 2017 Survey of Connecticut Energy & Energy Efficiency Workforce Needs, commissioned by the Connecticut Department of Energy and Environmental Protection, Xcel Energy, which provides electricity to 3.6 million customers and natural gas service to 2 million customers, notes that cyber skills are in high demand throughout the economy and as a result of a shortage of workers with this skill they have had to develop their own training program

to fill the gap. Xcel notes that one of their most important challenges is protecting the grid. For those positions, Xcel notes that they need people with both operational technology (OT) experience as well as IT experience.[26] These observations echo comments made by California based employers interviewed as part of this study.

The Organisation for Economic Co-operation and Development (OECD), an intergovernmental economic organization with 36 member countries, notes that in the energy sector, workers will need ICT skills to operate digital technologies within energy infrastructure, such as coding and cybersecurity expertise[27].

Energy digitalization is also noted in the literature as an emerging technology in the energy sector. As noted above, energy digitalization is the interaction and convergence between the digital and physical worlds, and is the process used in smart buildings and cities.

According to GE Power, the digitalization of energy systems is on the cusp of a major expansion with the rise of the Industrial Internet of Things (IIoT). GE Power states that "the IIoT promises to digitalize much of the world's industrial processes, including underlying physical infrastructure such as power generation, transmission and distribution." "The result will be an improvement in economic, environmental, and social outcomes across humanity's fundamental systems, none of which is more vital than the digitalization of the energy sector, the spark that drives economic and human progress."[28]

GE Power goes on to note that, the digital transformation of utilities can improve the efficiency of power generation and the transmission and distribution of electricity, all while providing consumers with more capabilities and choices around their energy use. According to GE Power, "all of this accelerates decarbonization because less fuel is needed to produce the same amount of power. Digital tools also enhance operation throughout the electricity value network. This increases grid reliability and security, and reduces the cost to generate, transmit, and deliver electricity. These outcomes are possible because digital technologies can help physical systems to be more productive and autonomous. In short, our energy infrastructure is getting smarter and the main beneficiaries are people and the planet."[29] The digital transformation of energy systems will put an increasing demand for workers in the ICT and information security sectors.

VII. Task 6: Employment Projections

As discussed in Task 2, three major energy policy initiatives in California are expected to impact jobs, 100% renewable portfolio strategy (RPS), the reduction in carbon emissions, and the increasing emphasis on energy efficiency. Exhibit 21 shows the selected energy related occupations that are expected to be impacted by these initiatives and whether the impact is expected to create more jobs or lead to a reduction of jobs for each impacted occupation.

Policies directed at California's 100% RPS and reducing carbon emissions are expected to create less demand for occupations that are concentrated in the production and distribution of energy produced from fossil fuels, such as gas and oil, and more demand in occupations related to renewable energy production and distribution. Occupations that are expected to experience increases in demand from 100% RPS and carbon reduction policies include solar photovoltaic installer, wind turbine service technicians, and civil,

[26] 2017 Survey of Connecticut Energy & Energy Efficiency Workforce Needs. (n.d.). Retrieved June 12, 2019, from https://www.cbia.com/resources/workforce-development/workforce-reports-surveys/2017-survey-energy-energy-efficiency-workforce/.
[27] OECD. (2016, December). Policy Brief on the Future of Work: Skills for a Digital World. Retrieved June 11, 2019, from https://www.oecd.org/els/emp/Skills-for-a-Digital-World.pdf.
[28] GE Power. (n.d.). What's in Store for the Digital Transformation of the Energy Sector? Retrieved June 19, 2019, from https://www.ge.com/power/digital-transformation-in-energy-industry.
[29] Ibid.

electrical, and environmental engineers and related technicians. Occupations that are expected to experience decreases in demand from 100% RPS and carbon reduction policies include petroleum, mining, and geological engineers, oil and gas derrick, rotary drill, and service unit operators, and gas plant and refinery operators.

Policies directed at increasing energy efficiency is expected to largely have positive impacts on employment in energy related occupations and minimal to no negative impacts. The positive impacts are driven by systems automation in the production and distribution of energy and efforts towards increasing energy efficiency in buildings, such as building automation systems (or smart buildings), described earlier. Energy and building automation systems is placing a large demand on occupations in the ICT sector, including computer systems and information security analyst, software developers, and network and computer systems administrators. Efforts towards increasing energy efficiency in buildings are expected to also increase the demand for construction and building related occupations, such as construction managers and supervisors, architectural and civil drafters, electricians, plumbers, HVAC installers and repairers, and stationary engineers.

Exhibit 21: Selected Energy Sector Occupations Projected to be Impacted by California Energy Policies

SOC	Occupation	How Growth May be Affected	CA Energy Policies that may affect Growth
11-9021	Construction Managers	+	100% RPS, Carbon Reduction
15-1121	Computer Systems Analysts	+	Energy Efficiency
15-1122	Information Security Analysts	+	Energy Efficiency
15-1133	Software Developers, Systems Software	+	Energy Efficiency
15-1142	Network and Computer Systems Administrators	+	Energy Efficiency
15-1143	Computer Network Architects	+	Energy Efficiency
15-1199	Computer Occupations, All Other	+	Energy Efficiency
17-2051	Civil Engineers	+	100% RPS, Carbon Reduction
17-2071	Electrical Engineers	+	100% RPS, Carbon Reduction
17-2081	Environmental Engineers	+	100% RPS, Carbon Reduction
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	-	100% RPS, Carbon Reduction
17-2171	Petroleum Engineers	-	100% RPS, Carbon Reduction
17-3011	Architectural and Civil Drafters	+	Energy Efficiency
19-4041	Geological and Petroleum Technicians	-	100% RPS, Carbon Reduction
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	+	100% RPS, Carbon Reduction
47-2111	Electricians	+	Energy Efficiency
47-2152	Plumbers, Pipefitters, and Steamfitters	+	Energy Efficiency
47-2231	Solar Photovoltaic Installers	+	100% RPS, Carbon Reduction
47-4098	Miscellaneous Construction and Related Workers	+	100% RPS, Carbon Reduction
47-5011	Derrick Operators, Oil and Gas	-	100% RPS, Carbon Reduction
47-5012	Rotary Drill Operators, Oil and Gas	-	100% RPS, Carbon Reduction
47-5013	Service Unit Operators, Oil, Gas, and Mining	-	100% RPS, Carbon Reduction

SOC	Occupation	How Growth May be Affected	CA Energy Policies that may affect Growth
47-5071	Roustabouts, Oil and Gas	-	100% RPS, Carbon Reduction
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	+	Energy Efficiency
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	+	Energy Efficiency
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	+	100% RPS, Carbon Reduction
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	+	Energy Efficiency
49-9051	Electrical Power-Line Installers and Repairers	+	100% RPS, Carbon Reduction
49-9052	Telecommunications Line Installers and Repairers	+	Energy Efficiency
49-9081	Wind Turbine Service Technicians	+	100% RPS, Carbon Reduction
51-8012	Power Distributors and Dispatchers	+	100% RPS, Carbon Reduction
51-8013	Power Plant Operators	+	100% RPS, Carbon Reduction
51-8021	Stationary Engineers and Boiler Operators	+	Energy Efficiency
51-8092	Gas Plant Operators	-	100% RPS, Carbon Reduction
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	-	100% RPS, Carbon Reduction
51-8099	Plant and System Operators, All Other	+	100% RPS, Carbon Reduction
53-7071	Gas Compressor and Gas Pumping Station Operators	-	100% RPS, Carbon Reduction

Source: ICF

Exhibit 22 shows employment projections for the selected energy related occupations that are projected to grow or decline at the greatest rate, between 2018 and 2022. The employment shown for these occupations include workers across all industry sectors and are sourced from the Emsi Developer labor market analytics tool. The employment projections are largely consistent with the expected changes resulting from California energy policies, discussed above. As a whole, across all industries, the energy related occupations are projected to add 160,000 jobs between 2018 and 2022 in California, a 5.2% growth rate. Solar Photovoltaic Installers (47-2231) and Wind Turbine Service Technicians (49-9081) are projected to have the greatest growth rate, 38% and 25.5%, respectively, reflecting the transition to more renewable forms of energy in California. A number of construction and building related occupations are also projected to grow rapidly over the next four years, including Electrical Power-Line Installers and Repairers (49-9051), HVAC Mechanics and Installers (49-9021), and Plumbers, Pipefitters, and Steamfitters (47-2152) and Electricians (47-2111). Other fast growing occupations include those in the ICT sector, which as noted above is being driven in the energy sector by systems and building automation and digitalization. Also consistent with the expected changes related to California's 100% RPS and carbon reduction policies are projected drops in employment in fossil fuel related occupations, such as those related to oil and gas extraction. Appendix F shows the employment projections for all selected energy related occupations.

Exhibit 22: Employment for Selected Energy Related Occupations with Greatest Projected Rate of Growth and Decline - California 2018-2022 (All Industry Sectors)

SOC	Occupation	Employed in All Sectors (2018)	Employed in All Sectors (2019)	Employed in All Sectors (2020)	Employed in All Sectors (2021)	Employed in All Sectors (2022)	Change 2018 - 2022	Percent Change 2018 - 2022
47-2231	Solar Photovoltaic Installers	4,736	5,246	5,711	6,142	6,535	1,798	38.0%
49-9081	Wind Turbine Service Technicians	1,256	1,347	1,430	1,507	1,575	320	25.5%
15-1122	Information Security Analysts	9,960	10,452	10,884	11,268	11,610	1,650	16.6%
49-9051	Electrical Power-Line Installers and Repairers	7,834	8,111	8,344	8,543	8,715	881	11.2%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	34,468	35,582	36,513	37,314	38,000	3,532	10.2%
47-2152	Plumbers, Pipefitters, and Steamfitters	61,490	63,379	64,948	66,291	67,435	5,945	9.7%
47-4098	Miscellaneous Construction and Related Workers	4,036	4,143	4,233	4,311	4,374	338	8.4%
47-2111	Electricians	81,242	83,383	85,146	86,647	87,892	6,649	8.2%
15-1143	Computer Network Architects	18,712	19,149	19,502	19,795	20,045	1,333	7.1%
15-1121	Computer Systems Analysts	87,125	89,176	90,812	92,154	93,276	6,151	7.1%
47-5013	Service Unit Operators, Oil, Gas, and Mining	2,941	3,006	3,062	3,112	3,144	203	6.9%
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	45,250	46,210	47,011	47,688	48,231	2,982	6.6%
15-1199	Computer Occupations, All Other	57,782	58,978	59,929	60,718	61,372	3,590	6.2%
15-1133	Software Developers, Systems Software	89,674	91,596	93,067	94,239	95,202	5,527	6.2%
15-1142	Network and Computer Systems Administrators	45,032	45,943	46,668	47,265	47,768	2,737	6.1%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	77,278	78,659	79,787	80,734	81,627	4,349	5.6%
11-9021	Construction Managers	66,241	67,354	68,272	69,055	69,707	3,465	5.2%
17-2171	Petroleum Engineers	2,521	2,516	2,509	2,500	2,492	-29	-1.1%
19-4041	Geological and Petroleum Technicians	1,746	1,743	1,737	1,730	1,723	-23	-1.3%
51-8092	Gas Plant Operators	1,240	1,232	1,226	1,220	1,213	-27	-2.2%
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	4,590	4,545	4,503	4,460	4,419	-171	-3.7%
53-7071	Gas Compressor and Gas Pumping Station Operators	1,176	1,128	1,085	1,046	1,016	-161	-13.7%
TOTAL		**3,082,010**	**3,135,340**	**3,178,311**	**3,213,889**	**3,241,955**	**159,945**	**5.2%**

Source: Emsi

To examine further recent growth trends in the selected energy related occupations, we collected and analyzed recent job postings and new hires data. This data is also sourced from Emsi's labor market analytics tool (Developer). Exhibit 23 shows the selected energy related occupations with the largest percent increase in active job postings between May 2018 and May 2019 in California. The job postings are across all industry sectors. Engineers, including civil, electrical, and environmental lead the list of energy related occupation with the greatest number of postings and the greatest percent increase in postings between May 2018 and May 2019. Also leading the list of energy related occupations with the greatest percent increase in postings are ICT occupations, such as computer systems analyst, software developers, and information security analyst. The large increase in posting could indicate increasing demand for these occupations over the past year.

Most of these occupations require advanced college degrees and many of the workers are recruited out of four-year colleges. It should be noted that job openings for these type of occupations are typically advertised in on-line job boards, which make up most of the postings that are captured in this data set. Jobs that may only require certifications and other less-than-college credentials, such as many construction, mechanics, and repair and installation occupations are not as prevalent in the job postings data set used here. Demand for these occupations, therefore, are likely underrepresented in this data set. See Appendix G for job postings data for the full set of selected energy related occupations.

Exhibit 23: Selected Energy Sector Occupations with the largest percent increase in active job postings between May 2018 and May 2019 in California (Job postings in All Sectors, 1,000+ postings)

SOC	Occupation	Unique Postings from Jun 2018 - May 2019	May 2018 Active Postings	May 2019 Active Postings	Change in Postings May 2018-May2019	Percent Change May 2018 - May 2019
17-2051	Civil Engineers	21,598	3,722	5,476	1,754	47%
17-2071	Electrical Engineers	26,033	4,974	7,194	2,220	45%
11-9199	Managers, All Other	61,985	10,725	15,508	4,783	45%
17-2081	Environmental Engineers	4,688	918	1,293	375	41%
15-1121	Computer Systems Analysts	58,940	9,507	13,302	3,795	40%
17-3029	Engineering Technicians, Except Drafters, All Other	1,455	270	376	106	39%
17-2072	Electronics Engineers, Except Computer	14,265	2,736	3,769	1,033	38%
17-2141	Mechanical Engineers	32,929	6,050	8,302	2,252	37%
11-3051	Industrial Production Managers	12,312	2,407	3,297	890	37%
15-1133	Software Developers, Systems Software	34,439	6,167	8,407	2,240	36%
17-2199	Engineers, All Other	4,362	815	1,100	285	35%
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	32,573	5,818	7,763	1,945	33%
15-1199	Computer Occupations, All Other	120,746	20,765	27,637	6,872	33%
15-1122	Information Security Analysts	32,906	5,682	7,496	1,814	32%
15-1142	Network and Computer Systems Administrators	57,307	10,022	13,128	3,106	31%
13-2011	Accountants and Auditors	89,395	15,178	19,664	4,486	30%
17-2112	Industrial Engineers	58,897	11,251	14,541	3,290	29%
13-1199	Business Operations Specialists, All Other	36,376	6,435	8,251	1,816	28%
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	21,214	3,920	4,972	1,052	27%
49-9071	Maintenance and Repair Workers, General	53,671	10,261	12,857	2,596	25%
17-3011	Architectural and Civil Drafters	3,619	696	856	160	23%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	6,107	1,224	1,505	281	23%
TOTAL		1,228,926	223,318	286,071	62,753	28%

Source: Emsi

Exhibit 24 shows the energy related occupations with the top percent change in annual hires between 2016 and 2018. This differs from the job postings data in that it represents actual hires and not job postings, which may not necessarily lead to a hire and may contain duplicate postings for each actual hire. As such, hires data represents a good measure of employer demand. This data set also does not

rely on on-line job postings, which as noted above may not capture many occupations that require less-than-college credentials. ICT occupations, Information Security Analyst (15-1122) and Computer Occupations, All Other (15-1199) lead the list with a 19% increase in the average monthly hires between 2016 and 2018. These occupations are in high demand across many industry sectors and are becoming increasingly important in the energy sector, as systems and building automation continues to expand. As will be shown in the Gap Analysis section below, some ICT occupations are projected to have significant shortages in the supply of workers in California, indicating that employers may be experience difficulty in staffing these important positions.

Solar Photovoltaic Installers (47-2231) and other construction and building related occupations, such as various construction managers and supervisors, Electricians (47-2111), Plumbers, Pipefitters and Steamfitters (47-2152) and HVAC Mechanics and Installers (40-9021) also experienced a significant increase in the number of hires between 2016 and 2018. These occupations are also becoming increasingly important in the energy sector as a result of energy efficiency and carbon reduction policy. Shortages of labor are also expected. See Appendix H for hires data for all selected energy related occupations.

Exhibit 24: Selected Energy Related Occupations with Top Percent Change in Annual Hires 2016 - 2019 (Jobs in All Sectors, 100+ annual hires)

SOC	Occupation	2016 Average Monthly Hires	2017 Average Monthly Hires	2018 Average Monthly Hires	Percent Change 2016 - 2018
15-1122	Information Security Analysts	381	433	455	19%
15-1199	Computer Occupations, All Other	1,838	2,153	2,191	19%
47-2231	Solar Photovoltaic Installers	245	258	290	18%
11-9021	Construction Managers	2,201	2,363	2,474	12%
13-1161	Market Research Analysts and Marketing Specialists	4,330	4,687	4,821	11%
11-9199	Managers, All Other	2,389	2,600	2,639	10%
17-2112	Industrial Engineers	768	813	847	10%
17-2141	Mechanical Engineers	926	980	1,018	10%
11-3071	Transportation, Storage, and Distribution Managers	819	881	900	10%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	3,721	3,847	4,057	9%
17-2051	Civil Engineers	1,633	1,723	1,771	8%
47-2111	Electricians	4,132	4,325	4,456	8%
41-3099	Sales Representatives, Services, All Other	7,871	8,308	8,480	8%
13-1199	Business Operations Specialists, All Other	6,708	7,143	7,226	8%
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	2,955	3,158	3,169	7%
47-2152	Plumbers, Pipefitters, and Steamfitters	3,014	3,103	3,221	7%
15-1143	Computer Network Architects	727	756	776	7%
11-3051	Industrial Production Managers	669	701	712	6%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	1,584	1,618	1,682	6%
17-2199	Engineers, All Other	693	719	733	6%
49-9099	Installation, Maintenance, and Repair Workers, All Other	1,187	1,239	1,253	6%
TOTAL		**118,703**	**121,787**	**124,360**	**5%**

Source: Emsi

VIII. Task 7: Gap Analysis

The gap analysis for the energy sector in California measures the supply and demand of labor in the selected energy related occupations. The gap analysis, using data from the Emsi Developer tool, compares the number of annual openings over the next four years to the number of average completions over the past four years. The underlining assumption is that the average number of annual completions over the next four years will remain constant to the number of completions over the past four years. Completions represent the number of degrees or certificates conferred for a specific course of study in a given year. Emsi matches degrees and certificates to occupations using the Classification of Instructional Programs (CIP) classification system developed by the National Center for Education Statistics (NCES). The CIP classification system provides a taxonomy of instructional programs linked to occupational codes (SOC codes). The number of completions by occupation (or SOC code), therefore, represents the number of degrees and certificates conferred in each occupation. An important limitation of note for this data set is that the completions that are captured are primarily from 4-year colleges, universities, and 2-year community colleges. Apprenticeship completions are included in the completions number for five occupations, 1) Electricians (47-2111), 2) Plumbers, Pipefitters, and Steamfitters (47-2152), 3) HVAC Mechanics and Installers (49-9021), 4) Telecommunication Line Installers and Repairers (49-9052), and 5) Electrical Power-Line Installers and Repairers (4909051)[30]. All other occupations do not include apprenticeships. Completions from other types of training providers, such as specific industry and employer-based providers are largely not represented.

Annual openings represent the number of job openings that are projected as a result of new jobs created (growth) and replacement jobs (from attrition and retirement). To calculate the "Gap" average annual openings across all sectors is used, since workers in the energy related occupations can chose to work in any industry sector, within and outside of energy.

The gap analysis also does not account for the migration of labor (only California is included). Labor completing instructional programs in California can move to other states and labor completing instructional programs in other states can move to California.

Exhibit 25 shows the selected energy related occupations that are projected to experience a shortage of workers over the next four years. These represent occupations that employers will likely have difficulty filling over the next four years. Leading the list are business operations related occupations, such as accountants and auditors, business operation specialist, and marketing specialists. Examining shortages in these occupations at the state or regional level can be misleading. These occupations generally require four-year college degrees and completers in the instructional programs related to these occupations are very mobile, competing for jobs throughout the country. Workers for these occupations are often recruited for at a national level. California colleges and universities may not graduating enough workers in these occupations to fill the demand from employers within the state, but labor completing programs in other states may migrate to California to fill these positions. While recent research indicates that migration of college graduates is dropping, California remains a net importer of four-year college graduates[31].

Significant shortages in ICT related occupations, such as Computer Systems Analysts (15-1121) and Network and Computer Systems Administrators (15-1142), are also projected. As noted throughout this report, these are occupations that are becoming increasingly important in the energy sector, as the sector automates and digitizes. Many ICT related occupations also require four-year college degrees and the labor gap findings may also be misleading when examined at the state level, similar to accountants and

[30] California Department of Industrial Relations, Division of Apprenticeship Standards, Retrieved June 20, 2019, from: https://www.dir.ca.gov/DAS/das.html.
[31] Klechen, R. (2018, January 22). New Research on Brain Drain and Recent College Graduates [blog post]. Retrieved from: https://robertkelchen.com/2018/01/22/new-research-on-brain-drain-and-recent-college-graduates/.

auditors, business operation specialist, and marketing specialists, described above. Many ICT occupations, however, do only require certifications or less than four-year degrees and many credentials are acquired at community colleges. Workers in occupations that only require certifications could be less mobile than college graduates, therefore the gap in ICT occupations can be more difficult to fill. Since demands for ICT workers in the Energy sector (and other sectors) are likely to continue to increase, the shortage of qualified labor in this area can be a major constraint on the energy sector in California.

Perhaps of greater concern is the large labor shortages projected in the construction and installation, maintenance, and repair occupations, such as Electricians and Plumbers, Pipefitters, and Steamfitters (47-2152), First-Line Supervisors of Construction Trades and Extraction Workers (47-1011), industrial machinery mechanics, HVAC mechanics and installers, and telecommunication line installers and repairers. Demand for these occupations in the energy sector are projected to increase rapidly, as energy efficiency, particularly in buildings, becomes increasingly important. Workers in these occupations will also be required to learn new skills, in addition the traditional hard skills, as energy automation in buildings requires these workers to have knowledge of those systems. The credentials required for occupations in the skilled construction trades and installation, maintenance, and repair are primarily certifications and are acquired at community colleges and other training providers, and the workers for these occupations will generally be recruited locally. A shortage of qualified labor in these occupations will also become a major constraint in on the energy sector in California.

Exhibit 25: Selected Energy Occupations in High Demand with Projected Shortages

SOC	Description	AVG Annual Openings All-Sectors 2018-2022 (TOTAL DEMAND)	AVG Annual Completions 2015-2018	Yearly Shortage of Workers (GAP)
13-2011	Accountants and Auditors	21,765	3,764	-18,001
13-1199	Business Operations Specialists, All Other	17,542	678	-16,864
13-1161	Market Research Analysts and Marketing Specialists	14,762	1,116	-13,646
47-2111	Electricians*	10,891	2,338	-8,553
47-2152	Plumbers, Pipefitters, and Steamfitters*	8,119	680	-7,439
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	8,882	2,618	-6,265
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	5,588	716	-4,872
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	4,663	61	-4,603
15-1121	Computer Systems Analysts	7,239	3,406	-3,834
49-9099	Installation, Maintenance, and Repair Workers, All Other	4,175	1,037	-3,138
49-9041	Industrial Machinery Mechanics	3,031	125	-2,906
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers*	4,315	1,824	-2,491
15-1142	Network and Computer Systems Administrators	3,536	1,415	-2,122
17-2051	Civil Engineers	4,309	2,713	-1,595
17-2112	Industrial Engineers	2,051	560	-1,491
49-9052	Telecommunications Line Installers and Repairers*	1,579	204	-1,375

SOC	Description	AVG Annual Openings All-Sectors 2018-2022 (TOTAL DEMAND)	AVG Annual Completions 2015-2018	Yearly Shortage of Workers (GAP)
17-3023	Electrical and Electronics Engineering Technicians	2,226	953	-1,273
47-2231	Solar Photovoltaic Installers	1,017	58	-960
17-3029	Engineering Technicians, Except Drafters, All Other	1,067	406	-661
49-9051	Electrical Power-Line Installers and Repairers*	875	305	-570
17-3011	Architectural and Civil Drafters	1,820	1,331	-489
17-3012	Electrical and Electronics Drafters	462	21	-441
17-3013	Mechanical Drafters	538	122	-416
47-4098	Miscellaneous Construction and Related Workers	524	187	-337
51-8013	Power Plant Operators	382	61	-321
17-2081	Environmental Engineers	623	354	-269
51-8099	Plant and System Operators, All Other	168	61	-107
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	685	597	-88
TOTAL		**325,663**	**384,854**	**59,191**

Source: Emsi, California Department of Industrial Relations/Division of Apprenticeship Standards, and ICF
* Includes reported Emsi completions and apprenticeships in 2017.
Note: All other completions include Emsi reported completions and do not include apprenticeship completions.

The full gap analysis is available as Appendix I.

Appendices

Appendix A: List of Energy Related Industries

NAICS Code	NAICS Title
211120	Crude Petroleum Extraction
211130	Natural Gas Extraction
212111	Bituminous Coal and Lignite Surface Mining
212112	Bituminous Coal Underground Mining
213111	Drilling Oil and Gas Wells
213112	Support Activities for Oil and Gas Operations
213113	Support Activities for Coal Mining
221111	Hydroelectric Power Generation
221112	Fossil Fuel Electric Power Generation
221113	Nuclear Electric Power Generation
221114	Solar Electric Power Generation
221115	Wind Electric Power Generation
221116	Geothermal Electric Power Generation
221117	Biomass Electric Power Generation
221118	Other Electric Power Generation
221121	Electric Bulk Power Transmission and Control
221122	Electric Power Distribution
221210	Natural Gas Distribution
237120	Oil and Gas Pipeline and Related Structures Construction
237130	Power and Communication Line and Related Structures Construction
333131	Mining Machinery and Equipment Manufacturing
333132	Oil and Gas Field Machinery and Equipment Manufacturing
333611	Turbine and Turbine Generator Set Units Manufacturing
333613	Mechanical Power Transmission Equipment Manufacturing
335311	Power, Distribution, and Specialty Transformer Manufacturing
423520	Coal and Other Mineral and Ore Merchant Wholesalers
424710	Petroleum Bulk Stations and Terminals
424720	Petroleum and Petroleum Products Merchant Wholesalers (except Bulk Stations and Terminals)
486110	Pipeline Transportation of Crude Oil
486210	Pipeline Transportation of Natural Gas
486910	Pipeline Transportation of Refined Petroleum Products

Appendix B: LMI Data – All Occupations: Energy Sector

All data sourced from Emsi.

SOC	Occupation	Employed in Energy Sectors (2018)	Employed in Energy Sectors Projected (2028)	Change (2018 - 2028)	% Change (2018 - 2028)	% of Total Jobs in Energy Sectors (2018)	Median Hourly Earnings	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
11-1021	General and Operations Managers	4,976	4,881	-95	-1.9%	1.9%	$51.16	Bachelor's degree	5 years or more	None
11-3051	Industrial Production Managers	525	530	5	1.0%	0.2%	$47.73	Bachelor's degree	5 years or more	None
11-3071	Transportation, Storage, and Distribution Managers	236	206	-30	-12.7%	0.2%	$41.93	High school diploma or equivalent	5 years or more	None
11-9021	Construction Managers	1,352	1,651	299	22.1%	0.9%	$24.58	Bachelor's degree	None	Moderate-term on-the-job training
11-9199	Managers, All Other	7,192	7,479	287	4.0%	32.9%	$20.81	Bachelor's degree	Less than 5 years	None
13-1161	Market Research Analysts and Marketing Specialists	660	726	66	10.0%	0.5%	$32.53	Bachelor's degree	None	None
13-1199	Business Operations Specialists, All Other	2,412	2,294	-118	-4.9%	1.4%	$37.42	Bachelor's degree	None	None
13-2011	Accountants and Auditors	3,190	3,376	186	5.8%	1.5%	$33.30	Bachelor's degree	None	None
15-1121	Computer Systems Analysts	763	729	-34	-4.5%	0.9%	$44.12	Bachelor's degree	None	None
15-1122	Information Security Analysts	111	119	8	7.2%	1.1%	$52.10	Bachelor's degree	Less than 5 years	None
15-1133	Software Developers, Systems Software	201	199	-2	-1.0%	0.2%	$58.21	Bachelor's degree	None	None
15-1142	Network and Computer Systems Administrators	507	561	54	10.7%	1.1%	$43.30	Bachelor's degree	None	None
15-1143	Computer Network Architects	177	173	-4	-2.3%	0.9%	$58.50	Bachelor's degree	5 years or more	None
15-1199	Computer Occupations, All Other	365	358	-7	-1.9%	0.6%	$41.18	Bachelor's degree	None	None
17-1021	Cartographers and Photogrammetrists	166	214	48	28.9%	9.3%	$38.30	Bachelor's degree	None	None
17-2051	Civil Engineers	680	662	-18	-2.6%	1.3%	$47.63	Bachelor's degree	None	None
17-2071	Electrical Engineers	2,014	2,404	390	19.4%	7.4%	$51.66	Bachelor's degree	None	None

SOC	Occupation	Employed in Energy Sectors (2018)	Employed in Energy Sectors Projected (2028)	Change (2018 - 2028)	% Change (2018 - 2028)	% of Total Jobs in Energy Sectors (2018)	Median Hourly Earnings	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
17-2072	Electronics Engineers, Except Computer	161	162	1	0.6%	0.5%	$56.64	Bachelor's degree	None	None
17-2081	Environmental Engineers	138	140	2	1.4%	1.6%	$49.09	Bachelor's degree	None	None
17-2112	Industrial Engineers	504	514	10	2.0%	2.0%	$48.70	Bachelor's degree	None	None
17-2141	Mechanical Engineers	508	505	-3	-0.6%	1.8%	$45.98	Bachelor's degree	None	None
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	38	48	10	26.3%	7.2%	$63.42	Bachelor's degree	None	None
17-2171	Petroleum Engineers	491	424	-67	-13.6%	19.5%	$58.57	Bachelor's degree	None	None
17-2199	Engineers, All Other	544	522	-22	-4.0%	2.1%	$43.54	Bachelor's degree	None	None
17-3011	Architectural and Civil Drafters	118	127	9	7.6%	0.6%	$28.28	Associate's degree	None	None
17-3012	Electrical and Electronics Drafters	148	157	9	6.1%	3.0%	$31.93	Associate's degree	None	None
17-3013	Mechanical Drafters	54	56	2	3.7%	1.0%	$28.24	Associate's degree	None	None
17-3023	Electrical and Electronics Engineering Technicians	675	716	41	6.1%	2.7%	$31.56	Associate's degree	None	None
17-3029	Engineering Technicians, Except Drafters, All Other	315	314	-1	-0.3%	2.8%	$33.46	Associate's degree	None	None
19-4041	Geological and Petroleum Technicians	276	255	-21	-7.6%	15.8%	$24.46	Associate's degree	None	Moderate-term on-the-job training
41-3099	Sales Representatives, Services, All Other	1,169	1,339	170	14.5%	0.7%	$26.23	High school diploma or equivalent	None	Moderate-term on-the-job training
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	219	212	-7	-3.2%	0.4%	$35.76	Bachelor's degree	None	Moderate-term on-the-job training
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	1,889	1,771	-118	-6.2%	1.1%	$26.08	High school diploma or equivalent	None	Moderate-term on-the-job training

SOC	Occupation	Employed in Energy Sectors (2018)	Employed in Energy Sectors Projected (2028)	Change (2018 - 2028)	% Change (2018 - 2028)	% of Total Jobs in Energy Sectors (2018)	Median Hourly Earnings	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
43-4051	Customer Service Representatives	3,036	3,041	5	0.2%	1.3%	$18.78	High school diploma or equivalent	None	Short-term on-the-job training
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	4,561	4,769	208	4.6%	5.9%	$30.77	High school diploma or equivalent	5 years or more	None
47-2111	Electricians	1,812	2,433	621	34.3%	2.2%	$28.01	High school diploma or equivalent	None	Apprenticeship
47-2152	Plumbers, Pipefitters, and Steamfitters	2,038	2,116	78	3.8%	3.3%	$22.55	High school diploma or equivalent	None	Apprenticeship
47-2231	Solar Photovoltaic Installers	166	203	37	22.3%	3.5%	$19.41	High school diploma or equivalent	None	Moderate-term on-the-job training
47-4098	Miscellaneous Construction and Related Workers	110	140	30	27.3%	2.7%	$18.30	High school diploma or equivalent	None	Moderate-term on-the-job training
47-5011	Derrick Operators, Oil and Gas	593	702	109	18.4%	88.3%	$24.12	No formal educational credential	None	Short-term on-the-job training
47-5012	Rotary Drill Operators, Oil and Gas	976	1,178	202	20.7%	75.3%	$28.41	No formal educational credential	None	Moderate-term on-the-job training
47-5013	Service Unit Operators, Oil, Gas, and Mining	2,083	2,649	566	27.2%	70.8%	$25.82	No formal educational credential	None	Moderate-term on-the-job training
47-5071	Roustabouts, Oil and Gas	1,322	1,852	530	40.1%	53.1%	$16.30	No formal educational credential	None	Moderate-term on-the-job training
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	1,769	2,056	287	16.2%	3.9%	$34.57	High school diploma or equivalent	Less than 5 years	None
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	231	248	17	7.4%	3.1%	$29.04	Postsecondary nondegree award	None	Long-term on-the-job training
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	1,182	1,203	21	1.8%	42.4%	$46.15	Postsecondary nondegree award	Less than 5 years	Moderate-term on-the-job training

SOC	Occupation	Employed in Energy Sectors (2018)	Employed in Energy Sectors Projected (2028)	Change (2018 - 2028)	% Change (2018 - 2028)	% of Total Jobs in Energy Sectors (2018)	Median Hourly Earnings	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	2,000	1,987	-13	-0.7%	53.8%	$32.78	High school diploma or equivalent	None	Moderate-term on-the-job training
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	293	278	-15	-5.1%	0.9%	$21.81	Postsecondary nondegree award	None	Long-term on-the-job training
49-9041	Industrial Machinery Mechanics	1,623	1,626	3	0.2%	5.3%	$25.48	High school diploma or equivalent	None	Long-term on-the-job training
49-9051	Electrical Power-Line Installers and Repairers	4,663	5,980	1,317	28.2%	59.5%	$50.71	High school diploma or equivalent	None	Long-term on-the-job training
49-9052	Telecommunications Line Installers and Repairers	2,007	2,618	611	30.4%	13.5%	$30.91	High school diploma or equivalent	None	Long-term on-the-job training
49-9071	Maintenance and Repair Workers, General	743	794	51	6.9%	0.5%	$20.09	High school diploma or equivalent	None	Moderate-term on-the-job training
49-9081	Wind Turbine Service Technicians	586	1,064	478	81.6%	46.7%	$22.21	Postsecondary nondegree award	None	Long-term on-the-job training
49-9099	Installation, Maintenance, and Repair Workers, All Other	446	463	17	3.8%	1.1%	$17.40	High school diploma or equivalent	None	Moderate-term on-the-job training
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	391	321	-70	-17.9%	1.1%	$15.68	High school diploma or equivalent	None	Moderate-term on-the-job training
51-8012	Power Distributors and Dispatchers	1,089	1,142	53	4.9%	63.1%	$37.38	High school diploma or equivalent	None	Long-term on-the-job training
51-8013	Power Plant Operators	2,131	2,539	408	19.1%	62.8%	$46.22	High school diploma or equivalent	None	Long-term on-the-job training
51-8021	Stationary Engineers and Boiler Operators	89	80	-9	-10.1%	2.3%	$38.63	High school diploma or equivalent	None	Long-term on-the-job training
51-8092	Gas Plant Operators	1,064	980	-84	-7.9%	85.8%	$47.90	High school diploma or equivalent	None	Long-term on-the-job training

SOC	Occupation	Employed in Energy Sectors (2018)	Employed in Energy Sectors Projected (2028)	Change (2018 - 2028)	% Change (2018 - 2028)	% of Total Jobs in Energy Sectors (2018)	Median Hourly Earnings	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	803	778	-25	-3.1%	17.5%	$39.00	High school diploma or equivalent	None	Moderate-term on-the-job training
51-8099	Plant and System Operators, All Other	105	110	5	4.8%	6.4%	$31.72	High school diploma or equivalent	None	Moderate-term on-the-job training
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	1,250	1,158	-92	-7.4%	1.9%	$20.20	High school diploma or equivalent	None	Moderate-term on-the-job training
53-7071	Gas Compressor and Gas Pumping Station Operators	743	522	-221	-29.7%	63.2%	$32.00	High school diploma or equivalent	None	Moderate-term on-the-job training
53-7072	Pump Operators, Except Wellhead Pumpers	1,167	1,095	-72	-6.2%	46.0%	$20.67	High school diploma or equivalent	None	Moderate-term on-the-job training
53-7073	Wellhead Pumpers	6,875	7,534	659	9.6%	98.6%	$22.20	High school diploma or equivalent	Less than 5 years	Moderate-term on-the-job training
TOTAL		**80,719**	**87,482**	**6,762**	**8.4%**	**51.8%**	**$32.62**			

Appendix C: LMI Data – All Occupations: All Sectors

In the tables below, the metric *Location Quotient* indicates how concentrated an occupation—in terms of jobs—is in California compared to the U.S. as a whole. A location quotient of 1.0 means there is an equivalent concentration of jobs for a given occupation in California as the U.S. A location quotient larger than 1.0 indicates that California employs a larger proportion of workers in that occupation than what is employed at the national level. The metric *Projected Openings* represents the sum of new jobs and replacement jobs for a given occupation. *Replacement Jobs* indicates the number of job openings resulting from attrition and retirements. The *Annual Replacement Rate* indicates the percentage of jobs being replaced for an occupation annually. All data sourced from Emsi.

SOC	Occupation	2018 Jobs	Projected 2028 Jobs	Projected 2018 - 2028 Change	Projected 2018 - 2028 % Change	2018 Location Quotient	Projected 2028 Location Quotient	Total Projected Openings 2018 - 2028	Projected Annual Openings	Projected 2018 - 2028 Replacement Jobs	Projected Annual Replacement Jobs	Annual Replacement Rate
11-1021	General and Operations Managers	280,199	307,207	27,008	9.6%	0.96	0.95	263,490	26,349	236,407	23,641	0.080
11-3051	Industrial Production Managers	21,891	22,371	480	2.2%	0.93	0.89	16,778	1,678	15,361	1,536	0.069
11-3071	Transportation, Storage, and Distribution Managers	21,363	23,594	2,231	10%	1.15	1.14	19,303	1,930	16,984	1,698	0.075
11-9021	Construction Managers	66,241	72,188	5,947	9%	0.90	0.90	53,704	5,370	46,629	4,663	0.067
11-9199	Managers, All Other	262,696	294,629	31,933	12.2%	1.03	1.00	225,104	22,510	192,998	19,300	0.069
13-1161	Market Research Analysts and Marketing Specialists	120,101	141,603	21,502	17.9%	1.31	1.26	146,594	14,659	125,090	12,509	0.095
13-1199	Business Operations Specialists, All Other	171,496	185,948	14,452	8.4%	1.28	1.24	174,077	17,408	159,616	15,962	0.089
13-2011	Accountants and Auditors	217,297	234,072	16,775	7.7%	1.03	1.01	214,548	21,455	197,350	19,735	0.087
15-1121	Computer Systems Analysts	87,125	97,280	10,155	11.7%	1.07	1.07	69,195	6,920	58,563	5,856	0.063
15-1122	Information Security Analysts	9,960	13,082	3,122	31.3%	0.70	0.73	10,798	1,080	7,662	766	0.066
15-1133	Software Developers, Systems Software	89,674	98,477	8,803	9.8%	1.70	1.66	68,872	6,887	59,767	5,977	0.063
15-1142	Network and Computer Systems Administrators	45,032	49,567	4,535	10.1%	0.92	0.93	33,853	3,385	29,053	2,905	0.061
15-1143	Computer Network Architects	18,712	20,934	2,222	11.9%	0.91	0.93	14,953	1,495	12,586	1,259	0.063

SOC	Occupation	2018 Jobs	Projected 2028 Jobs	Projected 2018 - 2028 Change	Projected 2018 - 2028 % Change	2018 Location Quotient	Projected 2028 Location Quotient	Total Projected Openings 2018 - 2028	Projected Annual Openings	Projected 2018 - 2028 Replacement Jobs	Projected Annual Replacement Jobs	Annual Replacement Rate
15-1199	Computer Occupations, All Other	57,782	64,098	6,316	10.9%	1.24	1.23	46,830	4,683	40,449	4,045	0.066
17-1021	Cartographers and Photogrammetrists	1,783	2,082	299	16.8%	0.88	0.83	1,672	167	1,354	135	0.070
17-2051	Civil Engineers	50,872	55,364	4,492	8.8%	1.21	1.18	42,540	4,254	37,797	3,780	0.071
17-2071	Electrical Engineers	27,241	29,160	1,919	7.0%	1.12	1.08	20,092	2,009	17,850	1,785	0.063
17-2072	Electronics Engineers, Except Computer	31,223	30,811	-412	-1.3%	1.74	1.64	20,342	2,034	19,597	1,960	0.063
17-2081	Environmental Engineers	8,453	8,870	417	4.9%	1.26	1.19	6,071	607	5,561	556	0.064
17-2112	Industrial Engineers	25,525	27,777	2,252	8.8%	0.77	0.75	19,746	1,975	17,184	1,718	0.064
17-2141	Mechanical Engineers	28,677	30,979	2,302	8.0%	0.77	0.75	21,240	2,124	18,593	1,859	0.062
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	524	602	78	14.9%	0.61	0.61	495	50	408	41	0.072
17-2171	Petroleum Engineers	2,521	2,507	-14	-0.6%	0.55	0.51	1,760	176	1,602	160	0.064
17-2199	Engineers, All Other	25,491	26,546	1,055	4.1%	1.11	1.07	17,874	1,787	16,466	1,647	0.063
17-3011	Architectural and Civil Drafters	18,694	20,176	1,482	7.9%	1.27	1.25	17,936	1,794	16,393	1,639	0.084
17-3012	Electrical and Electronics Drafters	4,844	5,124	280	5.8%	1.20	1.16	4,525	453	4,210	421	0.084
17-3013	Mechanical Drafters	5,313	5,810	497	9.4%	0.63	0.64	5,249	525	4,702	470	0.084
17-3023	Electrical and Electronics Engineering Technicians	24,715	24,749	34	0.1%	1.43	1.35	21,884	2,188	21,114	2,111	0.085
17-3029	Engineering Technicians, Except Drafters, All Other	11,411	11,845	434	3.8%	1.09	1.05	10,511	1,051	9,926	993	0.085
19-4041	Geological and Petroleum Technicians	1,746	1,709	-37	-2.1%	0.83	0.72	1,819	182	1,725	172	0.100
41-3099	Sales Representatives, Services, All Other	164,891	182,487	17,596	10.7%	1.09	1.09	223,864	22,386	206,178	20,618	0.118
41-4011	Sales Representatives,	50,757	52,171	1,414	2.8%	1.13	1.07	54,635	5,464	51,815	5,182	0.100

SOC	Occupation	2018 Jobs	Projected 2028 Jobs	Projected 2018 - 2028 Change	Projected 2018 - 2028 % Change	2018 Location Quotient	Projected 2028 Location Quotient	Total Projected Openings 2018 - 2028	Projected Annual Openings	Projected 2018 - 2028 Replacement Jobs	Projected Annual Replacement Jobs	Annual Replacement Rate
	Wholesale and Manufacturing, Technical and Scientific Products											
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	179,662	178,158	-1,504	-0.8%	0.93	0.86	185,812	18,581	179,647	17,965	0.100
43-4051	Customer Service Representatives	238,517	262,807	24,290	10.2%	0.67	0.68	342,200	34,220	317,731	31,773	0.126
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	77,278	83,884	6,606	8.5%	0.77	0.78	87,061	8,706	77,211	7,721	0.095
47-2111	Electricians	81,242	93,354	12,112	14.9%	0.84	0.86	108,283	10,828	95,721	9,572	0.109
47-2152	Plumbers, Pipefitters, and Steamfitters	61,490	72,464	10,974	17.8%	0.91	0.92	80,664	8,066	69,413	6,941	0.103
47-2231	Solar Photovoltaic Installers	4,736	8,413	3,677	77.6%	2.62	2.63	10,544	1,054	6,867	687	0.104
47-4098	Miscellaneous Construction and Related Workers	4,036	4,633	597	14.8%	0.62	0.64	5,171	517	4,539	454	0.104
47-5011	Derrick Operators, Oil and Gas	672	789	117	17.4%	0.44	0.38	981	98	857	86	0.118
47-5012	Rotary Drill Operators, Oil and Gas	1,296	1,503	207	16.0%	0.50	0.42	1,864	186	1,639	164	0.118
47-5013	Service Unit Operators, Oil, Gas, and Mining	2,941	3,511	570	19.4%	0.43	0.36	4,450	445	3,759	376	0.118
47-5071	Roustabouts, Oil and Gas	2,493	3,168	675	27.1%	0.31	0.29	4,086	409	3,397	340	0.121
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	45,250	50,711	5,461	12.1%	0.74	0.76	46,024	4,602	40,499	4,050	0.084
49-2094	Electrical and Electronics Repairers,	7,377	7,504	127	1.7%	0.80	0.77	6,718	672	6,430	643	0.086

SOC	Occupation	2018 Jobs	Projected 2028 Jobs	Projected 2018 - 2028 Change	Projected 2018 - 2028 % Change	2018 Location Quotient	Projected 2028 Location Quotient	Total Projected Openings 2018 - 2028	Projected Annual Openings	Projected 2018 - 2028 Replacement Jobs	Projected Annual Replacement Jobs	Annual Replacement Rate
	Commercial and Industrial Equipment											
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	2,787	2,853	66	2.4%	0.80	0.78	2,576	258	2,430	243	0.086
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	3,716	3,878	162	4.4%	0.62	0.60	3,156	316	2,827	283	0.074
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	34,468	41,022	6,554	19.0%	0.72	0.74	42,736	4,274	36,080	3,608	0.095
49-9041	Industrial Machinery Mechanics	30,670	32,830	2,160	7.0%	0.67	0.65	29,681	2,968	27,158	2,716	0.085
49-9051	Electrical Power-Line Installers and Repairers	7,834	9,463	1,629	20.8%	0.55	0.56	8,526	853	6,793	679	0.078
49-9052	Telecommunications Line Installers and Repairers	14,912	15,395	483	3.2%	0.91	0.90	15,709	1,571	14,834	1,483	0.098
49-9071	Maintenance and Repair Workers, General	156,364	173,330	16,966	10.9%	0.81	0.81	176,299	17,630	159,253	15,925	0.096
49-9081	Wind Turbine Service Technicians	1,256	1,913	657	52.3%	1.14	1.04	2,178	218	1,492	149	0.094
49-9099	Installation, Maintenance, and Repair Workers, All Other	40,167	42,674	2,507	6.2%	1.05	1.01	41,622	4,162	39,031	3,903	0.094
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	36,636	30,676	-5,960	-16.3%	1.15	1.09	39,627	3,963	39,387	3,939	0.116
51-8012	Power Distributors and Dispatchers	1,725	1,791	66	3.8%	1.00	1.01	1,692	169	1,522	152	0.086

SOC	Occupation	2018 Jobs	Projected 2028 Jobs	Projected 2018 - 2028 Change	Projected 2018 - 2028 % Change	2018 Location Quotient	Projected 2028 Location Quotient	Total Projected Openings 2018 - 2028	Projected Annual Openings	Projected 2018 - 2028 Replacement Jobs	Projected Annual Replacement Jobs	Annual Replacement Rate
51-8013	Power Plant Operators	3,394	3,842	448	13.2%	0.78	0.86	3,773	377	3,103	310	0.086
51-8021	Stationary Engineers and Boiler Operators	3,950	4,101	151	3.8%	0.81	0.80	4,347	435	4,164	416	0.103
51-8092	Gas Plant Operators	1,240	1,169	-71	-5.7%	0.66	0.60	1,308	131	1,185	118	0.098
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	4,590	4,193	-397	-8.6%	0.94	0.82	4,458	446	4,316	432	0.098
51-8099	Plant and System Operators, All Other	1,641	1,628	-13	-0.8%	0.89	0.84	1,647	165	1,607	161	0.098
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	64,735	61,145	-3,590	-5.5%	0.90	0.86	76,861	7,686	74,629	7,463	0.118
53-7071	Gas Compressor and Gas Pumping Station Operators	1,176	925	-251	-21.3%	1.13	1.07	1,260	126	1,225	123	0.119
53-7072	Pump Operators, Except Wellhead Pumpers	2,533	2,560	27	1.1%	0.53	0.49	3,197	320	3,040	304	0.119
53-7073	Wellhead Pumpers	6,974	7,646	672	9.6%	0.35	0.32	9,714	971	8,905	890	0.119
TOTAL		**3,082,010**	**3,357,750**	**275,744**	**8.9%**	**0.94**	**0.91**	**3,204,582**	**320,458**	**2,891,681**	**289,168**	**0.089**

Source: Emsi

SOC	Occupation	2018 Median Hourly Earnings	2018 Avg. Hourly Earnings	2018 Pct. 10 Hourly Earnings	2018 Pct. 25 Hourly Earnings	2018 Pct. 75 Hourly Earnings	2018 Pct. 90 Hourly Earnings	2018 Median Annual Earnings	2018 Pct. 10 Annual Earnings	2018 Pct. 25 Annual Earnings	2018 Pct. 75 Annual Earnings	2018 Pct. 90 Annual Earnings
11-1021	General and Operations Managers	$51.16	$63.38	$23.63	$32.41	$80.81	$126.41	$106,410	$49,147	$67,406	$168,083	$262,923
11-3051	Industrial Production Managers	$47.73	$54.59	$28.83	$32.90	$66.55	$89.69	$99,286	$59,969	$68,429	$138,434	$186,558
11-3071	Transportation, Storage, and Distribution Managers	$41.93	$47.32	$25.86	$29.72	$57.25	$75.53	$87,216.36	$53,785.38	$61,826.02	$119,082.52	$157,100.75
11-9021	Construction Managers	$24.58	$35.64	$14.42	$15.97	$50.11	$71.87	$51,133.47	$29,994.43	$33,224.18	$104,230.57	$149,493.00

SOC	Occupation	2018 Median Hourly Earnings	2018 Avg. Hourly Earnings	2018 Pct. 10 Hourly Earnings	2018 Pct. 25 Hourly Earnings	2018 Pct. 75 Hourly Earnings	2018 Pct. 90 Hourly Earnings	2018 Median Annual Earnings	2018 Pct. 10 Annual Earnings	2018 Pct. 25 Annual Earnings	2018 Pct. 75 Annual Earnings	2018 Pct. 90 Annual Earnings
11-9199	Managers, All Other	$20.81	$30.15	$15.26	$17.64	$26.23	$64.33	$43,277	$31,747	$36,690	$54,563	$133,810
13-1161	Market Research Analysts and Marketing Specialists	$32.53	$37.05	$17.80	$24.85	$45.26	$64.76	$67,659	$37,023	$51,695	$94,151	$134,708
13-1199	Business Operations Specialists, All Other	$37.42	$40.13	$19.47	$27.02	$48.51	$63.46	$77,843	$40,501	$56,209	$100,891	$132,006
13-2011	Accountants and Auditors	$33.30	$37.21	$23.32	$27.59	$41.91	$55.30	$69,264	$48,500	$57,395	$87,165	$115,016
15-1121	Computer Systems Analysts	$44.12	$47.37	$28.42	$34.29	$57.68	$72.28	$91,768	$59,113	$71,322	$119,965	$150,335
15-1122	Information Security Analysts	$52.10	$51.96	$28.06	$39.97	$62.98	$76.58	$108,372	$58,374	$83,141	$131,006	$159,294
15-1133	Software Developers, Systems Software	$58.21	$59.82	$35.13	$43.57	$73.73	$88.83	$121,072	$73,061	$90,625	$153,354	$184,765
15-1142	Network and Computer Systems Administrators	$43.30	$45.91	$26.12	$34.43	$56.22	$70.36	$90,057	$54,336	$71,618	$116,944	$146,348
15-1143	Computer Network Architects	$58.50	$60.73	$31.96	$41.69	$75.31	$92.42	$121,682	$66,483	$86,720	$156,638	$192,239
15-1199	Computer Occupations, All Other	$41.18	$44.78	$21.81	$28.33	$57.45	$73.37	$85,647	$45,366	$58,917	$119,502	$152,613
17-1021	Cartographers and Photogrammetrists	$38.30	$38.64	$23.33	$28.88	$46.79	$55.62	$79,658	$48,518	$60,061	$97,332	$115,694
17-2051	Civil Engineers	$47.63	$49.28	$28.71	$34.66	$59.90	$72.95	$99,064	$59,720	$72,096	$124,588	$151,745
17-2071	Electrical Engineers	$51.66	$53.47	$32.16	$39.56	$66.24	$78.09	$107,453	$66,902	$82,275	$137,779	$162,427
17-2072	Electronics Engineers, Except Computer	$56.64	$58.15	$34.67	$43.72	$71.17	$85.77	$117,819	$72,116	$90,945	$148,032	$178,393
17-2081	Environmental Engineers	$49.09	$49.86	$29.55	$38.35	$59.50	$70.76	$102,107	$61,464	$79,768	$123,760	$147,181
17-2112	Industrial Engineers	$48.70	$51.23	$31.47	$38.26	$61.33	$76.23	$101,293	$65,466	$79,576	$127,575	$158,550
17-2141	Mechanical Engineers	$45.98	$49.29	$29.45	$35.70	$60.04	$75.02	$95,644	$61,263	$74,248	$124,883	$156,037
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	$63.42	$59.26	$39.49	$53.49	$64.64	$71.66	$131,905	$82,146	$111,250	$134,459	$149,053
17-2171	Petroleum Engineers	$58.57	$63.37	$41.97	$49.24	$72.47	$91.49	$121,818	$87,301	$102,414	$150,745	$190,308
17-2199	Engineers, All Other	$43.54	$48.05	$30.46	$36.89	$59.27	$72.10	$90,568	$63,360	$76,739	$123,273	$149,978

SOC	Occupation	2018 Median Hourly Earnings	2018 Avg. Hourly Earnings	2018 Pct. 10 Hourly Earnings	2018 Pct. 25 Hourly Earnings	2018 Pct. 75 Hourly Earnings	2018 Pct. 90 Hourly Earnings	2018 Median Annual Earnings	2018 Pct. 10 Annual Earnings	2018 Pct. 25 Annual Earnings	2018 Pct. 75 Annual Earnings	2018 Pct. 90 Annual Earnings
17-3011	Architectural and Civil Drafters	$28.28	$28.91	$19.55	$23.47	$33.61	$39.87	$58,821	$40,672	$48,819	$69,904	$82,931
17-3012	Electrical and Electronics Drafters	$31.93	$35.05	$20.22	$26.39	$40.82	$53.22	$66,420	$42,057	$54,882	$84,911	$110,707
17-3013	Mechanical Drafters	$28.24	$29.35	$17.88	$22.88	$33.91	$43.34	$58,729	$37,196	$47,580	$70,534	$90,157
17-3023	Electrical and Electronics Engineering Technicians	$31.56	$32.70	$17.43	$23.11	$39.59	$49.22	$65,649	$36,254	$48,069	$82,346	$102,388
17-3029	Engineering Technicians, Except Drafters, All Other	$33.46	$33.74	$18.27	$25.70	$41.18	$49.20	$69,597	$37,994	$53,456	$85,645	$102,335
19-4041	Geological and Petroleum Technicians	$24.46	$25.76	$12.80	$17.87	$30.92	$42.11	$50,883	$26,621	$37,170	$64,322	$87,580
41-3099	Sales Representatives, Services, All Other	$26.23	$30.77	$13.13	$19.74	$36.30	$53.11	$54,559	$27,301	$41,050	$75,502	$110,464
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	$35.76	$42.37	$20.53	$27.43	$52.44	$73.65	$74,390	$42,697	$57,064	$109,085	$153,182
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	$26.08	$31.53	$13.44	$19.77	$36.49	$54.40	$54,236	$27,947	$41,112	$75,892	$113,145
43-4051	Customer Service Representatives	$18.78	$19.68	$11.98	$14.47	$22.90	$29.12	$39,059	$24,911	$30,099	$47,627	$60,569
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	$30.77	$32.23	$14.26	$16.85	$42.37	$54.43	$64,000	$29,666	$35,043	$88,126	$113,215
47-2111	Electricians	$28.01	$30.45	$15.32	$18.30	$39.81	$50.13	$58,256	$31,861	$38,054	$82,813	$104,280
47-2152	Plumbers, Pipefitters, and Steamfitters	$22.55	$25.90	$14.76	$16.78	$30.74	$43.72	$46,912	$30,698	$34,898	$63,945	$90,946
47-2231	Solar Photovoltaic Installers	$19.41	$21.24	$14.72	$16.64	$23.65	$29.70	$40,371	$30,620	$34,614	$49,186	$61,767

SOC	Occupation	2018 Median Hourly Earnings	2018 Avg. Hourly Earnings	2018 Pct. 10 Hourly Earnings	2018 Pct. 25 Hourly Earnings	2018 Pct. 75 Hourly Earnings	2018 Pct. 90 Hourly Earnings	2018 Median Annual Earnings	2018 Pct. 10 Annual Earnings	2018 Pct. 25 Annual Earnings	2018 Pct. 75 Annual Earnings	2018 Pct. 90 Annual Earnings
47-4098	Miscellaneous Construction and Related Workers	$18.30	$19.77	$13.25	$16.02	$22.60	$27.87	$38,062	$27,569	$33,321	$47,017	$57,975
47-5011	Derrick Operators, Oil and Gas	$24.12	$24.95	$17.05	$20.09	$28.63	$32.70	$50,168	$35,467	$41,782	$59,547	$68,011
47-5012	Rotary Drill Operators, Oil and Gas	$28.41	$30.78	$17.85	$23.57	$39.98	$46.41	$59,089	$37,138	$49,018	$83,161	$96,531
47-5013	Service Unit Operators, Oil, Gas, and Mining	$25.82	$26.75	$18.23	$22.20	$29.66	$35.79	$53,715	$37,908	$46,178	$61,685	$74,440
47-5071	Roustabouts, Oil and Gas	$16.30	$17.89	$12.14	$13.51	$19.94	$26.42	$33,897	$25,246	$28,099	$41,479	$54,945
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	$34.57	$36.44	$20.75	$25.63	$45.00	$56.82	$71,912	$43,153	$53,311	$93,601	$118,178
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	$29.04	$29.78	$15.65	$21.76	$37.18	$45.77	$60,403	$32,552	$45,261	$77,334	$95,202
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	$46.15	$45.26	$29.61	$37.86	$54.32	$60.60	$95,992	$61,589	$78,749	$112,986	$126,048
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	$32.78	$32.32	$17.63	$22.66	$40.75	$48.10	$68,182	$36,670	$47,133	$84,760	$100,048
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	$21.81	$24.53	$14.56	$15.92	$30.05	$40.24	$45,355	$30,281	$33,113	$62,502	$83,702
49-9041	Industrial Machinery Mechanics	$25.48	$27.27	$16.95	$21.54	$32.02	$40.31	$52,989	$35,266	$44,809	$66,600	$83,848
49-9051	Electrical Power-Line Installers and Repairers	$50.71	$45.35	$26.31	$33.81	$57.64	$61.53	$105,470	$54,721	$70,320	$119,898	$127,974

SOC	Occupation	2018 Median Hourly Earnings	2018 Avg. Hourly Earnings	2018 Pct. 10 Hourly Earnings	2018 Pct. 25 Hourly Earnings	2018 Pct. 75 Hourly Earnings	2018 Pct. 90 Hourly Earnings	2018 Median Annual Earnings	2018 Pct. 10 Annual Earnings	2018 Pct. 25 Annual Earnings	2018 Pct. 75 Annual Earnings	2018 Pct. 90 Annual Earnings
49-9052	Telecommunications Line Installers and Repairers	$30.91	$29.66	$17.29	$25.25	$35.61	$38.91	$64,285	$35,963	$52,517	$74,074	$80,929
49-9071	Maintenance and Repair Workers, General	$20.09	$21.39	$11.98	$15.33	$26.09	$32.67	$41,797	$24,924	$31,896	$54,263	$67,949
49-9081	Wind Turbine Service Technicians	$22.21	$23.17	$16.77	$18.86	$27.24	$29.98	$46,199	$34,879	$39,238	$56,658	$62,350
49-9099	Installation, Maintenance, and Repair Workers, All Other	$17.40	$19.29	$12.52	$15.17	$20.49	$28.73	$36,183	$26,043	$31,555	$42,618	$59,767
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	$15.68	$17.22	$10.94	$12.58	$19.84	$25.84	$32,614	$22,755	$26,166	$41,267	$53,747
51-8012	Power Distributors and Dispatchers	$37.38	$40.71	$32.07	$34.06	$45.60	$58.50	$77,750	$66,706	$70,845	$94,848	$121,680
51-8013	Power Plant Operators	$46.22	$44.35	$23.26	$36.70	$54.58	$61.29	$96,138	$48,381	$76,336	$113,526	$127,483
51-8021	Stationary Engineers and Boiler Operators	$38.63	$39.36	$30.03	$33.18	$46.44	$50.76	$80,350	$62,462	$69,014	$96,595	$105,581
51-8092	Gas Plant Operators	$47.90	$47.64	$37.04	$42.93	$54.62	$60.97	$99,632	$77,043	$89,294	$113,610	$126,818
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	$39.00	$37.34	$22.63	$30.81	$45.41	$49.09	$81,120	$47,070	$64,085	$94,453	$102,107
51-8099	Plant and System Operators, All Other	$31.72	$33.66	$20.81	$25.41	$40.24	$51.89	$65,978	$43,285	$52,853	$83,699	$107,931
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	$20.20	$21.62	$11.67	$14.52	$27.34	$33.38	$42,024	$24,268	$30,201	$56,874	$69,436
53-7071	Gas Compressor and Gas Pumping Station Operators	$32.00	$33.01	$21.32	$25.77	$38.89	$45.25	$66,569	$44,342	$53,594	$80,892	$94,111
53-7072	Pump Operators, Except Wellhead Pumpers	$20.67	$23.30	$15.33	$17.22	$26.90	$36.20	$43,002	$31,890	$35,822	$55,958	$75,292
53-7073	Wellhead Pumpers	$22.20	$22.06	$18.50	$19.19	$23.55	$25.55	$46,170	$38,478	$39,918	$48,993	$53,148

SOC	Occupation	2018 Median Hourly Earnings	2018 Avg. Hourly Earnings	2018 Pct. 10 Hourly Earnings	2018 Pct. 25 Hourly Earnings	2018 Pct. 75 Hourly Earnings	2018 Pct. 90 Hourly Earnings	2018 Median Annual Earnings	2018 Pct. 10 Annual Earnings	2018 Pct. 25 Annual Earnings	2018 Pct. 75 Annual Earnings	2018 Pct. 90 Annual Earnings
TOTAL		$32.53	$35.05	$19.55	$25.63	$41.91	$54.40	$67,659.02	$40,672.48	$53,311.10	$87,164.73	$113,144.79

Regional Completions data are listed below for each occupation and for each year between 2012 and 2017. This represents the number of degrees or certifications conferred by educational institutions in California associated to each occupation. This data indicates the available "supply" of workers who have earned appropriate credentials to potentially be employed in a given occupation. The *Automation Index* captures an occupation's risk of being affected by automation using four measures: the percent of time the occupation spends on high-risk work, the percent of time spent on low-risk work, the number of high-risk jobs in compatible occupations, and the overall industry automation risk. A resulting index of "100" indicates that the occupation has an average risk of being impacted by automation; an index over 100 signifies that the occupation has an above average risk of being impacted by automation.

SOC	Occupation	Regional Completions (2012)	Regional Completions (2013)	Regional Completions (2014)	Regional Completions (2015)	Regional Completions (2016)	Regional Completions (2017)	Automation Index
11-1021	General and Operations Managers	49,245	50,605	53,423	55,798	57,627	59,480	82.2
11-3051	Industrial Production Managers	46,202	47,371	49,944	52,379	54,225	56,214	80.9
11-3071	Transportation, Storage, and Distribution Managers	48,667	49,935	52,678	55,177	56,986	58,885	88.2
11-9021	Construction Managers	46,884	47,910	50,411	52,744	54,556	56,674	88.6
11-9199	Managers, All Other	55,979	58,398	61,465	62,209	63,580	65,697	84.5
13-1161	Market Research Analysts and Marketing Specialists	786	939	985	1,088	1,172	1,219	88.6
13-1199	Business Operations Specialists, All Other	671	738	719	712	658	623	86.8
13-2011	Accountants and Auditors	3,502	3,643	3,865	3,805	3,797	3,588	93.1
15-1121	Computer Systems Analysts	3,577	3,757	3,455	3,455	3,329	3,383	81.7
15-1122	Information Security Analysts	10,641	11,644	13,064	13,891	15,163	17,036	86.4
15-1133	Software Developers, Systems Software	7,280	7,815	8,888	10,271	12,858	14,727	78.2
15-1142	Network and Computer Systems Administrators	962	1,195	1,454	1,504	1,347	1,354	87.2
15-1143	Computer Network Architects	10,641	11,644	13,064	13,891	15,163	17,036	87.1
15-1199	Computer Occupations, All Other	4,906	5,010	5,929	6,742	8,568	10,322	85.5
17-1021	Cartographers and Photogrammetrists	149	189	167	237	215	219	94.2
17-2051	Civil Engineers	2,609	2,779	2,784	2,606	2,719	2,744	81.7
17-2071	Electrical Engineers	3,884	3,814	3,990	4,351	4,927	5,014	84.8
17-2072	Electronics Engineers, Except Computer	4,003	3,941	4,110	4,470	5,055	5,135	85.4
17-2081	Environmental Engineers	198	274	353	371	357	335	76.6
17-2112	Industrial Engineers	348	362	369	541	587	742	92.0

SOC	Occupation	Regional Completions (2012)	Regional Completions (2013)	Regional Completions (2014)	Regional Completions (2015)	Regional Completions (2016)	Regional Completions (2017)	Automation Index
17-2141	Mechanical Engineers	3,216	3,375	3,623	3,913	4,367	4,657	83.4
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	0	0	0	0	0	0	81.1
17-2171	Petroleum Engineers	60	59	90	103	97	91	82.0
17-2199	Engineers, All Other	1,681	2,021	2,060	2,096	2,114	2,084	88.2
17-3011	Architectural and Civil Drafters	1,442	1,373	1,358	1,260	1,072	1,634	88.9
17-3012	Electrical and Electronics Drafters	23	15	28	20	20	16	91.0
17-3013	Mechanical Drafters	71	70	101	107	118	163	84.6
17-3023	Electrical and Electronics Engineering Technicians	1,950	1,656	1,612	1,211	510	477	98.6
17-3029	Engineering Technicians, Except Drafters, All Other	443	436	469	389	398	369	92.1
19-4041	Geological and Petroleum Technicians	0	0	0	0	0	12	87.9
41-3099	Sales Representatives, Services, All Other	792	867	810	854	771	696	96.7
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	710	782	743	775	695	651	93.5
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	2,090	2,162	2,056	2,043	1,866	1,699	91.5
43-4051	Customer Service Representatives	14	18	19	14	15	14	96.4
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	3,821	3,591	3,249	2,128	2,508	2,585	106.2
47-2111	Electricians	1,696	1,629	1,440	845	1,324	1,563	110.3
47-2152	Plumbers, Pipefitters, and Steamfitters	299	255	181	72	58	85	116.3
47-2231	Solar Photovoltaic Installers	223	204	125	105	0	0	119.7
47-4098	Miscellaneous Construction and Related Workers	352	608	273	256	127	93	118.8
47-5011	Derrick Operators, Oil and Gas	0	0	0	0	0	0	106.6
47-5012	Rotary Drill Operators, Oil and Gas	0	0	0	0	0	0	110.9
47-5013	Service Unit Operators, Oil, Gas, and Mining	0	0	0	0	0	0	106.1
47-5071	Roustabouts, Oil and Gas	0	0	0	0	0	0	123.5
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	26	59	82	57	45	58	94.0
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	266	262	344	736	648	659	97.3
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	2,409	2,274	1,927	1,330	1,636	1,820	99.9
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	187	112	135	102	133	130	109.4

SOC	Occupation	Regional Completions (2012)	Regional Completions (2013)	Regional Completions (2014)	Regional Completions (2015)	Regional Completions (2016)	Regional Completions (2017)	Automation Index
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	2,689	2,382	1,970	1,898	1,683	1,675	113.0
49-9041	Industrial Machinery Mechanics	187	112	135	102	133	130	109.8
49-9051	Electrical Power-Line Installers and Repairers	603	523	353	302	182	105	114.0
49-9052	Telecommunications Line Installers and Repairers	46	51	65	41	84	101	116.9
49-9071	Maintenance and Repair Workers, General	75	36	0	0	0	0	109.6
49-9081	Wind Turbine Service Technicians	305	237	220	194	241	261	106.3
49-9099	Installation, Maintenance, and Repair Workers, All Other	1,112	1,173	1,037	1,075	1,075	960	110.6
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	192	189	200	226	215	265	110.9
51-8012	Power Distributors and Dispatchers	26	59	82	57	45	58	94.7
51-8013	Power Plant Operators	26	59	82	57	45	58	108.8
51-8021	Stationary Engineers and Boiler Operators	3,242	3,434	3,705	3,970	4,412	4,715	109.9
51-8092	Gas Plant Operators	41	78	105	81	70	95	101.1
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	26	59	82	57	45	70	104.0
51-8099	Plant and System Operators, All Other	26	59	82	57	45	58	110.2
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	30	30	40	43	40	33	106.1
53-7071	Gas Compressor and Gas Pumping Station Operators	0	0	0	0	0	0	97.9
53-7072	Pump Operators, Except Wellhead Pumpers	0	0	0	0	0	0	105.6
53-7073	Wellhead Pumpers	0	0	0	0	0	0	115.1
TOTAL		**331,531**	**342,272**	**360,000**	**372,818**	**389,726**	**408,567**	**97.4**

SOC	Occupation	Age 14-18	Age 19-21	Age 22-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65+	Age 14-18 % of Occupation	Age 19-21 % of Occupation	Age 22-24 % of Occupation	Age 25-34 % of Occupation
11-1021	General and Operations Managers	74	863	4,077	52,523	78,512	78,282	51,200	14,667	0%	0%	1%	19%
11-3051	Industrial Production Managers	5	135	266	3,060	5,543	6,700	5,038	1,139	0%	1%	1%	14%
11-3071	Transportation, Storage, and Distribution Managers	24	217	592	4,382	5,349	5,627	4,149	1,024	0%	1%	3%	21%
11-9021	Construction Managers	28	210	707	9,461	16,373	19,034	15,544	4,884	0%	0%	1%	14%
11-9199	Managers, All Other	226	1,899	5,296	39,627	58,079	69,099	58,662	29,808	0%	1%	2%	15%

SOC	Occupation	Age 14-18	Age 19-21	Age 22-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65+	Age 14-18 % of Occupation	Age 19-21 % of Occupation	Age 22-24 % of Occupation	Age 25-34 % of Occupation
13-1161	Market Research Analysts and Marketing Specialists	247	1,494	7,507	38,981	31,767	21,511	13,291	5,302	0%	1%	6%	32%
13-1199	Business Operations Specialists, All Other	247	1,918	6,524	41,982	40,811	36,787	31,559	11,668	0%	1%	4%	24%
13-2011	Accountants and Auditors	28	667	7,882	43,268	44,246	47,635	44,973	28,598	0%	0%	4%	20%
15-1121	Computer Systems Analysts	44	583	2,817	23,820	23,668	20,604	12,709	2,882	0%	1%	3%	27%
15-1122	Information Security Analysts	5	52	341	2,823	3,067	2,114	1,282	275	0%	1%	3%	28%
15-1133	Software Developers, Systems Software	34	464	2,978	29,026	27,328	18,803	9,364	1,678	0%	1%	3%	32%
15-1142	Network and Computer Systems Administrators	61	422	1,385	13,661	14,134	9,792	4,779	796	0%	1%	3%	30%
15-1143	Computer Network Architects	51	135	476	5,025	6,721	4,160	1,915	229	0%	1%	3%	27%
15-1199	Computer Occupations, All Other	84	803	2,258	16,288	16,741	12,982	7,192	1,434	0%	1%	4%	28%
17-1021	Cartographers and Photogrammetrists	5	21	99	480	407	342	331	99	0%	1%	6%	27%
17-2051	Civil Engineers	28	281	1,945	11,911	10,532	10,395	10,087	5,692	0%	1%	4%	23%
17-2071	Electrical Engineers	5	64	650	5,366	6,096	7,136	6,001	1,926	0%	0%	2%	20%
17-2072	Electronics Engineers, Except Computer	5	69	707	6,241	7,219	8,544	6,630	1,812	0%	0%	2%	20%
17-2081	Environmental Engineers	5	20	289	2,159	2,147	2,013	1,467	357	0%	0%	3%	26%
17-2112	Industrial Engineers	5	85	753	5,316	5,431	6,715	5,882	1,342	0%	0%	3%	21%
17-2141	Mechanical Engineers	5	140	1,196	6,900	6,541	6,639	5,424	1,833	0%	0%	4%	24%
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	0	5	28	161	91	105	106	33	0%	1%	5%	31%
17-2171	Petroleum Engineers	0	5	154	681	471	578	475	159	0%	0%	6%	27%
17-2199	Engineers, All Other	5	101	801	4,808	4,695	5,721	5,509	3,851	0%	0%	3%	19%
17-3011	Architectural and Civil Drafters	68	486	1,097	4,536	3,808	3,710	3,335	1,655	0%	3%	6%	24%
17-3012	Electrical and Electronics Drafters	15	98	225	1,077	1,044	1,099	926	361	0%	2%	5%	22%
17-3013	Mechanical Drafters	16	116	286	1,127	1,015	1,143	1,088	522	0%	2%	5%	21%

SOC	Occupation	Age 14-18	Age 19-21	Age 22-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65+	Age 14-18 % of Occupation	Age 19-21 % of Occupation	Age 22-24 % of Occupation	Age 25-34 % of Occupation
17-3023	Electrical and Electronics Engineering Technicians	61	438	863	4,392	5,303	6,829	5,611	1,218	0%	2%	3%	18%
17-3029	Engineering Technicians, Except Drafters, All Other	49	317	506	2,267	2,431	2,892	2,397	553	0%	3%	4%	20%
19-4041	Geological and Petroleum Technicians	11	42	103	445	318	415	336	77	1%	2%	6%	25%
41-3099	Sales Representatives, Services, All Other	425	3,037	8,992	41,687	38,081	36,321	25,298	11,050	0%	2%	5%	25%
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	41	313	1,372	10,839	12,864	12,935	9,293	3,101	0%	1%	3%	21%
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	342	1,939	5,188	32,934	41,337	43,564	37,256	17,101	0%	1%	3%	18%
43-4051	Customer Service Representatives	2,345	11,636	20,451	70,061	50,614	42,087	30,895	10,427	1%	5%	9%	29%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	74	366	1,077	11,358	18,916	22,729	17,007	5,750	0%	0%	1%	15%
47-2111	Electricians	228	1,931	3,767	20,104	21,006	18,481	12,498	3,226	0%	2%	5%	25%
47-2152	Plumbers, Pipefitters, and Steamfitters	146	1,301	2,632	14,967	16,015	14,374	9,566	2,490	0%	2%	4%	24%
47-2231	Solar Photovoltaic Installers	35	197	340	1,396	1,240	899	488	140	1%	4%	7%	29%
47-4098	Miscellaneous Construction and Related Workers	71	203	256	1,036	863	868	570	169	2%	5%	6%	26%
47-5011	Derrick Operators, Oil and Gas	5	5	29	248	187	105	73	20	1%	1%	4%	37%
47-5012	Rotary Drill Operators, Oil and Gas	5	22	64	460	350	219	142	38	0%	2%	5%	35%
47-5013	Service Unit Operators, Oil, Gas, and Mining	5	35	127	992	685	565	419	114	0%	1%	4%	34%
47-5071	Roustabouts, Oil and Gas	5	68	186	860	502	438	329	106	0%	3%	7%	34%

SOC	Occupation	Age 14-18	Age 19-21	Age 22-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65+	Age 14-18 % of Occupation	Age 19-21 % of Occupation	Age 22-24 % of Occupation	Age 25-34 % of Occupation
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	5	260	777	6,574	10,523	14,005	10,399	2,702	0%	1%	2%	15%
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	5	384	660	1,939	1,347	1,502	1,297	240	0%	5%	9%	26%
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	5	170	194	706	602	606	453	54	0%	6%	7%	25%
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	5	43	106	800	934	885	863	82	0%	1%	3%	22%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	141	800	1,481	8,106	8,861	8,095	5,438	1,546	0%	2%	4%	24%
49-9041	Industrial Machinery Mechanics	42	350	745	4,917	6,432	8,586	7,594	2,005	0%	1%	2%	16%
49-9051	Electrical Power-Line Installers and Repairers	11	156	339	2,250	2,202	1,757	1,001	118	0%	2%	4%	29%
49-9052	Telecommunications Line Installers and Repairers	31	312	627	4,164	4,069	3,469	1,720	522	0%	2%	4%	28%
49-9071	Maintenance and Repair Workers, General	416	2,756	4,246	24,645	32,738	43,543	36,009	12,012	0%	2%	3%	16%
49-9081	Wind Turbine Service Technicians	5	25	50	237	270	295	288	88	0%	2%	4%	19%
49-9099	Installation, Maintenance, and Repair Workers, All Other	346	1,342	1,884	8,087	7,945	8,981	8,207	3,375	1%	3%	5%	20%
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	102	703	1,444	5,783	7,432	9,624	9,180	2,367	0%	2%	4%	16%
51-8012	Power Distributors and Dispatchers	5	5	31	318	440	450	429	49	0%	0%	2%	18%
51-8013	Power Plant Operators	5	15	66	612	882	943	784	91	0%	0%	2%	18%

SOC	Occupation	Age 14-18	Age 19-21	Age 22-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65+	Age 14-18 % of Occupation	Age 19-21 % of Occupation	Age 22-24 % of Occupation	Age 25-34 % of Occupation
51-8021	Stationary Engineers and Boiler Operators	32	113	101	520	812	1,194	962	217	1%	3%	3%	13%
51-8092	Gas Plant Operators	0	5	14	217	327	296	356	27	0%	0%	1%	18%
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	5	21	53	849	1,077	1,298	1,154	137	0%	0%	1%	18%
51-8099	Plant and System Operators, All Other	5	20	30	307	391	467	371	56	0%	1%	2%	19%
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	179	1,317	2,930	12,415	12,623	15,345	14,201	5,726	0%	2%	5%	19%
53-7071	Gas Compressor and Gas Pumping Station Operators	5	28	37	277	261	265	206	101	0%	2%	3%	24%
53-7072	Pump Operators, Except Wellhead Pumpers	5	72	75	513	452	636	422	359	0%	3%	3%	20%
53-7073	Wellhead Pumpers	5	19	24	851	746	1,941	1,358	2,035	0%	0%	0%	12%
TOTAL		**6,527**	**42,123**	**113,200**	**673,822**	**733,914**	**735,172**	**563,790**	**213,514**	**0%**	**2%**	**4%**	**23%**

SOC	Occupation	Age 35-44 % of Occupation	Age 45-54 % of Occupation	Age 55-64 % of Occupation	Age 65+ % of Occupation	Males	Females	Males % of Occupation	Females % of Occupation	Hispanic or Latino	White
11-1021	General and Operations Managers	28%	28%	18%	5%	198,362	81,837	71%	29%	63,854	160,193
11-3051	Industrial Production Managers	25%	31%	23%	5%	17,472	4,419	80%	20%	5,470	11,702
11-3071	Transportation, Storage, and Distribution Managers	25%	26%	19%	5%	16,900	4,463	79%	21%	6,819	9,817
11-9021	Construction Managers	25%	29%	23%	7%	60,937	5,304	92%	8%	17,481	40,577
11-9199	Managers, All Other	22%	26%	22%	11%	180,941	81,755	69%	31%	53,367	159,997
13-1161	Market Research Analysts and Marketing Specialists	26%	18%	11%	4%	51,284	68,817	43%	57%	19,202	64,001
13-1199	Business Operations Specialists, All Other	24%	21%	18%	7%	72,645	98,851	42%	58%	39,309	78,019
13-2011	Accountants and Auditors	20%	22%	21%	13%	96,025	121,272	44%	56%	30,769	116,231

SOC	Occupation	Age 35-44 % of Occupation	Age 45-54 % of Occupation	Age 55-64 % of Occupation	Age 65+ % of Occupation	Males	Females	Males % of Occupation	Females % of Occupation	Hispanic or Latino	White
15-1121	Computer Systems Analysts	27%	24%	15%	3%	59,269	27,856	68%	32%	10,130	36,339
15-1122	Information Security Analysts	31%	21%	13%	3%	7,800	2,160	78%	22%	1,652	4,853
15-1133	Software Developers, Systems Software	30%	21%	10%	2%	72,015	17,659	80%	20%	5,516	27,484
15-1142	Network and Computer Systems Administrators	31%	22%	11%	2%	36,286	8,746	81%	19%	7,588	21,791
15-1143	Computer Network Architects	36%	22%	10%	1%	15,901	2,810	85%	15%	2,514	8,261
15-1199	Computer Occupations, All Other	29%	22%	12%	2%	44,283	13,499	77%	23%	8,554	25,013
17-1021	Cartographers and Photogrammetrists	23%	19%	19%	6%	1,365	418	77%	23%	255	1,187
17-2051	Civil Engineers	21%	20%	20%	11%	43,377	7,495	85%	15%	7,459	26,807
17-2071	Electrical Engineers	22%	26%	22%	7%	24,957	2,284	92%	8%	3,180	11,495
17-2072	Electronics Engineers, Except Computer	23%	27%	21%	6%	28,452	2,771	91%	9%	3,691	11,897
17-2081	Environmental Engineers	25%	24%	17%	4%	6,162	2,291	73%	27%	1,101	4,557
17-2112	Industrial Engineers	21%	26%	23%	5%	20,308	5,217	80%	20%	4,670	11,679
17-2141	Mechanical Engineers	23%	23%	19%	6%	26,566	2,111	93%	7%	4,563	14,595
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	17%	20%	20%	6%	465	59	89%	11%	129	273
17-2171	Petroleum Engineers	19%	23%	19%	6%	2,242	279	89%	11%	842	1,202
17-2199	Engineers, All Other	18%	22%	22%	15%	22,731	2,760	89%	11%	3,216	12,626
17-3011	Architectural and Civil Drafters	20%	20%	18%	9%	14,318	4,376	77%	23%	4,494	10,480
17-3012	Electrical and Electronics Drafters	22%	23%	19%	7%	3,778	1,066	78%	22%	1,029	2,663
17-3013	Mechanical Drafters	19%	22%	20%	10%	4,282	1,031	81%	19%	1,309	2,986
17-3023	Electrical and Electronics Engineering Technicians	21%	28%	23%	5%	20,257	4,458	82%	18%	5,286	10,862
17-3029	Engineering Technicians, Except Drafters, All Other	21%	25%	21%	5%	9,212	2,200	81%	19%	2,771	5,275
19-4041	Geological and Petroleum Technicians	18%	24%	19%	4%	1,285	461	74%	26%	426	1,038

SOC	Occupation	Age 35-44 % of Occupation	Age 45-54 % of Occupation	Age 55-64 % of Occupation	Age 65+ % of Occupation	Males	Females	Males % of Occupation	Females % of Occupation	Hispanic or Latino	White
41-3099	Sales Representatives, Services, All Other	23%	22%	15%	7%	106,542	58,349	65%	35%	38,186	95,535
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	25%	25%	18%	6%	35,397	15,360	70%	30%	9,177	31,207
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	23%	24%	21%	10%	126,392	53,270	70%	30%	43,041	105,184
43-4051	Customer Service Representatives	21%	18%	13%	4%	79,104	159,413	33%	67%	84,089	95,186
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	24%	29%	22%	7%	74,006	3,272	96%	4%	26,288	44,572
47-2111	Electricians	26%	23%	15%	4%	79,131	2,111	97%	3%	30,752	40,859
47-2152	Plumbers, Pipefitters, and Steamfitters	26%	23%	16%	4%	60,473	1,016	98%	2%	26,284	29,149
47-2231	Solar Photovoltaic Installers	26%	19%	10%	3%	4,533	203	96%	4%	2,206	1,996
47-4098	Miscellaneous Construction and Related Workers	21%	22%	14%	4%	3,830	206	95%	5%	1,719	1,790
47-5011	Derrick Operators, Oil and Gas	28%	16%	11%	3%	654	18	97%	3%	294	337
47-5012	Rotary Drill Operators, Oil and Gas	27%	17%	11%	3%	1,263	33	97%	3%	590	621
47-5013	Service Unit Operators, Oil, Gas, and Mining	23%	19%	14%	4%	2,854	87	97%	3%	1,369	1,403
47-5071	Roustabouts, Oil and Gas	20%	18%	13%	4%	2,427	66	97%	3%	1,151	1,204
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	23%	31%	23%	6%	42,284	2,966	93%	7%	13,174	25,388
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	18%	20%	18%	3%	7,056	321	96%	4%	1,544	4,237
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	22%	22%	16%	2%	2,668	120	96%	4%	731	1,495

SOC	Occupation	Age 35-44 % of Occupation	Age 45-54 % of Occupation	Age 55-64 % of Occupation	Age 65+ % of Occupation	Males	Females	Males % of Occupation	Females % of Occupation	Hispanic or Latino	White
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	25%	24%	23%	2%	3,475	241	94%	6%	1,247	1,973
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	26%	23%	16%	4%	33,995	473	99%	1%	13,005	17,480
49-9041	Industrial Machinery Mechanics	21%	28%	25%	7%	29,638	1,032	97%	3%	11,525	14,957
49-9051	Electrical Power-Line Installers and Repairers	28%	22%	13%	2%	7,634	200	97%	3%	2,618	4,373
49-9052	Telecommunications Line Installers and Repairers	27%	23%	12%	4%	14,202	710	95%	5%	5,865	6,712
49-9071	Maintenance and Repair Workers, General	21%	28%	23%	8%	151,037	5,327	97%	3%	60,696	70,873
49-9081	Wind Turbine Service Technicians	21%	23%	23%	7%	1,137	119	91%	9%	401	725
49-9099	Installation, Maintenance, and Repair Workers, All Other	20%	22%	20%	8%	37,798	2,369	94%	6%	14,394	20,878
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	20%	26%	25%	6%	16,492	20,144	45%	55%	10,110	7,896
51-8012	Power Distributors and Dispatchers	26%	26%	25%	3%	1,596	129	93%	7%	358	1,116
51-8013	Power Plant Operators	26%	28%	23%	3%	3,076	319	91%	9%	678	2,218
51-8021	Stationary Engineers and Boiler Operators	21%	30%	24%	5%	3,803	146	96%	4%	1,069	1,896
51-8092	Gas Plant Operators	26%	24%	29%	2%	1,071	170	86%	14%	470	617
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	23%	28%	25%	3%	4,220	370	92%	8%	1,257	2,639
51-8099	Plant and System Operators, All Other	24%	28%	23%	3%	1,518	123	93%	7%	618	787
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	19%	24%	22%	9%	38,326	26,409	59%	41%	23,511	24,110

SOC	Occupation	Age 35-44 % of Occupation	Age 45-54 % of Occupation	Age 55-64 % of Occupation	Age 65+ % of Occupation	Males	Females	Males % of Occupation	Females % of Occupation	Hispanic or Latino	White
53-7071	Gas Compressor and Gas Pumping Station Operators	22%	23%	18%	9%	1,108	68	94%	6%	492	559
53-7072	Pump Operators, Except Wellhead Pumpers	18%	25%	17%	14%	2,431	103	96%	4%	913	1,429
53-7073	Wellhead Pumpers	11%	28%	19%	29%	6,811	162	98%	2%	2,288	4,396
TOTAL		**23%**	**24%**	**19%**	**6%**	**2,147,859**	**934,151**	**83%**	**17%**	**748,753**	**1,559,699**

SOC	Occupation	Black or African American	American Indian or Alaska Native	Asian	Native Hawaiian or other Pacific Islander	Two or More Races	Hispanic or Latino % of Occupation	White % of Occupation	Black or African American % of Occupation	American Indian or Alaska Native % of Occupation	Asian % of Occupation	Native Hawaiian or Other Pacific Islander % of Occupation
11-1021	General and Operations Managers	9,334	749	39,292	872	5,905	23%	57%	3%	0%	14%	0%
11-3051	Industrial Production Managers	419	43	3,906	58	293	25%	53%	2%	0%	18%	0%
11-3071	Transportation, Storage, and Distribution Managers	1,386	53	2,819	128	341	32%	46%	6%	0%	13%	1%
11-9021	Construction Managers	1,286	153	5,449	163	1,132	26%	61%	2%	0%	8%	0%
11-9199	Managers, All Other	9,632	627	31,490	551	7,032	20%	61%	4%	0%	12%	0%
13-1161	Market Research Analysts and Marketing Specialists	3,251	226	29,767	290	3,364	16%	53%	3%	0%	25%	0%
13-1199	Business Operations Specialists, All Other	10,974	598	37,676	559	4,360	23%	45%	6%	0%	22%	0%
13-2011	Accountants and Auditors	7,570	358	57,760	468	4,141	14%	53%	3%	0%	27%	0%
15-1121	Computer Systems Analysts	3,266	195	34,354	188	2,653	12%	42%	4%	0%	39%	0%
15-1122	Information Security Analysts	628	32	2,340	64	391	17%	49%	6%	0%	23%	1%
15-1133	Software Developers, Systems Software	1,322	79	53,352	106	1,815	6%	31%	1%	0%	59%	0%
15-1142	Network and Computer Systems Administrators	1,859	96	12,373	129	1,196	17%	48%	4%	0%	27%	0%
15-1143	Computer Network Architects	688	29	6,668	54	498	13%	44%	4%	0%	36%	0%

SOC	Occupation	Black or African American	American Indian or Alaska Native	Asian	Native Hawaiian or other Pacific Islander	Two or More Races	Hispanic or Latino % of Occupation	White % of Occupation	Black or African American % of Occupation	American Indian or Alaska Native % of Occupation	Asian % of Occupation	Native Hawaiian or Other Pacific Islander % of Occupation
15-1199	Computer Occupations, All Other	3,031	187	19,163	162	1,671	15%	43%	5%	0%	33%	0%
17-1021	Cartographers and Photogrammetrists	55	5	226	5	54	14%	67%	3%	0%	13%	0%
17-2051	Civil Engineers	1,104	101	14,073	86	1,243	15%	53%	2%	0%	28%	0%
17-2071	Electrical Engineers	561	45	11,411	54	495	12%	42%	2%	0%	42%	0%
17-2072	Electronics Engineers, Except Computer	655	45	14,328	66	541	12%	38%	2%	0%	46%	0%
17-2081	Environmental Engineers	267	29	2,325	30	143	13%	54%	3%	0%	28%	0%
17-2112	Industrial Engineers	511	34	8,118	74	438	18%	46%	2%	0%	32%	0%
17-2141	Mechanical Engineers	491	39	8,362	88	539	16%	51%	2%	0%	29%	0%
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	11	5	100	0	10	25%	52%	2%	1%	19%	0%
17-2171	Petroleum Engineers	51	5	362	0	60	33%	48%	2%	0%	14%	0%
17-2199	Engineers, All Other	463	42	8,556	58	529	13%	50%	2%	0%	34%	0%
17-3011	Architectural and Civil Drafters	413	52	2,733	55	467	24%	56%	2%	0%	15%	0%
17-3012	Electrical and Electronics Drafters	102	13	915	13	108	21%	55%	2%	0%	19%	0%
17-3013	Mechanical Drafters	97	13	780	13	116	25%	56%	2%	0%	15%	0%
17-3023	Electrical and Electronics Engineering Technicians	971	82	6,781	120	613	21%	44%	4%	0%	27%	0%
17-3029	Engineering Technicians, Except Drafters, All Other	525	47	2,416	60	319	24%	46%	5%	0%	21%	1%
19-4041	Geological and Petroleum Technicians	45	5	190	5	38	24%	59%	3%	0%	11%	0%
41-3099	Sales Representatives, Services, All Other	7,587	569	19,397	309	3,308	23%	58%	5%	0%	12%	0%
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	1,053	106	8,057	99	1,058	18%	61%	2%	0%	16%	0%
41-4012	Sales Representatives, Wholesale and Manufacturing, Except	3,952	376	23,520	418	3,172	24%	59%	2%	0%	13%	0%

SOC	Occupation	Black or African American	American Indian or Alaska Native	Asian	Native Hawaiian or other Pacific Islander	Two or More Races	Hispanic or Latino % of Occupation	White % of Occupation	Black or African American % of Occupation	American Indian or Alaska Native % of Occupation	Asian % of Occupation	Native Hawaiian or Other Pacific Islander % of Occupation
	Technical and Scientific Products											
43-4051	Customer Service Representatives	21,290	673	29,320	1,140	6,819	35%	40%	9%	0%	12%	0%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	1,780	302	2,949	314	1,072	34%	58%	2%	0%	4%	0%
47-2111	Electricians	2,902	346	4,580	316	1,488	38%	50%	4%	0%	6%	0%
47-2152	Plumbers, Pipefitters, and Steamfitters	2,006	282	2,509	207	1,052	43%	47%	3%	0%	4%	0%
47-2231	Solar Photovoltaic Installers	166	17	182	54	114	47%	42%	4%	0%	4%	1%
47-4098	Miscellaneous Construction and Related Workers	194	12	181	35	105	43%	44%	5%	0%	4%	1%
47-5011	Derrick Operators, Oil and Gas	18	5	5	5	5	44%	50%	3%	1%	1%	1%
47-5012	Rotary Drill Operators, Oil and Gas	39	5	17	5	16	46%	48%	3%	0%	1%	0%
47-5013	Service Unit Operators, Oil, Gas, and Mining	63	16	50	5	34	47%	48%	2%	1%	2%	0%
47-5071	Roustabouts, Oil and Gas	57	15	38	5	23	46%	48%	2%	1%	2%	0%
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	2,196	198	3,054	219	1,021	29%	56%	5%	0%	7%	0%
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	522	48	622	41	363	21%	57%	7%	1%	8%	1%
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	215	22	191	5	126	26%	54%	8%	1%	7%	0%
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	284	16	105	5	85	34%	53%	8%	0%	3%	0%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	1,075	141	2,124	59	583	38%	51%	3%	0%	6%	0%

SOC	Occupation	Black or African American	American Indian or Alaska Native	Asian	Native Hawaiian or other Pacific Islander	Two or More Races	Hispanic or Latino % of Occupation	White % of Occupation	Black or African American % of Occupation	American Indian or Alaska Native % of Occupation	Asian % of Occupation	Native Hawaiian or Other Pacific Islander % of Occupation
49-9041	Industrial Machinery Mechanics	982	110	2,493	102	501	38%	49%	3%	0%	8%	0%
49-9051	Electrical Power-Line Installers and Repairers	410	38	207	41	146	33%	56%	5%	0%	3%	1%
49-9052	Telecommunications Line Installers and Repairers	1,086	42	831	72	304	39%	45%	7%	0%	6%	0%
49-9071	Maintenance and Repair Workers, General	7,790	679	12,755	767	2,805	39%	45%	5%	0%	8%	0%
49-9081	Wind Turbine Service Technicians	34	5	64	5	24	32%	58%	3%	0%	5%	0%
49-9099	Installation, Maintenance, and Repair Workers, All Other	1,184	127	2,670	129	785	36%	52%	3%	0%	7%	0%
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	1,281	110	16,780	85	375	28%	22%	3%	0%	46%	0%
51-8012	Power Distributors and Dispatchers	104	22	73	10	40	21%	65%	6%	1%	4%	1%
51-8013	Power Plant Operators	177	46	173	16	89	20%	65%	5%	1%	5%	0%
51-8021	Stationary Engineers and Boiler Operators	268	16	578	5	116	27%	48%	7%	0%	15%	0%
51-8092	Gas Plant Operators	86	14	33	5	17	38%	50%	7%	1%	3%	0%
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	294	18	238	27	117	27%	57%	6%	0%	5%	1%
51-8099	Plant and System Operators, All Other	117	15	64	5	34	38%	48%	7%	1%	4%	0%
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	3,139	152	12,274	276	1,274	36%	37%	5%	0%	19%	0%
53-7071	Gas Compressor and Gas Pumping Station Operators	69	5	26	5	20	42%	48%	6%	0%	2%	0%
53-7072	Pump Operators, Except Wellhead Pumpers	74	11	46	13	47	36%	56%	3%	0%	2%	1%

SOC	Occupation	Black or African American	American Indian or Alaska Native	Asian	Native Hawaiian or other Pacific Islander	Two or More Races	Hispanic or Latino % of Occupation	White % of Occupation	Black or African American % of Occupation	American Indian or Alaska Native % of Occupation	Asian % of Occupation	Native Hawaiian or Other Pacific Islander % of Occupation
53-7073	Wellhead Pumpers	13	5	67	5	205	33%	63%	0%	0%	1%	0%
TOTAL		**123,474**	**8,552**	**564,357**	**9,330**	**67,849**	**27%**	**51%**	**4%**	**0%**	**15%**	**0%**

SOC	Occupation	Two or More Races % of Occupation	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
11-1021	General and Operations Managers	2%	Bachelor's degree	5 years or more	None
11-3051	Industrial Production Managers	1%	Bachelor's degree	5 years or more	None
11-3071	Transportation, Storage, and Distribution Managers	2%	High school diploma or equivalent	5 years or more	None
11-9021	Construction Managers	2%	Bachelor's degree	None	Moderate-term on-the-job training
11-9199	Managers, All Other	3%	Bachelor's degree	Less than 5 years	None
13-1161	Market Research Analysts and Marketing Specialists	3%	Bachelor's degree	None	None
13-1199	Business Operations Specialists, All Other	3%	Bachelor's degree	None	None
13-2011	Accountants and Auditors	2%	Bachelor's degree	None	None
15-1121	Computer Systems Analysts	3%	Bachelor's degree	None	None
15-1122	Information Security Analysts	4%	Bachelor's degree	Less than 5 years	None
15-1133	Software Developers, Systems Software	2%	Bachelor's degree	None	None
15-1142	Network and Computer Systems Administrators	3%	Bachelor's degree	None	None
15-1143	Computer Network Architects	3%	Bachelor's degree	5 years or more	None
15-1199	Computer Occupations, All Other	3%	Bachelor's degree	None	None
17-1021	Cartographers and Photogrammetrists	3%	Bachelor's degree	None	None
17-2051	Civil Engineers	2%	Bachelor's degree	None	None
17-2071	Electrical Engineers	2%	Bachelor's degree	None	None
17-2072	Electronics Engineers, Except Computer	2%	Bachelor's degree	None	None
17-2081	Environmental Engineers	2%	Bachelor's degree	None	None
17-2112	Industrial Engineers	2%	Bachelor's degree	None	None
17-2141	Mechanical Engineers	2%	Bachelor's degree	None	None
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	2%	Bachelor's degree	None	None
17-2171	Petroleum Engineers	2%	Bachelor's degree	None	None
17-2199	Engineers, All Other	2%	Bachelor's degree	None	None
17-3011	Architectural and Civil Drafters	2%	Associate's degree	None	None
17-3012	Electrical and Electronics Drafters	2%	Associate's degree	None	None
17-3013	Mechanical Drafters	2%	Associate's degree	None	None
17-3023	Electrical and Electronics Engineering Technicians	2%	Associate's degree	None	None
17-3029	Engineering Technicians, Except Drafters, All Other	3%	Associate's degree	None	None
19-4041	Geological and Petroleum Technicians	2%	Associate's degree	None	Moderate-term on-the-job training
41-3099	Sales Representatives, Services, All Other	2%	High school diploma or equivalent	None	Moderate-term on-the-job training

SOC	Occupation	Two or More Races % of Occupation	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	2%	Bachelor's degree	None	Moderate-term on-the-job training
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	2%	High school diploma or equivalent	None	Moderate-term on-the-job training
43-4051	Customer Service Representatives	3%	High school diploma or equivalent	None	Short-term on-the-job training
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	1%	High school diploma or equivalent	5 years or more	None
47-2111	Electricians	2%	High school diploma or equivalent	None	Apprenticeship
47-2152	Plumbers, Pipefitters, and Steamfitters	2%	High school diploma or equivalent	None	Apprenticeship
47-2231	Solar Photovoltaic Installers	2%	High school diploma or equivalent	None	Moderate-term on-the-job training
47-4098	Miscellaneous Construction and Related Workers	3%	High school diploma or equivalent	None	Moderate-term on-the-job training
47-5011	Derrick Operators, Oil and Gas	1%	No formal educational credential	None	Short-term on-the-job training
47-5012	Rotary Drill Operators, Oil and Gas	1%	No formal educational credential	None	Moderate-term on-the-job training
47-5013	Service Unit Operators, Oil, Gas, and Mining	1%	No formal educational credential	None	Moderate-term on-the-job training
47-5071	Roustabouts, Oil and Gas	1%	No formal educational credential	None	Moderate-term on-the-job training
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	2%	High school diploma or equivalent	Less than 5 years	None
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	5%	Postsecondary nondegree award	None	Long-term on-the-job training
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	5%	Postsecondary nondegree award	Less than 5 years	Moderate-term on-the-job training
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	2%	High school diploma or equivalent	None	Moderate-term on-the-job training
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	2%	Postsecondary nondegree award	None	Long-term on-the-job training
49-9041	Industrial Machinery Mechanics	2%	High school diploma or equivalent	None	Long-term on-the-job training
49-9051	Electrical Power-Line Installers and Repairers	2%	High school diploma or equivalent	None	Long-term on-the-job training
49-9052	Telecommunications Line Installers and Repairers	2%	High school diploma or equivalent	None	Long-term on-the-job training
49-9071	Maintenance and Repair Workers, General	2%	High school diploma or equivalent	None	Moderate-term on-the-job training
49-9081	Wind Turbine Service Technicians	2%	Postsecondary nondegree award	None	Long-term on-the-job training
49-9099	Installation, Maintenance, and Repair Workers, All Other	2%	High school diploma or equivalent	None	Moderate-term on-the-job training
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	1%	High school diploma or equivalent	None	Moderate-term on-the-job training
51-8012	Power Distributors and Dispatchers	2%	High school diploma or equivalent	None	Long-term on-the-job training
51-8013	Power Plant Operators	3%	High school diploma or equivalent	None	Long-term on-the-job training
51-8021	Stationary Engineers and Boiler Operators	3%	High school diploma or equivalent	None	Long-term on-the-job training
51-8092	Gas Plant Operators	1%	High school diploma or equivalent	None	Long-term on-the-job training
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	3%	High school diploma or equivalent	None	Moderate-term on-the-job training
51-8099	Plant and System Operators, All Other	2%	High school diploma or equivalent	None	Moderate-term on-the-job training
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	2%	High school diploma or equivalent	None	Moderate-term on-the-job training
53-7071	Gas Compressor and Gas Pumping Station Operators	2%	High school diploma or equivalent	None	Moderate-term on-the-job training

SOC	Occupation	Two or More Races % of Occupation	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
53-7072	Pump Operators, Except Wellhead Pumpers	2%	High school diploma or equivalent	None	Moderate-term on-the-job training
53-7073	Wellhead Pumpers	3%	High school diploma or equivalent	Less than 5 years	Moderate-term on-the-job training
TOTAL		2%			

Appendix D: Full Literature Review -- How California Policies affect Demand for Energy Related Occupations

Executive Summary

California is a global leader in aggressively implementing policies and legislation to combat climate change and to de-carbonize its economy, particularly in the energy, construction, and transportation sectors. Climate policies have been implemented variably through Executive Orders, legislation, and regulation – commonly, an Executive Order is issued, which the legislature codifies and directs agencies (Public Utility Commission, Energy Commission) to act by implementing regulations. We present here the key findings from a broad survey of academic and industry literature, reinforced by a series of employer interviews.

Current legislation calls for the state to power 100% of its electricity grid through renewable sources by 2045, a reduction of Greenhouse Gases (GHG) emissions to 40% below 1990 levels by 2030, and a doubling of energy efficiency by 2030. Former Governor Brown expanded the GHG goal through Executive Order to be completely carbon neutral by 2045. The 2019 Update to Title 24 requires all new low-rise residential buildings to install solar power beginning in 2020. Beginning with the 2002 passage of California's first Renewables Portfolio Standard (RPS), evidence shows positive economic and workforce impacts from climate legislation.

From 2002-2018, California's legislature passed dozens of key pieces of legislation addressing climate in three primary ways: 1) Renewable Energy; 2) GHG Reduction; and 3) Energy Efficiency. In addition, the Transportation sector gets much specific attention in the legislation because it accounts for 40% of GHG emissions. Approximately half of the bills funded, authorized, or encouraged workforce training and job creation explicitly.

By 2017, California had achieved 29% of its total electricity consumption from renewable sources, including 30% of in-state generation. Evidence of the impact of this and other climate-related actions on the California economy and workforce is weighted fairly positively as presented in three academic studies:

- A 2016 San Joaquin Valley study found that RPS, Cap-and-Trade, and Energy Efficiency measures had generated $13.6 billion in net economic benefit and was responsible for the creation of over 38,000 direct and 67,000 indirect jobs.[32]
- A similar study in the Inland Empire for the same period found net economic benefits of $9.1 billion and net jobs gained of 41,000.[33]
- A statewide 2016 study estimates that California's RPS during a 5-year study period created 25,500 blue-collar job-years and 7,200 white-collar construction job-years. Solar photovoltaic (Solar PV) projects were responsible for two-thirds of the jobs, with Wind projects making up 9%.[34]

A review of the academic and industry literature focused on workforce impacts for blue collar and white collar "trades" jobs (versus scientific and engineering jobs). As should be expected with tectonic policy

[32] Jones, B. (2017, February 06). California's Climate Policies Bring Good Jobs to the San Joaquin Valley, Retrieved May 10, 2019, from http://laborcenter.berkeley.edu/californias-climate-policies-bring-good-jobs-to-the-san-joaquin-valley/.
[33] Jones, B., Duncan, K., Elkind, E., & Hanson, M. (2017, August 03). The Net Economic Impacts of California's Major Climate Programs in the Inland Empire, .Retrieved May 10, 2019, from http://laborcenter.berkeley.edu/the-net-economic-impacts-of-californias-major-climate-programs-in-the-inland-empire/.
[34] Jones, B., Philips, P., & Zabin, C. (2016, July). The Link between Good Jobs and a Low Carbon Future. Retrieved May 11, 2019, from http://laborcenter.berkeley.edu/pdf/2016/Link-Between-Good-Jobs-and-a-Low-Carbon-Future.pdf.

shifts away from conventional energy to production from renewable energy sources, the literature finds significant impact on general construction occupations, followed by a need for up-skilling of operations and maintenance (O&M) occupations to deal with new technologies – up-skilling is a far more common finding than new classes of occupations. Studies found that renewables created more construction and O&M jobs per megawatt (MW) than conventional sources.

Solar power will be provided through utility-scale solar plants and large commercial and industrial behind-the-meter (BTM) installations, built and operated by a unionized workforce, and distributed residential BTM solar, built largely through non-union contract labor. While the energy costs per MW of the latter are shown to be double the former, policy has supported both through legislation and regulations. O&M labor at utility-scale plants will require up-skilling, while contractors are reporting a hard time filling openings, they are showing preference for basic construction skills over specific solar technology skills, and prefer on-the-job training. As will be noted, this is a common employer practice across industry sectors.

Wind has the potential to produce up to 40% of California's power needs, but will continue to lag solar. Wind has an interesting characteristic in that, unlike BTM (commercial or residential) solar, wind plants are virtually all rurally sited. This has an added benefit of bringing quality jobs throughout its supply chain and life cycle to communities with otherwise limited economic opportunities.

Transportation is the single largest contributor to GHG emissions, at 41% - almost double industrial at 23% and more than four times electrical generation at 10%. Net workforce impacts of electrification of this sector are largely in the construction sector, building electric vehicle (EV) charging infrastructure, with accompanying electrical grid infrastructure impacts. Achieving the GHG emission goals of legislation will not be accomplished without significant inroads in electrifying this sector.

Automation, and specifically Building Automation Systems, plays a key role in achieving the legislated doubling of energy efficiency mandate through lighting and HVAC controls. “Smart Buildings” will control their energy usage through connected sensors, assessing the environment inside and outside the building, and automatically adjusting systems for optimum comfort and maximum efficiency. Connected sensors are foundational to automation, collecting and processing massive amounts of data in smart buildings. A skilled workforce will be required to ensure that these systems are properly installed and maintained to achieve the desired savings and comfort, and be more proactive in the efficient and smooth operation of a building's systems. Competence in basic Information and Communications Technology (ICT) concepts is important in Building Automation occupations in addition to traditional maintenance skills.

Core technologies involved in the automation of buildings and cities are being applied to the energy sector and utilities in general. Sensors and smart meters are being deployed to monitor, adjust, and change the billing structure of the energy grid to make it more responsive and efficient. Massive amounts of data are being collected on real-time grid performance; these data must be communicated to a central processing center, interpreted, and acted upon, invoking elements of machine learning and artificial intelligence. ICT skills will be increasingly in demand in this sector. In addition, this non-traditional interconnectedness exposes the grid to a non-traditional vulnerability: cyberthreats. Cybersecurity will become a skillset of increasing importance as the grid becomes smarter and more adaptive.[35]

Interviews were conducted with seven employers to validate/invalidate general and specific themes in the literature. Respondents included executives, training managers, operations managers, and contractors from automation controls, HVAC, refrigeration, and manufacturing companies. All questions and answers are presented in Appendix E but employers largely agreed that more conventional construction jobs

[35] DNV-GL. (n.d.). Digitalization and the Future of Energy: Beyond the Hype. Retrieved May 11, 2019, from https://www.dnvgl.com/power-renewables/themes/digitalization/index.html.

would be created and that O&M jobs would be up-skilled to support new technologies like automation. Several respondents reiterated that core electrical and mechanical skills would continue to be foundational, but that ICT skills would be layered onto traditional jobs. Employers find that staffing of skilled occupations is difficult, and that they reach beyond their own industries for workers with foundational skills, training them internally for company- and industry-specific tasks. Workers with a combination of mechanical / electrical and computer skills are in high demand.

Evidence from recent studies regionally and statewide supports the assertion that GHG reduction, renewable energy, and energy efficiency mandates of California's climate legislation will have positive net economic and employment impacts. Employers support the general findings and note a layering of new ICT skills in non-ICT occupations. While academic literature does not predict changes to specific jobs, several general conclusions can be drawn:

- Technology will continue to have a profound impact on labor, both directly and indirectly. Directly, there will be a growing demand for white collar science, technology, engineering, and math jobs (STEM - outside the scope of this review) to support the technological improvements and cost reductions anticipated in meeting the climate mandates.
- Indirectly, technology and technological improvements will continue to be a growing component of blue collar work. Energy efficiency is as key to ensuring enough power is available in coming years as rationing was to ensure sufficient water during the drought. Up-skilling the building trades for ever-tightening codes, standards, and the impacts of automation is essential.
- While the literature does not specify new types of workers, elements of energy skills are appearing in diverse occupations, some traditional, some emerging. For example, energy auditing is a desirable skill in occupations like facility management, which used to be about floorspace allocation and basic maintenance, but now manages whole-building health and is expected to deliver financial savings through energy management.
- Mandates for reduction in GHGs and deployment of renewables will initially impact the traditional construction trades; relatively more construction workers are required per MW in construction of wind and solar plants than in natural gas plants.
- Deployment of renewable energy will require more operations and maintenance personnel per MW generated than conventional power plants.
- California has maintained a favorable environment for distributed solar through consumer-friendly net metering policies that, while reduced, are still economically favorable to the consumer.
- Achieving GHG reduction goals cannot be accomplished without electrification of the transportation sector; this will impact construction trades for build-out of charging infrastructure and utilities for adapting the electrical grid to support this growing load.
- Automation will continue to grow in its impact on many occupations, requiring new generations of workers to have basic understanding of ICT concepts and their application in performing tasks that were traditionally the realm of blue-collar workers, like building maintenance. Building Automation Systems and smart buildings are key to achieving energy efficiency mandates, and will require workers comfortable with both a wrench and a computer.
- Among general ICT skills, cyber security is of particular importance in the utility sector as connected sensors, smart meters, etc., provide an entry path for malefactors into the utility grids.
- Employer interviews largely reinforced these themes, particularly with regard to the up-skilling of conventional trades to support the increasing digitization of equipment and deployment of Building Automation Systems. Conventional electrical and mechanical skills will continue to be

foundational as new ICT skills are layered onto traditional trade occupations. Strong soft skills are also in high demand.

Legacy of California Energy Policy in Response to Climate Change

With the passage of SB 1078 in 2002, California established its first Renewables Portfolio Standard (RPS), requiring 20% of the state's electricity come from renewable sources by 2017. In 2003, this goal was accelerated to 2010. A series of other legislative and executive actions culminated in SB 32 in 2016 and SB 100 in 2018, codifying the present goals of a reduction in greenhouse gas (GHG) emissions in the state to 40% below 1990 levels, doubling of statewide energy efficiency savings in electricity and natural gas by 2030, and establishing a 100% carbon-free RPS by 2045. Table 1 summarizes key climate change legislation, with workforce training, safety, or job creation-related measures highlighted in bold.

Table 1. Key Climate Change Legislation[36]

Year	Legislation	Emphasis	Brief Description
2002	Senate Bill 1078	Renewable Energy	Established the California Renewables Portfolio Standard (RPS) Program, requiring electric utilities to provide 20% of their power through renewable sources by the end of 2017. **Will create "new employment opportunities" (unspecified).**
2006	Senate Bill 107	Renewable Energy	Increases the RPS from 17% to an amount that equals at least 20% of the total electricity sold to retail customers in California per year by December 31, 2010. **Will create "new employment opportunities" (unspecified).**
	Assembly Bill 32	GHG Reduction	California Global Warming Solutions Act of 2006. Requires the Air Resources Board (ARB) to adopt a statewide greenhouse gas emissions limit equivalent to the statewide emissions levels in 1990 to be achieved by 2020.
2007	Senate Bill 97	GHG Reduction	California Environmental Quality Act (CEQA): Directs Governor's Office of Planning and Research to develop CEQA guidelines "for the mitigation of greenhouse gas emissions or the effects of greenhouse gas emissions."
	Assembly Bill 118	GHG Reduction	Created the Alternative and Renewable Fuel and Vehicle Technology Program to provide funding to develop innovative technologies that transform California's fuel and vehicle types to help attain the state's climate change policies. **Authorizes funding for workforce training partnerships related to the program.**
2008	Senate Bill 375	GHG Reduction	Sustainable Communities & Climate Protection Act of 2008 requires the ARB to develop regional GHG emission reduction targets for passenger vehicles.
2009	Assembly Bill 758	Energy Efficiency	Establishes a regulatory proceeding to implement a comprehensive program to achieve greater energy savings in California's existing residential and nonresidential building stock that fall significantly below the current standards in Title 24. **A comprehensive program may include green workforce training.**
2010	Assembly Bill 2514	GHG Reduction	Directs the California Public Utilities Commission (CPUC) to set targets for public utilities for procurement of 1,325 megawatts (MW) of energy storage to support renewable energy by 2020.

[36] California Energy Commission. (n.d.). California Climate Change Legislation. Retrieved May 10, 2019, from https://www.climatechange.ca.gov/state/legislation.html.

Year	Legislation	Emphasis	Brief Description
2011	Senate Bill X1-2[37]	GHG Reduction	Codifies the ambitious 33 percent by 2020 goal; increases the amount of electricity generated from eligible renewable energy resources per year to an amount that equals at least 20% of the total electricity sold to retail customers in California per year by December 31, 2013, 25% by December 31, 2016 and 33% by December 31, 2020. **Prioritizes projects with demonstrable workforce recruiting, training, and retention efforts, including the employment growth associated with the construction and operation of eligible renewable energy resources and goals for recruitment and training of women, minorities, and disabled veterans.**
2012	Senate Bill 1122	Renewable Energy	Requires 250 MW of electricity generated from organic waste, including 110 MW generated from organic waste that would otherwise be landfilled, wastewater treatment, co-digestion and food processing; 90 MW from dairy and agricultural waste; and 50 MW from forestry waste from high wildfire hazard zones.
	Assembly Bill 1532	GHG Reduction	Requires the Department of Finance to submit an investment plan every three years for the use of the Greenhouse Gas Reduction Fund and requires revenue collected pursuant to a market-based compliance mechanism to be appropriated in the Annual Budget. **Funds to foster job creation by promoting in-state greenhouse gas emissions reduction projects carried out by California workers and businesses.**
	Senate Bill 535	GHG Reduction	Greenhouse Gas Reduction Fund and Disadvantaged Communities. Requires that 25% of all funds allocated pursuant to an investment plan for the use of moneys collected through a cap-and-trade program be allocated to projects that benefit disadvantaged communities.
2013	Senate Bill 73	Energy Efficiency	Implementation of Prop 39. $550M transferred to the Clean Energy Jobs Fund annually for 5 years. Fund are available, upon appropriation by the Legislature, for purposes of funding eligible projects that create jobs in California improving energy efficiency and expanding clean energy generation. **Multiple workforce education and training initiatives.**
	Assembly Bill 8	GHG Reduction	Extends until January 1, 2024, extra fees on vehicle registrations, boat registrations, and tire sales in order to fund programs that support the production, distribution, and sale of alternative fuels and vehicle technologies and air emissions reduction efforts. **Workforce training initiatives related to advanced energy technology designed to reduce air pollution, including state-of-the-art equipment and goods, and new processes and systems. Preferences to projects that provide economic benefits for California by promoting California-based technology firms, jobs, and businesses.**
	Assembly Bill 1092	GHG Reduction	Building standards: electric vehicle charging infrastructure. Requires the Building Standards Commission to adopt mandatory building standards for the installation of future electric vehicle charging infrastructure for parking spaces in multifamily dwellings and nonresidential development.
2014	Senate Bill 1204	GHG Reduction	Creates the California Clean Truck, Bus, and Off-Road Vehicle and Equipment Technology Program for development, demonstration, pre-commercial pilot, and early commercial deployment of zero- and near-zero emission truck, bus, and off-road vehicle and equipment technologies, with priority given to projects benefiting disadvantaged communities.

[37] In November 2018, the California Energy Commission reported that the state had exceeded its RPS mandate of 33% renewables by 2020, two years early: California Energy Commission. (2018, December). Tracking Progress: Renewable Energy. Retrieved May 10, 2019, from https://www.energy.ca.gov/data-reports/tracking-progress/renewable-energy.

Year	Legislation	Emphasis	Brief Description
	Senate Bill 1275	GHG Reduction	Establishes a state goal of 1 million zero-emission and near-zero-emission vehicles in service by 2020. Acknowledges that California ranks high among the states in the number of workers and facilities supporting the clean vehicle and electric vehicle industries.
2015	Senate Bill 350	Renewable Energy; Energy Efficiency; GHG Reduction	Clean Energy and Pollution Reduction Act of 2015. Establishes targets to increase retail sales of renewable electricity to 50 percent by 2030 and double the energy efficiency savings in electricity and natural gas end uses by 2030. **Comprehensive programs to achieve energy efficiency goals may include green workforce training. Policies will be adopted to ensure workmanship quality standards for contractors. Commission programs shall consider workforce development and job training for residents in disadvantaged communities, including veterans, at-risk youth, and members of the state and local community conservation corps.**
	Assembly Bill 802	Energy Efficiency	Energy efficiency. Requires the state to double statewide energy efficiency savings in electricity and natural gas end uses by 2030.
2016	Senate Bill 32	GHG Reduction	Greenhouse Gas emission reduction target for 2030. Establishes a statewide greenhouse gas (GHG) emission reduction target of 40 percent below 1990 levels by 2030.
	Assembly Bill 197	GHG Reduction	Greenhouse gas regulations. Prioritizes direct emission reductions from large stationary sources and mobile sources.
	Senate Bill 1383	GHG Reduction	Short-lived Climate Pollutants. Establishes statewide reduction targets for short-lived climate pollutants. **Incorporate measures that prioritize job growth and local economic benefits in the state.**
	Assembly Bill 2868	GHG Reduction	Mandates the procurement of an additional 500 MW of behind-the-meter (BTM) electrical storage to support renewable energy by 2024. **It anticipates that new energy storage technology will drive new jobs.**
2017	Assembly Bill 398	GHG Reduction	Extends and improves the Cap and Trade Program, which will enable the state to meet its 2030 emission reduction goals in the most cost-effective manner. **Requires the California Workforce Development Board to submit a specified report to the Legislature on the need for increased education, career technical education, job training, and workforce development resources or capacity to help industry, workers, and communities transition to economic and labor-market changes related to specified statewide greenhouse gas emissions reduction goals.**
	Assembly Bill 617	GHG Reduction	Establishes a groundbreaking program to measure and reduce air pollution from mobile and stationary sources at the neighborhood level in the communities most impacted by air pollutants. The focus on community-based air monitoring and emission reductions will provide a national model for enhanced community protection.
	Senate Bill 338	Energy Efficiency	Integrated resource plan: peak demand. Directs California's utilities to rely on energy efficiency, demand management, energy storage and other strategies to meet peak electricity needs.
2018	Senate Bill 1477	GHG Reduction	Authorizes the CPUC to allocate up to $50 million per year to two new programs: The Building Initiative for Low-Emissions Development (BUILD), which will provide incentives for energy storage, solar thermal and other technologies to help new buildings reduce greenhouse gas emissions; and TECH (Technology and Equipment for Clean Heating), which spurs market development for low-emissions space and water heating technologies by incentivizing distributors and retailers to make equipment available. **Provides customer education and contractor training.**

Year	Legislation	Emphasis	Brief Description
	Assembly Bill 3232	GHG Reduction	Requires the CPUC to assess the potential for the state to reduce the emissions of greenhouse gases from residential and commercial buildings by at least 40% below 1990 levels by 2030.
	Senate Bill 1339	Renewable Energy	Requires that publicly owned electric utilities take action to support microgrids, such as creating separate electric rates and tariffs for those installed by utility customers. Also requires a streamlining of interconnection standards and permitting to reduce cost barriers to microgrid development. **Prioritizes worker safety in utility support for microgrids.**
	Senate Bill 100	Renewable Energy	California Renewables Portfolio Standard Program: emissions of greenhouse gases. Requires 100% of the California's electricity to be generated by carbon-free renewable sources by 2045.[38]
	Senate Bill 700	GHG Reduction	Authorizes the continuation of the Self-Generation Incentive Program through 2025, with funding to supply roughly $166 million per year in incentives for qualifying BTM technologies, or $830 million total.

As of May 13, 2019, there were 45 energy-related bills introduced or passed by one house in the California legislature related to electricity generation, emissions, and energy efficiency and 12 related to jobs/economic development in 2019, according to Advanced Energy Legislation Tracker.[39] It is an active area of legislation.

Executive orders have been issued by California's governors, some of which have been codified in legislation, others in rulemaking and regulations by state agencies (CPUC and Air Resources Board, among others). For example, Governor Brown issued Executive Order B-55-18 in concert with the signing of SB 100 to achieve carbon neutrality in the state no later than 2045.[40] Other executive orders not codified in current legislation will be referenced throughout this memo.

California's climate and energy mandates are addressed through the legislation in four primary macro-sectors: Renewable energy from carbon-free sources; reduction in greenhouse gas emissions through cap-and-trade markets and other technological innovations; energy efficiency in new and existing commercial and residential building stocks; and electrification of the transportation sector. Achieving the goals of each has workforce implications:

Carbon-free renewable energy goals are ahead of schedule to be achieved through distributed, BTM and utility-scale solar generation, wind, geothermal, and other renewable sources. The solar and wind energy industries, comprising 80% of the renewables portfolio,[41] support occupations in research, design, logistics, manufacturing, construction, operations, and maintenance.[42]

[38] A significant contributor to reaching this goal will be the implementation of Title 24 Part 6 2019 Update Building Energy Efficiency Standards in 2020, requiring all new low-rise residential construction to install BTM solar; discussed in section III.

[39] Search Advanced Energy Legislation. (n.d.). Retrieved May 10, 2019, from http://aeltracker.org/.

[40] Poloncarz, K., & Levine, J. (2018, September 11). Governor Jerry Brown signs SB 100 and Executive Order to achieve carbon neutrality by 2045. Retrieved May 12, 2019, from https://www.insideenergyandenvironment.com/2018/09/governor-jerry-brown-signs-sb-100-and-executive-order-to-achieve-carbon-neutrality-by-2045/.

[41] In 2017, the CEC reported that 80% of the renewable energy sources making up 30% of California's total in-state generation came from solar, wind, and geothermal: California Air Resources Board. (2018, July 11). California Greenhouse Gas Emission Inventory - 2018 Edition. Retrieved May 11, 2019, from https://www.arb.ca.gov/cc/inventory/data/data.htm.

[42] Hamilton, J. (n.d.). Careers in Solar Power. Retrieved May 11, 2019, from https://www.bls.gov/green/solar_power/ and Hamilton, J., & Liming, D. (n.d.). Careers in Wind Energy. Retrieved May 11, 2019, from https://www.bls.gov/green/wind_energy/.

Cap-and-trade legislation supports funding for job training, career education, and community transformation. Through 2018, $3.4 billion has been invested in projects across the state, a significant percentage of which have gone to job training and job creation for energy efficiency projects.[43]

- Energy efficiency legislation addresses workforce training and job creation through the need to retrofit a significant percentage of existing residential and commercial properties to meet not just current standards, but goals for doubling efficiency by 2030. In addition, technology is having a workforce impact in this area through automation and demand-response controls.
- Transportation is the single largest contributor to GHG emissions, at 41%.[44] Achieving the GHG emission goals of legislation will not be accomplished without significant inroads in electrifying this sector.

What the Evidence Says

Legislation to address climate change has been around for 17 years, which is enough time to assess empirical evidence of its impact. At the end of 2017, California's electricity was supplied 70% by non-renewable and large-hydro sources (including nuclear at 9%, which will go off-line by 2025) and 30% by solar, wind, geothermal, and other renewable sources.[45]

2017 Total System Electric Generation in Gigawatt Hours

Fuel Type	California In-State Generation (GWh)	Percent of California In-State Generation	Northwest Imports (GWh)	Southwest Imports (GWh)	California Energy Mix (GWh)	California Power Mix
Coal	302	0.15%	409	11,364	12,075	4.13%
Large Hydro	36,920	17.89%	4,531	1,536	42,987	14.72%
Natural Gas	89,564	43.40%	46	8,705	98,315	33.67%
Nuclear	17,925	8.69%	0	8,594	26,519	9.08%
Oil	33	0.02%	0	0	33	0.01%
Other (Petroleum Coke/Waste Heat)	409	0.20%	0	0	409	0.14%
Renewables	61,183	29.65%	12,502	10,999	84,684	29.00%
Biomass	5,827	2.82%	1,015	32	6,874	2.35%
Geothermal	11,745	5.69%	23	937	12,705	4.35%
Small Hydro	6,413	3.11%	1,449	5	7,867	2.70%
Solar	24,331	11.79%	0	5,465	29,796	10.20%
Wind	12,867	6.24%	10,015	4,560	27,442	9.40%
Unspecified Sources of Power	N/A	N/A	22,385	4,632	27,017	9.25%

[43] California Air Resources Board. (2019, March 25). Report: Cap-and-trade spending doubles to $1.4 billion in 2018. Retrieved May 11, 2019, from https://ww2.arb.ca.gov/news/report-cap-and-trade-spending-doubles-14-billion-2018.

[44] Retrieved May 11, 2019, from https://ww2.arb.ca.gov/news/report-cap-and-trade-spending-doubles-14-billion-2018.
California Air Resources Board. (2018, July 11). California Greenhouse Gas Emission Inventory - 2018 Edition. Retrieved May 11, 2019, from https://www.arb.ca.gov/cc/inventory/data/data.htm.

[45] California Energy Commission. (2018, June 21). Total System Electric Generation. Retrieved May 12, 2019, from https://ww2.energy.ca.gov/almanac/electricity_data/total_system_power.html.

Fuel Type	California In-State Generation (GWh)	Percent of California In-State Generation	Northwest Imports (GWh)	Southwest Imports (GWh)	California Energy Mix (GWh)	California Power Mix
TOTAL	206,336	100.00%	39,873	45, 830	292,039	100.00%

Source: California Energy Commission

Three recent case studies on the impact of climate change legislation are noteworthy: San Joaquin Valley; Inland Empire; and Statewide RPS Effects.

San Joaquin Valley

In 2016, The Don Vial Center for Employment in the Green Economy at the University of California, Berkeley (UC Berkeley) released a comprehensive economic and labor study of the impact of climate legislation through 2015 on eight counties in the San Joaquin Valley.[46] The study focused on three macro-elements of the legislation: Cap-and-Trade; increased RPS; and Energy Efficiency. Findings are summarized as follows:

The Cap-and-Trade program generated $200 million in net economic benefit to the valley and was responsible for the creation of 709 direct and 903 indirect jobs.[47] Thirty-six million had been invested in construction activity from auction revenue, excluding High Speed Rail, with another $103 million anticipated but not yet invested at the time of the study. Construction activity includes the building of new affordable housing, solar panel installation, weatherization, transit improvements, and construction work on digesters and composters.

- RPS generated $11.6 billion in net economic benefit to the valley through construction projects and was responsible for the creation of 31,000 direct and 57,000 indirect jobs. Since 2002, 4,547 MW of RPS-qualifying energy projects have been built, three quarters of which were built since 2011. Construction of solar, wind, biomass, and solar thermal projects resulted in 29.1 direct jobs per MW produced. Operation and maintenance of these projects resulted in 5 direct jobs per MW annually.
- Energy Efficiency projects generated $1.8 billion in net economic benefit to the valley through job creation, mainly in the construction sector, and lower energy costs, and was responsible for the creation of an estimated 6,660 direct and 10,730 indirect jobs.

While this study does not specifically identify job gains for particular occupations, the findings are indicative of the sectors in which job gains should be expected as a result of legislation implementation.

Inland Empire

Another study was conducted by the Center for Labor Research and Education at UC Berkeley in the Inland Empire for the same period, ending in 2016.[48] This study found net economic benefits of $9.1 billion and net jobs gained of 41,000. This study also focused on Cap-and-Trade, RPS, and Energy Efficiency program impacts. Key findings over the 6-year study period follows:

- Cap-and-Trade generated $95 million in auction proceeds, offset by $58 million in compliance costs for a net direct benefit of $37 million and direct job gains of 240.

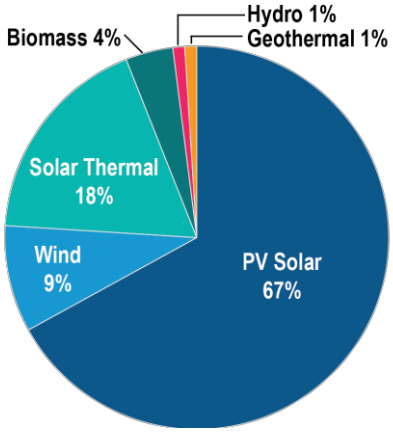
[46] Jones, B. (2017, February 06). California's Climate Policies Bring Good Jobs to the San Joaquin Valley. Retrieved May 10, 2019, from http://laborcenter.berkeley.edu/californias-climate-policies-bring-good-jobs-to-the-san-joaquin-valley/.
[47] "Jobs" are calculated as 1 man-year, or 2,080 work hours.
[48] Jones, B., Duncan, K., Elkind, E., & Hanson, M. (2017, December 05). The Net Economic Impacts of California's Major Climate Programs in the Inland Empire. Retrieved May 10, 2019, from http://laborcenter.berkeley.edu/the-net-economic-impacts-of-californias-major-climate-programs-in-the-inland-empire/.

- RPS generated direct benefits of $8.4 billion in renewable energy project construction, $587 million in increased grid-scale solar, and $1,307 in increased grid-scale wind energy, offset by a reduction of $2.0 billion in natural gas electricity generation for a net benefit of $8.3 billion. 29,000 construction jobs were gained, and a net 233 jobs were lost in energy generation (1,167 jobs lost in natural gas generation versus 934 gained in renewable generation).

Energy Efficiency, combined with BTM solar, generated $1.7 billion in economic benefits, offset by $894 million in costs for a net benefit of $821 million. During the study period, $365 million was invested in energy efficiency construction projects, divided 25/75 between residential and non-residential projects, and created over 2,000 construction jobs. The employment outlook for distributed solar is unclear, as many of the projects were funded by subsidies. Costs for distributed solar continue to decline, which should have a positive impetus.

Statewide RPS

A 2016 study from UC Berkeley explores the types and quality (in terms of living wage earnings) of jobs resulting from construction in the renewable energy industry.[49] The report estimates that California's RPS during the 2010-2015 study period created 25,500 blue-collar job-years (about 53 million hours of blue-collar construction work) and 7,200 white-collar construction job-years (about 15 million hours of white-collar construction work), almost 90% of which have been created since 2012. Solar PV projects were responsible for two-thirds of the jobs (over 80% if Solar Thermal is included), with Wind projects making up 9%. For every MW of renewable energy project built, 2.3 blue-collar jobs are created. This does not count the jobs created by grid interconnection projects that arise from new renewable plants, nor a significant number of white-collar jobs (0.6 per MW) created in support of a project.



Source: UC Berkeley Don Vial Center

The study makes an interesting geographical point: Because utility-scale renewable projects typically require a lot of land (or in the case of hydro or geothermal a very specific location where those resources exist), they are generally built in non-urban areas. This requires workers to travel distances to job sites, and in many cases generates preferences for local hiring, creating good economic and training opportunities in areas that may not have many. In addition, the broader geographic nature of supply chains often generate economic benefits in urban areas that cannot support the construction of the actual projects. The benefits are widespread in both rural and urban geographic areas.

The following table shows typical construction jobs, benefits, and wages for renewable projects during the study period.

[49] Jones, B., Philips, P., & Zabin, C. (2016, July). The Link Between Good Jobs and a Low Carbon Future. Retrieved May 11, 2019, from http://laborcenter.berkeley.edu/pdf/2016/Link-Between-Good-Jobs-and-a-Low-Carbon-Future.pdf.

Average benefits as a percent of the average wage weighted by relative craft employment for construction workers on renewable energy projects, California, 2002-2015					
Craft	**Training**	**Pension**	**Health**	**Total Benefits**	**Wage**
Boilermaker	$0.75	$16.20	$8.57	$25.52	$41.66
Bricklayer	$0.82	$7.37	$7.90	$16.09	$40.56
Carpenter	$0.57	$4.41	$6.60	$11.58	$40.40
Cement Mason	$0.60	$8.09	$7.52	$16.21	$32.30
Electrical Utility Lineman	$0.26	$8.18	$5.50	$13.94	$52.85
Electrician Wireman	$0.93	$8.52	$8.97	$18.42	$38.20
Insulators	$0.64	$11.51	$8.14	$20.29	$37.99
Ironworker	$0.72	$12.97	$9.42	$32.11	$33.50
Laborers	$0.64	$6.50	$6.86	$14.00	$31.39
Millwright	$0.57	$4.41	$6.60	$11.58	$40.90
Operating Engineer	$0.80	$9.65	$11.20	$21.65	$31.39
Painter, Industrial	$0.79	$3.04	$8.05	$11.88	$30.72
Pipefitter	$2.55	$11.05	$7.11	$20.71	$42.93
Roofer	$0.30	$1.62	$6.00	$7.92	$28.73
Sheet Metal	$0.73	$.14.54	$7.92	$23.19	$35.55
Teamster	$1.52	$5.00	$16.02	$22.54	$28.24
Average weighted by share of work	**$0.91**	**$8.59**	**$8.63**	**$18.13**	**$36.84**

Source: UC Berkeley Don Vial Center

This report also highlights a tension between BTM, residential solar and larger, commercial and utility-scale solar projects in the employment market: union versus non-union labor. Residential solar projects tend to be dominated by non-union contractors; commercial and utility-scale are dominated by union labor. There are disparities in union versus non-union wages and benefits, and also in efficiency as measured by price per installed watt of generation. Lawrence Berkeley Labs' 2018 report on installed solar prices estimated a national median price in 2017 of $4/W$_{AC}$ for residential solar and $2/W$_{AC}$ for utility-scale solar PV.[50] This tension has played out in political forums, but BTM solar should continue; California still has some of the best incentives in the US for BTM solar.[51]

What the Literature Projects

Evidence is fairly weighted in favor of positive net economic benefits and job creations from implementation of climate legislation since 2002. The balance of this memo reviews outstanding literature in terms of the impact of current legislation on the nature of work.

[50] Barbose, G., Darghouth, (2018, September). Tracking the Sun: Installed Price Trends for Distributed Photovoltaic Systems in the United States - 2018 Edition. Retrieved May 12, 2019, from https://emp.lbl.gov/sites/default/files/tracking_the_sun_2018_edition_final_0.pdf.
[51] Zientara, B. (2019, January 18). How to save big with California's Net Metering 2.0. Retrieved May 12, 2019, from https://www.solarpowerrocks.com/affordable-solar/save-big-californias-net-metering-2-0/.

In a paper published in Energy Policy, Wei et al. looked at a number of studies comparing construction, installation, and manufacturing (CIM) and operations and maintenance (O&M) job-years created/supported by a range of energy technologies, from coal to renewable energy sources.[52] They found that, compared to hydrocarbon (natural gas), electricity generation, solar and wind had much higher ratios of CIM to O&M jobs per MW; the renewable energy and low carbon sectors generate more jobs per unit of energy delivered than the conventional fuel-based sector, and among the common RPS technologies, Solar PV creates the most jobs per unit of electricity output. The following table summarizes the study.

Comparison of jobs/MWp, jobs/MWa and job-years/GWh across technologies.

Work-hours per year	2000	Capacity factor (%)	Equipment lifetime (years)	Employment components			Average employment over life of facility							
							Total jobs/MWp		Total jobs/MWa		Total job-years/GWh			
Energy technology	Source of numbers			CIM (job-years/MWp)	O&M (jobs/MWp)	Fuel extraction and processing (job-years/GWh)	CIM	O&M and fuel processing	CIM	O&M and fuel processing	CIM	O&M and fuel processing	Total	Avg
Biomass 1	EPRI 2001	85	40	4.29	1.53	0.00	0.11	1.53	0.13	1.80	0.01	0.21	0.22	0.21
Biomass 2	REPP 2001	85	40	8.50	0.24	0.13	0.21	1.21	0.25	1.42	0.03	0.16	0.19	
Geothermal 1	WGA 2005	90	40	6.43	1.79	0.00	0.16	1.79	0.18	1.98	0.02	0.23	0.25	0.25
Geothermal 2	CALPIRG 2002	90	40	17.50	1.70	0.00	0.44	1.70	0.49	1.89	0.06	0.22	0.27	
Geothermal 3	EPRI 2001	90	40	4.00	1.67	0.00	0.10	1.67	0.11	1.86	0.01	0.21	0.22	
Landfill Gas 1	CALPIRG 2002	85	40	21.30	7.80	0.00	0.53	7.80	0.63	9.18	0.07	1.05	1.12	0.72
Landfill Gas 2	EPRI 2001	85	40	3.71	2.28	0.00	0.09	2.28	0.11	2.68	0.01	0.31	0.32	
Small Hydro	EPRI 2001	55	40	5.71	1.14	0.00	0.14	1.14	0.26	2.07	0.03	0.24	0.27	0.27
Solar PV 1	EPIA/Greenpeace 2006	20	25	37.00	1.00	0.00	1.48	1.00	7.40	5.00	0.84	0.57	1.42	0.87
Solar PV 2	REPP 2006	20	25	32.34	0.37	0.00	1.29	0.37	6.47	1.85	0.74	0.21	0.95	
Solar PV 3	EPRI 2001	20	25	7.14	0.12	0.00	0.29	0.12	1.43	0.60	0.16	0.07	0.23	
Solar Thermal 1	Skyfuels/NREL 2009	40	25	10.31	1.00	0.00	0.41	1.00	1.03	2.50	0.12	0.29	0.40	0.23
Solar Thermal 2	NREL 2006	40	25	4.50	0.38	0.00	0.18	0.38	0.45	0.95	0.05	0.11	0.16	
Solar Thermal 3	EPRI 2001	40	25	5.71	0.22	0.00	0.23	0.22	0.57	0.55	0.07	0.06	0.13	
Wind 1	EWEA 2008	35	25	10.10	0.40	0.00	0.40	0.40	1.15	1.14	0.13	0.13	0.26	0.17
Wind 2	REPP 2006	35	25	3.80	0.14	0.00	0.15	0.14	0.43	0.41	0.05	0.05	0.10	
Wind 3	McKinsey 2006	35	25	10.96	0.18	0.00	0.44	0.18	1.25	0.50	0.14	0.06	0.20	
Wind 4	CALPIRG 2002	35	25	7.40	0.20	0.00	0.30	0.20	0.85	0.57	0.10	0.07	0.16	
Wind 5	EPRI 2001	35	25	2.57	0.29	0.00	0.10	0.29	0.29	0.83	0.03	0.09	0.13	
Carbon Capture & Storage	Friedmann, 2009	80	40	20.48	0.31	0.06	0.51	0.73	0.64	0.91	0.07	0.10	0.18	0.18
Nuclear	INEEL 2004	90	40	15.20	0.70	0.00	0.38	0.70	0.42	0.78	0.05	0.09	0.14	0.14
Coal	REPP 2001	80	40	8.50	0.18	0.06	0.21	0.59	0.27	0.74	0.03	0.08	0.11	0.11
Natural Gas	CALPIRG 2002	85	40	1.02	0.10	0.09	0.03	0.77	0.03	0.91	0.00	0.10	0.11	0.11
Energy Efficiency 1	ACEEE 2008	100	20										0.17	0.38
Energy Efficiency 2	Goldemberg, 2009	100	20										0.59	

Source: Wei et al., Putting renewable and energy efficiency to work

Solar

Through the end of 2018, California ranked first in solar capacity (24,464 MW), 1st in solar jobs (76,838), and 1st in five year growth projections (14,683 MW) in the US.[53] A two-year retraction in job growth in all sectors (manufacturing, installation, distribution) was expected to reverse in 2019. One impetus for growth, not just in solar, is the deal agreed regarding the shutdown of the Diablo Canyon nuclear generating facility by 2025, which generates 9% of the state's power. In this deal, replacement power will be filled with renewable sources, generating direct and indirect jobs across sectors.[54]

Another impetus to distributed solar growth in the state is the adoption of Title 24 Part 6 mandates for BTM solar in low-rise (3 stories or fewer) residential buildings. This requirement is an integral part of achieving the goals of SB 32 and SB 100. It can be anticipated that the primary workforce effects will be a necessary up-skilling of residential construction labor rather than significant growth in direct construction labor demand. Because the code allows credits for onsite energy storage, often paired with distributed systems, indirect labor effects should be seen in technology businesses designing and producing such systems. News reports note the increase in up-front building costs of $10,000 to $30,000, offset by

[52] Wei, M., Patadia, S., & Kammen, D. M. (2010). Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? Energy Policy, 38(2), 919-931. doi:10.1016/j.enpol.2009.10.044.

[53] Solar Energy Industries Association. (2019, March). Solar Spotlight – California. Retrieved May 11, 2019, from https://www.seia.org/sites/default/files/2019-03/Federal_2019Q1_California.pdf.

[54] Dalzell, T. (2018, November 30). Diablo Canyon: A Just Transition for Workers and the Environment. Retrieved May 11, 2019, from http://laborcenter.berkeley.edu/diablo-canyon-just-transition-workers-environment/.

savings in energy costs of $20,000 to $60,000 over 25 years, which will likely lead to a "normalization" of consumer attitudes toward solar power.[55]

Up-skilling of labor puts stresses on employer who are having difficulty hiring qualified workers now. A 2017 study by the Solar Foundation[56] found that 84% of solar installers reported difficulty in filling open installation positions, with over three-quarters reporting that candidates had no specific training or relevant work experience. Recruiting costs are significant, and contribute a measurable amount to the price per watt of installed solar. Key findings from the study:

- Employers report that they look less to installation-specific training among job applicants, and place more value on those experiences that develop technical abilities, safety techniques, and soft skills that are common to all companies.
- A lack of relevant work experience was the most commonly cited (77.9%) reason for difficulty hiring. This is despite the fact that a majority of installation companies (57.9%) expect less than a year of experience in a comparable position for entry-level candidates, with 21.2% of those expecting either no formal experience or 1-4 weeks as an apprentice, intern, or volunteer in a comparable position.
- A majority of employers (61%) consider experience in a non-solar construction trade important to their hiring considerations.
- Over three quarters (79.6%) of employers stated that there was a general need for additional solar training. However, only 40.9% of employers stated that completion of a semester-long course in solar installation training is either "important" or "somewhat important" for entry-level installers.
- The industry is almost evenly split on the importance of entry-level installers obtaining a solar certification, with 48.1% considering it either important or somewhat important, and 51.9% considering certifications unimportant.
- Only 34% of employer respondents to the broad 400+ employer survey indicated that they provide a formal on-the-job training (OJT) program. Of those that offer OJT, the average training length was 40-hours. Safety training was the primary focus of most OJT programs.
- 66% of respondents stated that a standardized industry-wide OJT training program would be highly valuable to their company. The three topics which companies felt would be most valuable to cover in a standardized training program were:
    - System Installation and Connection (78%) including basic knowledge of system components and basics of installation/ connection of a system
    - System Components (75%) including the ability to identify and correctly handle solar system components

Electricity Basics (75%) including basic electrical principals and common electrical system components

[55] Bach, N. (2018, December 6). California Becomes 1st State to Require Solar Panels on New Homes. Retrieved March 10, 2019, from http://fortune.com/2018/12/06/california-solar-panels-new-homes/.
[56] Olson, T., & Nackerman, C. (2017, April). Solar Training and Hiring Highlights. Retrieved May 12, 2019, from https://www.americansolarworkforce.org/wp-content/uploads/2018/09/sthr.pdf.

Wind

In 2018, California had installed onshore wind generation capacity of 5,674 MW, approximately 25% of the utility-scale renewable energy generation capacity.[57] A 2014 Stanford study projected that wind could deliver approximately 73 GW of delivered power, or roughly 40% of California's all-purpose demand if fully developed.[58] (It should be noted that local and environmental constraints, plus the phase out in 2019 of investment and production tax credits may impact build-out to full capacity[59]).

In 2016, the wind energy industry in the US employed approximately 50,000 with an anticipated growth rate through 2024 of over 100%; the American Wind Energy Association projects 500,000 jobs across the industry by 2030.[60] [61] The number of manufacturing jobs in 2017 was estimated at more than 23,000, with growth in the development, transportation and construction segment of the supply chain. This reflects the fact that by year-end 2017, more than 13 GW of capacity were under construction and 15 GW in advanced stages of development. More than 80% of all US wind capacity is located in low-income rural counties. Land lease payments totaling $267 million in 2017 are helping to stimulate these rural economies, in addition to tax revenues and income earned from segments of the value chain.[62]

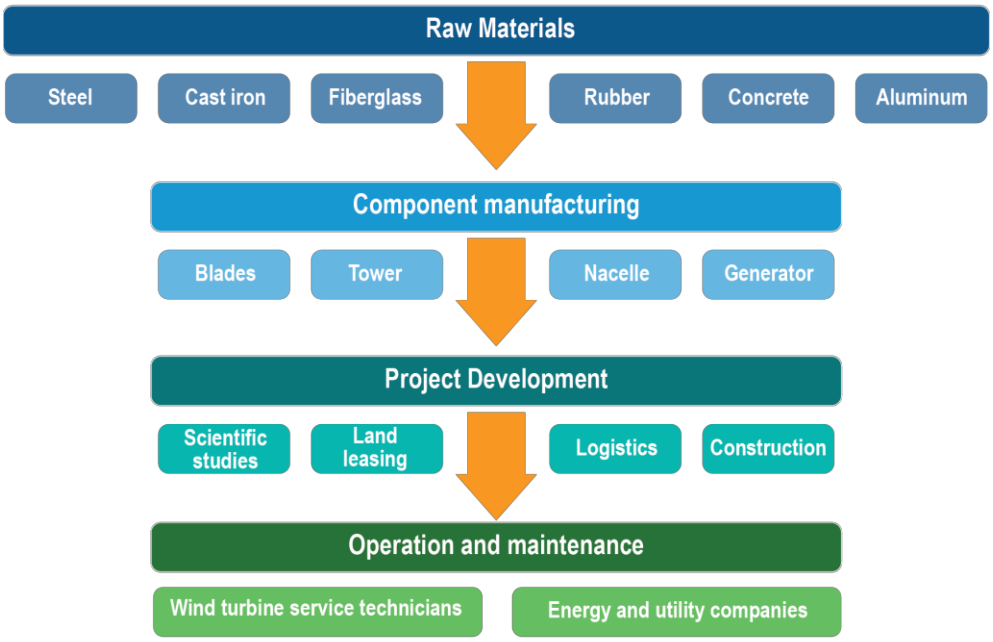
The employment cycle in the production and operation of a wind farm follows this pattern:[63]

- Production of the rotor blades, the nacelle with incorporated mechatronics, and the steel or concrete tower at a manufacturing plant.
- Shipments of wind turbine components to the installation site, either onshore (using large trucks) or offshore (using large trucks and boats).
- Field research is needed, before installation, on environmental impact assessment studies, wind studies, civil works and electrical works planning.
- Preparation of the field with pathways and roads, wind turbine foundations and electricity grid extension and substations construction.
- Commissioning (Note: A UC Berkeley study found that wind turbine installation requires less on-site construction labor per MW than other renewable technologies[64]).
- Operations and Maintenance

[57] California Energy Comission. (n.d.). 2018 Integrated Energy Policy Report Update Vol. 1. Retrieved May 18, 2019, from https://ww2.energy.ca.gov/2018publications/CEC-100-2018-001/CEC-100-2018-001-V1_spreads.pdf.
[58] Jacobson, M., Delucchi, M., Ingraffea, A., Howarth, R., Bazouin, G., Bridgeland, B., Yeskoo, T. (2014). A roadmap for repowering California for all purposes with wind, water, and sunlight. Energy Policy, 73, 875-889. doi: 10.1016/j.energy.2014.06.099.
[59] California Energy Commission. (2016, December 26). The California Natural Resources Agency Completes the Renewable Energy Transmission Initiative (RETI 2.0) Plenary Report. Retrieved May 17, 2019, from https://www.ctcglobal.com/blog/california-natural-resources-agency-completes-renewable-energy-transmission-initiative-reti-2-0-plenary-report/.
[60] O'Leary, B. (2016, July). Earth, Wind & Hire. Electrical Apparatus, 69(7).
[61] AWEA reported 105,000 wind energy jobs in the United States in 2017, consistent with the predicted growth rate from 50,000 in 2016.
[62] American Wind Energy Association. (2018). AWEA U.S. Wind Industry Annual Market Report, Year Ending 2017. Retrieved May 15, 2019, from https://www.awea.org/resources/publications-and-reports/market-reports/2017-u-s-wind-industry-market-reports.
[63] European Centre for the Development and Vocational Training. (2015). Green Skills and Innovation for Inclusive Growth(Rep.). Luxembourg: Publications Office of the European Union.
[64] Jones, B., Philips, P., & Zabin, C. (2016, July). The Link between Good Jobs and a Low Carbon Future. Retrieved May 11, 2019, from http://laborcenter.berkeley.edu/pdf/2016/Link-Between-Good-Jobs-and-a-Low-Carbon-Future.pdf.

Graphically, the supply chain looks like the following diagram.[65] Remember that up-front construction (CIM) jobs in wind will outnumber ongoing O&M jobs by a ratio of approximately 30:1 per MW produced (versus approximately 5:1 per MW produced for natural gas, including gas extraction, 10:1 without).

Source: Bureau of Labor Statistics



Technical training in wind operations and maintenance includes courses in DC and AC Electronics, Industrial Electronics, Motors and Generators, Wind Turbine Design, Wind Turbine Maintenance and Troubleshooting, along with safety and soft skills training.[66]

Offshore wind presents different challenges and opportunities than onshore. Because California's coastal waters slope deeply near shore, offshore wind platforms would have to be installed on floating platforms rather than anchored to the ocean floor as they are on the East Coast of the US and in much of Europe. This poses cost, technology, and logistics challenges. Recent studies suggest that with price declines in core technologies, the cost challenges could be overcome within a decade.[67] Likely siting of such installations would require construction of electrical grid interconnection facilities, port upgrades, and an extensive local supply chain in rural coastal counties.[68] The study concludes that 13,000 full-time CIM and 4,000 full-time O&M jobs would be created by 2040-50, adding 16 GW of generating capacity to the grid that would potentially bridge the gap between diminishing solar and rising afternoon demand.

Integrated Distributed Energy Resources (IDERs)

Integrated Distributed Energy Resources combine consumer-side, BTM generation (e.g., solar, wind) with battery storage, energy efficiency, automation, and demand response technology to offload and supplement the electrical grid.[69] In 2007, CPUC Decision D.07-10-032 directed that utilities "Integrate customer demand-side programs, such as energy efficiency, self-generation, advanced metering, and

[65] Hamilton, J., & Liming, D. (n.d.). Careers in Wind Energy. Retrieved May 11, 2019, from https://www.bls.gov/green/wind_energy/.
[66] O'Leary, B. (2016, July). Earth, Wind & Hire. Electrical Apparatus, 69(7).
[67] Collier, R. (2019, February 04). High Road for Deep Water: Policy Options for a California Offshore Wind Industry, Retrieved May 18, 2019, from http://laborcenter.berkeley.edu/high-road-for-deep-water/.
[68] Collier, R. (2017, November 09). California's plans for offshore wind power run into Navy opposition. Retrieved May 18, 2019, from https://www.sfchronicle.com/opinion/openforum/article/Wind-farm-auctions-delayed-as-US-Navy-says-12345413.php#photo-14520001.
[69] Energy Market Innovations, Inc. (n.d.). HVAC Educational Needs Assessment (Rep.). submitted to Southern California Edison on August 2012.

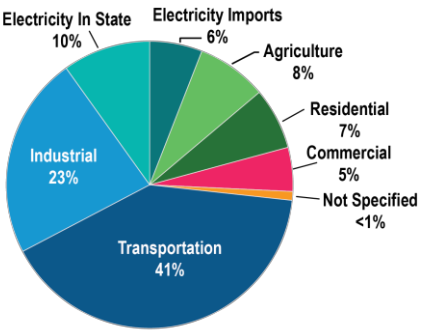
demand response, in a coherent and efficient manner."[70] Utilities were not conceived with the idea of power flowing onto the grid from customer endpoints. However, passage of SB 1339 in 2018 requires them to support and facilitate microgrid interconnection to the grid and provides cost recovery mechanisms for the utilities.[71] Other legislation, such as AB 2514 (2010) and AB 2868 (2016), and CPUC rulings require the procurement of battery storage to support renewables and microgrids. Such demand-side technologies require skills infused into a number of traditional occupations. According to the 2011 Workforce Education and Training Needs Assessment, two-thirds of the occupations impacted by these technologies will be in the construction trades: electricians; plumbers and pipefitters; sheet metal workers; carpenters; laborers; and construction supervisors.[72]

Biomass

Biomass is organic material from plants and animals that can be processed and converted into a renewable source of energy. In 2017, approximately 5% of primary energy in the US was provided through biomass, of which 47% was from biofuels (e.g., ethanol) and 44% from wood and wood-derived sources.[73] This review focused on forest-sourced biomass for two reasons: 1) the carbon neutrality of biomass fuels is controversial (the concept that plants only release the amount of carbon they sequester during photosynthesis;[74] and 2) the California Forest Climate Action Team has made forest-waste conversion to biomass energy an integral part of recovery plans from the devastating wildfires of the past years.[75] Because forested areas are by nature remote, small biomass employment effects can have large impacts on communities that have already been impacted negatively by the shrinking traditional logging and wood-processing industries. One study in the Pacific Northwest found job gains in the low hundreds in rural counties with an average wage of $43,000 related to the gathering, transport, and processing of forest waste products into bioenergy.[76]

Transportation

Transportation is the single largest contributor to GHG emissions, at 41% - almost double industrial at 23% and more than four times electrical generation at 10%.[77] California standards for vehicle emissions, exceeding Federal standards, have been in place since 1970. In 2013, the California Air Resources Board adopted a Zero Emissions Vehicle (ZEV) plan as part of the Advanced Clean Car (ACC) program. The goal of the plan was to have 1.5 million ZEVs on the road by 2025; a 2017 review revised that goal to 1.2 million vehicles, but a 2018 Executive



Source: California Air Resources Board

[70] California Public Utilities Commission. (n.d.). Integrated Distributed Energy Resources. Retrieved May 15, 2019, from https://www.cpuc.ca.gov/General.aspx?id=10710.
[71] Wood, E. (2018, September 5). Microgrid Bill (SB 1339) Passes California Legislature. Retrieved May 14, 2019, from https://microgridknowledge.com/microgrid-bill-california-sb-1339/.
[72] Donald Vial Center on Employment in the Green Economy, Institute for Research on Labor and Employment, University of California, Berkeley. (2011). California Workforce Education and Training Needs Assessment: For Energy Efficiency, Distributed Generation, and Demand Response (Rep.). Berkley, CA. Retrieved May 14, 2019, from http://laborcenter.berkeley.edu/pdf/2011/WET_Part1.pdf.
[73] U.S. Energy Information Administration. (2018, June 21). Biomass Explained. Retrieved May 12, 2019, from https://www.eia.gov/energyexplained/?page=biomass_home.
[74] Harvey, C., & Heikkinen, N. (2018, March 23). Congress Says Biomass Is Carbon-Neutral, but Scientists Disagree. Retrieved May 16, 2019, from https://www.scientificamerican.com/article/congress-says-biomass-is-carbon-neutral-but-scientists-disagree.
[75] Forest Climate Action Team. (2018). California Forest Carbon Plan: Managing Our Forest Landscapes in a Changing Climate (Rep.). Sacramento, CA.
[76] Saul, D., Newman, S., Peterson, S., Kosse, E., Jacobson, R., Keefe, R., Moroney, J. (2018). Evaluation of Three Forest-Based Bioenergy Development Strategies in the Inland Northwest, United States. Journal of Forestry, 116(6), 497-504. doi:10.1093/jofore/fvy042.
[77] California Air Resources Board. (2018, July 11). California Greenhouse Gas Emission Inventory - 2018 Edition. Retrieved May 11, 2019, from https://www.arb.ca.gov/cc/inventory/data/data.htm.

Order (B-48-18[78]) increased the goal to 5 million by 2030. Regulations were put in place that require manufacturers to have an increasing percentage of sales from ZEVs through 2025.[79]

SB 350 recognizes the importance of electric vehicle (EV) charging infrastructure in accelerating EV market growth, and includes these findings:

- Widespread transportation electrification should stimulate innovation and competition, enable consumer options in charging equipment and services, attract private capital investments, and create high-quality jobs for Californians, where technologically feasible.
- Deploying electric vehicles should assist in grid management, integrating generation from eligible renewable energy resources, and reducing fuel costs for vehicle drivers who charge in a manner consistent with electric grid conditions.

Deploying electric vehicle charging infrastructure should facilitate increased sales of electric vehicles by making charging easily accessible and should provide the opportunity to access electricity as a fuel that is cleaner and less costly than gasoline or other fossil fuels in public and private locations.[80]

Under the provisions, the law gives the CPUC a mandate to approve utility infrastructure projects that contribute to the electrification of this sector.[81] Net workforce impacts are largely in the construction sector (building EV charging infrastructure, with accompanying electrical grid infrastructure impacts).[82]

Another key element in decarbonizing transportation is Executive Order B-32-15[83], which ordered the creation of a Sustainable Freight Action Plan in 2016. Freight accounts for 6% of GHG emissions in the state.[84] A sustainable freight transportation system is one that meets California's environmental, energy, mobility, safety, and economic needs by improving community livability, enhancing system efficiency, deploying zero and near-zero emission freight equipment powered by renewable energy sources, providing reliable performance while increasing safety, mobility and capacity, and improving the competitiveness of the logistics system. The plan is informed by existing state agency strategies, including the California Freight Mobility Plan, Sustainable Freight Pathways to Zero and Near-Zero Emissions, and the Integrated Energy Policy Report.[85] A number of pilot projects were submitted under the plan, many of which require infrastructure changes and improvements that will have workforce and electrical grid impacts. In 2018, the Port of Long Beach was awarded a $50 million grant for demonstration of a "near zero and zero emissions supply chain"[86] and the South Coast Air Quality Management District and Daimler Trucks North America announced the launch of a $31.3 million project to develop and demonstrate heavy-duty battery-electric trucks, which will be deployed at the Ports of Long Beach and Los Angeles.[87]

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[78] State of California. (2018, January 26). Governor Brown Takes Action to Increase Zero-Emission Vehicles, Fund New Climate Investments. Retrieved May 15, 2019, from https://www.ca.gov/archive/gov39/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/index.html.

[79] Klass, A. (2019). Public Utilities and Transportation Electrification. 104 Iowa Law Review,104(2), 545-617. Retrieved May 18, 2019

[80] State of California. (2015, October 7). SB-350 Clean Energy and Pollution Reduction Act of 2015 (Section 740.12). Retrieved May 16, 2019, from https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB350.

[81] Prior to SB 350, there was concern that utility ownership of EV charging infrastructure would stifle private capital investment; when this didn't materialize by 2014, provisions for utility ownership were written into the bill.

[82] Hamilton, J. (n.d.). Careers in Electric Vehicles. Retrieved May 11, 2019, from https://www.bls.gov/green/electric_vehicles/.

[83] State of California. (n.d.). Executive Order B-32-15. Retrieved May 16, 2019, from https://www.ca.gov/archive/gov39/2015/07/17/news19046/index.html.

[84] Lamm, T. (2018, May 9). California's road to sustainable freight. Retrieved May 12, 2019, from https://capitolweekly.net/californias-road-sustainable-freight-2/.

[85] California Air Resources Board. (2019, February 6). Sustainable Freight Transport: California Sustainable Freight Action Plan. Retrieved May 12, 2019, from https://www.arb.ca.gov/gmp/sfti/sfti.htm

[86] Port of Long Beach. (2018, September 11). Port Awarded $50 Million for Zero Emissions Project: California Air Resources Board funds project to transform goods movement [Press release]. Retrieved May 15, 2019, from http://www.polb.com/civica/filebank/blobdload.asp?BlobID=14694.

[87] South Coast Air Quality Management District. (2018, July 6). SCAQMD and Daimler Trucks North America Partner To Demonstrate Zero-Emission Vehicles at Ports [Press release]. Retrieved May 14, 2019, from https://www.aqmd.gov/docs/default-source/news-archive/2018/scaqmd-and-daimler-trucks-partnership.pdf.

Legislation and regulation recognize that GHG emission reduction goals will not be accomplished without significant inroads in electrifying the transportation sector.

Automation

Automation is creating a paradigm shift in work not unlike in scope the shift from agriculture to industrialization. The McKinsey Global Institute projects that by 2030, 60% of all occupations have 30% constituent work activities that can be automated.[88] The study asserts there will be pressure on training and education, as some 2-5 million AA/AS degree-level jobs will be lost and 6-8 million BA/BS degree-level jobs gained.

Building Automation Systems play a key role in achieving the doubling of energy efficiency mandate in SB 350 through lighting and HVAC controls – in 2017, Commercial Buildings consumed 36% of the state's electricity.[89] "Smart Buildings" will control their energy usage through automated lighting and HVAC systems, assessing the environment inside and outside the building, and automatically adjusting systems for optimum comfort and maximum efficiency. Connected sensors – the Internet of Things (IoT) – are foundational to automation, collecting and processing massive amounts of data in smart buildings. A skilled workforce that can understand and manipulate those data will be required to ensure that these systems are properly installed and maintained to achieve the desired savings and comfort, and be more proactive in the efficient and smooth operation of a building's systems.[90] Facility Managers are a key emerging occupation in this area, but as the McKinsey study infers, automation and related disciplines, like energy auditing, will be a component part of jobs that aren't specifically automation jobs. Here is a representative list of BAS occupation titles:[91]

- Commercial Building Controls Installer
- Building Lighting Systems Programmer
- Commercial HVAC Control System Programmer
- Commercial Building Control Systems Service Technician
- Building Commissioning Technician
- Energy Conservation Measure Technician
- Systems Integration Technician
- Facilities Management Technician
- Physical Plant Operations Technician
- Physical Plant Maintenance Technician

Several sources cite core competencies for BAS professionals, a composite subset of which is listed here:[92]

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[88] McKinsey & Company. (2017). A Future that Works: Automation, Employment and Productivity (Rep.). McKinsey Global Institute.
[89] California Energy Commission. (n.d.). Retrieved from https://www.energy.ca.gov/.
[90] Rotello, F. (2014, November 3). Integration Intel: Determining the Costs and ROI of a Smart Building. Retrieved May 12, 2019, from https://www.hpac.com/building-controls/integration-intel-determining-costs-and-roi-smart-building.
[91] Delaware Technical Community College. (2018, June 13). Building Automation Systems Option. Retrieved May 15, 2019, from https://www.dtcc.edu/academics/programs-study/building-automation-systems-option.
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- Controls Fundamentals
- Mechanical Fundamentals
- Bldg. Mechanical Systems
  - HVAC
  - Potable Water
  - Fire Suppression
  - Irrigation
  - Escalators and Elevators
- Electronics Fundamentals (AC and DC)
- Controls Programming (PLCs)
- Data Communication
- Systems Integration
- Energy Efficiency
  - Codes and standards
  - Performance monitoring
  - Performance predictive controls
  - Occupants behavior
  - Design point vs. part load
  - Heat transfer vs. heat generation/rejection
  - Variable speed
  - Energy storage
  - Renewables

The Association of Controls Professionals (ACP) was commissioned to conduct a study of Building Automation and related occupations for the Los Angeles-Orange County Region of the California Community Colleges.[93] Employer responses to select interview questions about skills, hiring, and training needs in a draft release of the report can be summarized as follows:

- Education: a two-year or technical college degree or equivalent is preferred. Experience is preferred, but given the number of vacancies, employers would hire for entry-level positions without prior experience.
- Training: short-term internships (1-2 month) were considered inadequate for these positions due to the amount of training required (6 months to 2 years).
- Knowledge, Skills, and Abilities (KSAs): a background in basic computer science, IT, networking, and some programming courses. Other skills mentioned were good verbal communication skills,

[93] Lovell, B., & Vyapari, S. (2018). *Assessment of Automation Employment Opportunities: Preparing 21st Century Automation Professionals (Draft)* (Rep.). Association of Controls Professionals.

logical mindset, ability to apply knowledge in an independent setting, problem solving, grit ("not an office job"), be able to read and properly interpret documents, and time management.

- Certifications: Employers considered hands-on learning and the ability to apply knowledge as more valuable for entry-level positions.

Orange County, CA, Community Colleges have launched an innovative, cross-sector automation controls certificate program that touches energy efficiency, manufacturing, industrial automation, and other sectors. One interesting potential outcome of the move to automation is the need for improved soft skills. Indeed, the literature suggests that soft skills – the ability to communicate and have good inter-personal interactions – becomes more important as less of work involves the repetitive tasks that can be automated.[94]

Digitalization of the Energy Sector

Core technologies involved in the automation of buildings and cities are being applied to the energy sector and utilities in general. Sensors and smart meters are being deployed to monitor, adjust, and change the billing structure of the energy grid to make it more responsive and efficient. Massive amounts of data are being collected on real-time grid performance; these data must be communicated to a central processing center, interpreted, and acted upon, invoking elements of machine learning and artificial intelligence. ICT skills will be increasingly in demand in this sector. In addition, this non-traditional interconnectedness exposes the grid to a non-traditional vulnerability: cyber threats. Cyber security will become a skill set of increasing importance as the grid becomes smarter and more adaptive.[95]

Validation: What Employers Say

Interviews were conducted with seven employers to validate/invalidate general and specific themes in the literature. Respondents included executives, training managers, operations managers, and contractors from automation controls, HVAC, refrigeration, and manufacturing companies. All questions and answers are presented in Appendix E but summarized here.

- All respondents agreed to the premise in the literature that more conventional construction jobs would be created and that operations & maintenance jobs would be up skilled to support new technologies like automation. Several respondents reiterated that core electrical and mechanical skills would continue to be foundational, but that ICT skills would be layered onto traditional jobs. One respondent noted particularly the challenges of achieving energy efficiency goals in existing building stock that reinforced the need for traditional skill sets; new HVAC equipment pushing air through existing, iinefficiently designed ducts do not achieve the energy efficiency savings potential of the system.
- Most respondents indicated ICT and networking skills as growing in importance, particularly the interconnection of disparate types of equipment from different vendors in the absence of many standards; a lack of standardized interfaces between disparate vendors' equipment created a need for networking and interconnection skills, while retaining the fundamental understanding of what the equipment is doing. Most emphasized that the traditional electrical and mechanical skills for installing and maintaining equipment were foundational and necessary; computer skills were important in addition to those skills. A couple of the respondents indicated their dependence on

[94] This article is indicative, but this is found in many studies: Oesch, T. (2018, October 22). The Rising Importance of Soft Skills in an Automated Workplace. Retrieved May 14, 2019, from https://trainingindustry.com/articles/leadership/the-rising-importance-of-soft-skills-in-an-automated-workplace/.
[95] DNV-GL. (n.d). Digitalization and the Future of Energy: Beyond the Hype. Retrieved May 11, 2019, from https://www.dnvgl.com/power-renewables/themes/digitalization/index.html.

vendors for training and troubleshooting and saw a need for more efficient (e.g., digitized, online, real-time) training for their workforce.

- All respondents agreed with an increasing demand for improved soft skills. Soft skills were seen by several as a bottom line issue for their companies – Technicians are a customer-facing front line in their business, and inability to be responsive and communicate effectively were seen as threatening future revenue streams.
- Bottom line, all respondents agreed that staffing of skilled positions is difficult. Most respondents look outside their industry for applicants with a core set of technical skills who can be trained for company- and industry-specific job functions. Several indicated that recruiting for “trades” (e.g., HVAC Technicians) is impacted by public perceptions of blue-collar work, when the reality is that many of these jobs are highly skilled and highly paid. Another bottleneck indicated by respondents is the increasing merging of “wrench-turning” and computer skills; it is easier to find candidates strong in one or the other, but not both. The lack of qualified applicants was their number one pain point in hiring workers. A second frequent pain point was applicants' work-readiness, i.e., desire to work, soft skills, professionalism. A third common pain point was lack of hard skills in applicants, with competition for skilled applicants between a proliferation of small vendors cited as a primary cause. A common lament in the contracting industry is that workers tend to get trained and then set themselves up in business. There was general agreement that this happens too easily and frequently, and leads to lower quality work in the industry.
- Due to the lack of qualified candidates and difficulty in staffing, virtually all respondents indicated that they conduct a high level of internal training with significant company investment and on-the-job training/mentoring. Community Colleges and Technical Trade Schools were mentioned next as a source of training; these were considered to be of good quality, but often lagging in current industry trends and technologies. Union training centers were mentioned frequently and held in high regard. One factor frequently mentioned was the need for vendor-specific training, a factor of the lack of standardization in this field.

Conclusions

Evidence from recent studies regionally and statewide supports the assertion that GHG reduction, renewable energy, and energy efficiency mandates of California's climate legislation will have positive net economic and employment impacts. Employers support the general findings and note a layering of new ICT skills in non-ICT occupations. While academic literature does not predict changes to specific jobs, several general conclusions can be drawn:

- Technology will continue to have a profound impact on labor, both directly and indirectly. Directly, there will be a growing demand for white collar science, technology, engineering, and math jobs (STEM - outside the scope of this review) to support the technological improvements and cost reductions anticipated in meeting the climate mandates.
- Indirectly, technology and technological improvements will continue to be a growing component of blue-collar work. Energy efficiency is as key to ensuring enough power is available in coming years as rationing was to ensure sufficient water during the drought. Up-skilling the building trades for ever-tightening codes, standards, and the impacts of automation is essential.
- While the literature does not specify new types of workers, elements of energy skills are appearing in diverse occupations, some traditional, some emerging. For example, energy auditing is a desirable skill in occupations like facility management, which used to be about floorspace

allocation and basic maintenance, but now manages whole-building health and is expected to deliver financial savings through energy management.

- Mandates for reduction in GHGs and deployment of renewables will initially impact the traditional construction trades; relatively more construction workers are required per MW in construction of wind and solar plants than in natural gas plants.
- Deployment of renewable energy will require more operations and maintenance personnel per MW generated than conventional power plants.
- California has maintained a favorable environment for distributed solar through consumer-friendly net metering policies that, while reduced, are still economically favorable to the consumer.
- Achieving GHG reduction goals cannot be accomplished without electrification of the transportation sector; this will impact construction trades for build-out of charging infrastructure and utilities for adapting the electrical grid.
- Automation will continue to grow in its impact on many occupations, requiring new generations of workers to have basic understanding of Information and Communications Technology (ICT) concepts and their application in performing tasks that were traditionally the realm of blue collar workers, like building maintenance. Building Automation Systems and smart buildings are key to achieving energy efficiency mandates, and will require workers comfortable with both a hammer and a computer.
- Among general ICT skills, cyber security is of particular importance in the utility sector as connected sensors, smart meters, etc., provide an entry path for malefactors into the utility grids.
- Employer interviews largely reinforced these themes, particularly with regard to the up-skilling of conventional trades to support the increasing digitization of equipment and deployment of Building Automation Systems. Conventional electrical and mechanical skills will continue to be foundational as new ICT skills are layered onto traditional trade occupations. Strong soft skills are also in high demand.

Appendix E: Employer Interviews Full Questions and Answers

Respondents

Respondent	Position, Industry
#1	Technical Training Manager, highly automated specialty electronic equipment manufacturer
#2	HVAC Contractor and Industry Association Leader
#3	Training Manager, building automation system manufacturer
#4	Vice President, facility energy management solutions and services provider
#5	Training Manager, building automation system manufacturer
#6	Operations and Training Manager, commercial refrigeration contractor
#7	CEO, commercial HVAC system contractor

Responses

Question	Respondent	Response
Literature indicates that staffing of skilled energy-related jobs is difficult, particularly in emerging energy industries. Is that true for your business? If not, where are you getting your employees? If so, what are your biggest bottlenecks, and what compromises do you make to accomplish your mission?	#1	▪ Hiring skilled labor is difficult ▪ We often have to hire lower-skilled workers, then train or send to school ▪ Referring to manufacturing automation, also building automation jobs
	#2	▪ Hiring skilled workers is difficult ▪ Bottleneck: Perceptions. Kids do not see HVAC as "green;" kids and parents perceive HVAC as blue collar work; parents push against that type of career even though the money is quite good. ▪ Average age of applicants is 31, indicating they have already tried something, failed, and are starting over. ▪ Industry reacts by targeting unskilled workers and training them.
	#3	▪ Staffing is generally difficult, particularly as digitization and automation proliferates ▪ Locating applicants is tough; hiring and retaining workers is tough ▪ Particularly true for Building Automation Techs; supply of techs directly impacts customer satisfaction ▪ The Building Management industry spends significant money on recruitment, and often recruits from "adjacent" industries (e.g., general electricians), then spends a couple of years training them ▪ This can backfire when trainees take the training and move to other companies – lack of supply creates great fluidity and high turnover; very costly
	#4	▪ Very true, particularly in California and with skilled positions ▪ HVAC is sophisticated work; bottleneck in technician positions

Question	Respondent	Response
		▪ Can be seasonal; when it gets hot in the summer, firms compete for a limited supply of workers, tends to inflate wages, then workers get laid off when the weather cools off. ▪ Expects the supply problem to get worse over the next 10 years due to retirements, attrition.
	#5	▪ Enthusiastically agrees ▪ Biggest bottlenecks are finding candidates with talent, experience, and good credentials
	#6	▪ Absolutely agrees ▪ Commercial refrigeration business needs techs with HVAC, Electrical, and Plumbing (multiple trades bundled into one job) ▪ Compromise: Hire someone strong in one area, train in the rest (usually HVAC)
	#7	▪ Agrees ▪ Tends to look outside industry for qualified applicants ▪ Specifically mentioned energy optimization as a skillset of growing need in his industry
What specific technical skills/knowledge do you see as growing (by occupation/occupation type) given energy policy changes and the emergence of new technologies in your industry?	#1	▪ Skills lacking: "Tinkering" skills, mechanical and electrical (foundational to other skills) ▪ Robotics are a new skills area necessary in his business ▪ Skills needed ("new" foundational): Controls, PLC programming, "vision" systems (robotics), networking/ICT ▪ Everything is connected, skills needed working with switches and routers (both on manufacturing network and business network); IP addressing, correct switch settings, etc. ▪ IT skills important for workers supporting manufacturing the equipment but also for those operating the equipment so they can identify problems earlier
	#2	▪ The HVAC industry is dominated by vendor-specific technology with little standardization. General HVAC skills become less important. ▪ Vendors don't want (and can't) run enough field support personnel, so it would be desirable for vendors to be able to mentor techs in some way that doesn't cost one-on-one interaction (too costly and time consuming). ▪ Codes and standards exist [e.g., American Society of Heating, Refrigeration, Air Conditioning Engineers (ASHRAE) and Air Conditioning Contractors of America (ACCA)], but are only enforced on permitted jobs (commercial & residential); < 10% of retrofit obs are permitted (both residential & commercial); code enforcement is lax. ▪ Tighter regulations have the contrary effect of driving contractors underground; expense of code compliance causes more jobs to go un-permitted.
	#3	▪ Growing: Programming ▪ Need for: Understanding integration of disparate types of equipment ▪ Need for: Troubleshooting skills ▪ Need for: Soft and Business skills (more in Question 8)
	#4	▪ Growing/need for: Technical skills related to changing codes and standards (e.g., Title 24 adding more automation controls) – programming, wiring, electrical

Question	Respondent	Response
	#5	▪ Need for: Automation knowledge, integration of disparate technologies/equipment, networking, interconnectivity
	#6	▪ Need for: Refrigeration is lacking in many HVAC programs ▪ Automation happening in commercial refrigeration; some "standardization," mainly that there are 2 main vendors (and not too many more) that own the industry ▪ Some standardization is happening in HVAC automation interfaces
	#7	▪ Need for: Computer literacy; confidence dealing with data, web portals ▪ Need for: High attention to detail ▪ Need for: Abstraction; ability to integrate complex systems
What are your top three pain points in hiring skilled workers?	#1	▪ Lack of applicants ▪ Lack of well-rounded applicants ▪ Lack of soft skills (communication, tech writing, quality mindset, punctuality)
	#2	▪ Applicants who want to do work that is both manual/physical/outdoor and technical; it takes 3-5 years to become highly skilled, which requires patience on the part of prospective technicians. ▪ Low barriers to entry in the industry leads to a proliferation of small companies and market fragmentation (in Southern California no company has > 4% market share). This in turn drives prices down and increases the number of practitioners who do lower quality work.
	#3	▪ Finding applicants ▪ "Grievous" lack of "work-ready" applicants, which leads to hiring from adjacent industry (and significant training costs) ▪ (After hiring) Retention and attrition
	#4	▪ "Large company" on-boarding causes delays in getting workers on the job; workers at smaller companies can go straight to work ▪ Availability of talent (available talent tends to be available for a reason)
	#5	▪ Lack of candidates with adequate qualifications and experience ▪ Candidates need higher education, experience, and good references ▪ Lots of competition for good candidates in the industry
	#6	▪ Desire to work – commercial refrigeration requires on-call nights and weekends ▪ Technical (refrigeration) skills – not being taught in trade schools
	#7	▪ Finding qualified applicants ▪ Work ethic; work life balance (not LIFE work) ▪ Perception of career opportunities in skilled trades; high schools do not have industrial arts programs and parents push for four-year college; in career fares, finds presenting as "environmental controls" and "energy efficiency" vs "air conditioning" to be more effective

Question	Respondent	Response
What sources of training (college, industry, specific programs, etc.) do you value based on your past experience?	#1	▪ Community College ▪ Vocational schools ▪ Vendor training ▪ Soft skills training providers
	#2	▪ In-house, almost exclusively. ▪ Do occasionally use outside curriculum, particularly vendor-specific. ▪ Some vendors have better training resources than others. ▪ Finds outside training to be too general and lacking in vendor specific information that is critical to performing the work.
	#3	▪ Internal training ▪ Values what is happening in the Community and Technical Colleges; hopes to have more emphasis on 2-yr Associates and competency certification due to sheer number of vacancies; hopeful that kind of training can fill the gap and reduce training costs. ▪ There is a perception gap on jobs working with Building Automation Systems, that they are blue collar and "middle-skilled;" they are not. They are highly skilled, well paid, and well served by Community College-like training ("Community College is the answer").
	#4	▪ Predominantly a union workforce; union training is very reliable and dependable ▪ For non-union workforce, tends to align with community college and other industry training organizations; mentioned Mt. San Antonio College (Mt. SAC) as having good training ▪ Does in-house training for safety and specific skills development
	#5	▪ Internal, OJT critical ▪ Union training tends to keep up with technology changes
	#6	▪ Primarily internal; investing in large commercial refrigeration training center ▪ Looking at incorporating Virtual Reality/Augmented Reality (VR/AR) in internal training programs ▪ Values Community College HVAC training (but needs updating), and would consider partnering – take HVAC graduates and teach them refrigeration (mentioned Mt. SAC) ▪ Any training by a candidate speaks to candidate's character – they care enough to go to school
	#7	▪ Community College ▪ Prior military technical training ▪ Apprenticeship (runs his own registered apprenticeship program) ▪ Internal modular craft training (welding, electrical, controls, refrigeration) at a purpose-built lab/lecture facility
A review of the literature supports the creation of conventional construction jobs for the expansion of renewable energy and the up-skilling of operations	#1	▪ Agrees with all the data generally; particularly singled-out more automation training (affirming automation-related occupations in the data)

Question	Respondent	Response
& maintenance jobs to support new technologies like automation; labor market intelligence largely agrees with this assessment. Do you? [If possible, validate growth and the accuracy of Emsi projections for the major occupations.]	#2	▪ Focused mainly on the magnitude of the numbers ▪ HVAC Techs seems low in comparison to other trades, both in job creation and annual openings ▪ Unsure why plumbers would be higher than HVACs
	#3	▪ Fundamentally agrees; up-skilling of conventional versus creation of new job classes ▪ Automation requires up-skilling in digitization and interconnection between systems ▪ Basic skills are still important (mechanical, electrical, etc.); up-skilling for specific technologies is needed ▪ LMI numbers look reasonable
	#4	▪ Generally agrees with the trend toward expansion and up-skilling of the conventional construction trades ▪ Sees new technology (like battery storage) adding to skills requirements of conventional occupations (like electricians)
	#6	▪ Agree ▪ Discussed problem of attrition (retirements) with insufficient younger workers coming into the industry
	#7	▪ Agree ▪ Existing jobs are morphing and keeping up with the times ▪ Automation is replacing some manufacturing jobs, but others are expanding ▪ More refurbish/retrofit construction happening than new builds ▪ HVAC numbers feel about 20-25% low, possibly due to underestimating the outflow of workers who get trained in a larger business then set themselves up as individual or small business contractors
Literature indicates a disconnect between knowledge, skills, abilities, and experience asked for in hiring ads and knowledge, skills, abilities, and experience actually hired to fill jobs; what's your position?	#1	▪ Does not see a big disconnect at his company
	#2	▪ Agrees, but sees it as a supply side disconnect; employers are asking for what they need, the supply of applicants just is not there to fill the jobs.
	#3	▪ Does not see the disconnect ▪ Problem is the supply (applicants), not the demand (postings)
	#4	▪ Not as relevant at his company; disconnects driven by supply ▪ Does a lot of union hiring
	#5	▪ Company requires higher education because employees are interacting with C-level buyers ▪ Need 8-10 years' experience (without higher degree) to be effective
	#7	▪ Yes, and the disconnect is due to supply of qualified applicants rather than over-reach on the demand side ▪ "Gray tsunami" (retirements) is impacting a key element of knowledge transfer from experienced workers to new entrants ("tribal knowledge"); some of this is even captured on YouTube; a growing issue
Literature indicates that automation (smart buildings, integrated distributed energy resources) is critical to achieving energy efficiency goals and mandates; what employment gaps related to automation knowledge, skills,	#1	▪ His company fills gaps through maintenance contracts with vendors, followed up by training (outsource and train) ▪ Depends on vendors, but desires to keep skills in house

Question	Respondent	Response
and abilities do you perceive in your business/industry? How do you expect gaps to be filled?	#2	▪ Vendor-specific equipment having to integrate with Building Automation Systems is a gap. ▪ Does not expect standardization around interfaces, interconnection (some standardization exists in commercial equipment, but it is not universal) ▪ There needs to be a technology solution for training field personnel to solve problems that would avoid a call to vendors – such calls are time-consuming and expensive for the vendors, contractors, and customers
	#3	▪ There is no industry-recognized standard certification (e.g., with ISO stamp) ▪ Troubleshooting, integration of disparate systems, digitization skills are lacking ▪ Tends to see applicants with good mechanical/electrical skills but no digital, or good digital with no mechanical/electrical; Building Automation needs both
	#4	▪ Not as relevant in his business (conventional HVAC) ▪ Automation not a core focus
	#6	▪ Automation is important in commercial refrigeration industry, but must come after a fundamental understanding of what is being automated; foundational refrigeration skills come first
	#7	▪ The gap is widening ▪ Many times, the information required to operate systems is proprietary; there is industry-common jargon, but proprietary software solutions ▪ Some standardization is occurring, e.g., BACnet and LonWorks in HVAC; NEST brought standards to thermostats from outside the industry, which may be a model for future standardization ▪ Analogy: Climate Change may eventually drive the same sort of standardization in regulation, interfaces, etc., as pollution did with automobile diagnostics.
Literature also indicates that automation may lead to an increase in demand for soft skills – interpersonal skills, ability to communicate effectively – what's your position?	#1	▪ Strongly agrees ▪ Communication happens between shifts (3 x 8 hr), between disciplines (e.g., manufacturing and engineering) ▪ His company has a lot of team-based work, with continuous improvement mindset ▪ Punctuality is important (and hard to find)
	#2	▪ Agree
	#3	▪ Strongly agrees ▪ Professionalism is a needed skill (encompassing presence, communication, punctuality, diplomacy) ▪ Lack of skilled technicians is a bottom line issue for companies; his company studies customer complaints, which were heavily skewed toward lack of technician response, punctuality, shortage of available techs. ▪ Work-life balance is difficult because of the need to work overtime and be responsive to customer needs
	#4	▪ In a service industry, soft skills are critical ▪ Does in house training on “customer focus”
	#5	▪ Huge need; have to be able to present and communicate to high-level audiences ▪ Multi-tasking (juggling multiple projects) essential

Question	Respondent	Response
	#6	▪ Very important ▪ Technicians have to know how to talk to customers and have empathy for their situation (commercial refrigeration problems always have large dollars attached with high stress on the customer side)
	#7	▪ Absolutely – technicians need to be able to explain complex systems and repairs to customers ▪ More important as labor costs rise due to scarcity of labor; customer expectations are higher ▪ Tends to segregate on personality (introverts in construction jobs, extroverts in customer-facing maintenance jobs)
The literature said that solar and wind will achieve the bulk of renewable energy goals, electrification of the transportation sector about half of the greenhouse gas reduction goals, and automation was key to energy efficiency; many construction jobs would be needed to build out the carbon-free infrastructure and its interconnection to the grid plus transportation infrastructure, and operations & maintenance jobs would need to be up-skilled to support the new technologies. Information & communications technologies would become much more important in achieving energy efficiency goals. What did the literature get wrong or miss? What didn't we ask?	#1	▪ No company opinions or plans on renewables (IDER, etc.); he thinks it's a good idea. ▪ Storage is important ▪ Found the job forecasts interesting, singled out the increase in workers with mechanical and electrical skills
	#2	▪ Speaking to HVAC industry in general, it has not adopted “digital” yet ▪ Industry needs to adopt cost effective ways to up-skill workers for digitalization that use technology and are less time consuming
	#3	▪ Microgrids, islanding, IDERS, storage are going to be important (not represented in the interview questions) ▪ Predictive and preventative maintenance can alleviate shortage of technicians ▪ Strong focus in legislation and literature on new construction, however achieving climate goals requires retrofit of existing infrastructure ▪ Reiterated up-skilling rather than creation of new job classes ▪ Community Colleges have an increasingly important role (he is encouraged by what he is seeing in the Community and Technical College sector, including recent emphasis on social equity)
	#4	▪ Literature is generally accurate ▪ While infrastructure is changing and technology is improving, his business provides a foundational piece of the infrastructure that improves, becomes more efficient over time, but fundamentally requires the same types of skills, grown over time.
	#6	▪ Commenting on new technology, automation specifically: Reinforced that a fundamental understanding of the trade (commercial refrigeration) comes before understanding automation; first have to know what to tell the computers to do.
	#7	▪ Typical HVAC systems are 50% efficient (residential is worse than commercial); much of this is not due to the equipment itself, which may have higher efficiency, but due to the system environment (ducts, etc.) in existing buildings ▪ Industry and regulation are not keeping up with this issue (high efficiency systems are tested in an ideal lab environment that does not take existing build and undersized ducting into account); payback for bringing a commercial HVAC system from 50-90% efficiency is typically 2-3 years ▪ Working on an ASHRAE standard for Bluetooth sensors to measure and present the efficiency of airflow, humidity in ducts; with those data, system efficiency can be increased through mechanical means

Appendix F: Employment Projections – All Sectors

SOC	Occupation	Employed in All Sectors (2018)	Employed in All Sectors (2019)	Employed in All Sectors (2020)	Employed in All Sectors (2021)	Employed in All Sectors (2022)	Change 2018 - 2022	% Change 2018 - 2022	AVG Annual Openings Total	AVG Annual Growth Openings	AVG Annual Replacement Openings
11-1021	General and Operations Managers	280,199	285,466	289,688	293,172	296,081	15,882	5.7%	26,950	3,970	22,979
11-3051	Industrial Production Managers	21,891	22,079	22,204	22,282	22,310	419	1.9%	1,728	105	1,623
11-3071	Transportation, Storage, and Distribution Managers	21,363	21,823	22,182	22,474	22,688	1,325	6.2%	1,989	331	1,657
11-9021	Construction Managers	66,241	67,354	68,272	69,055	69,707	3,465	5.2%	5,513	866	4,646
11-9199	Managers, All Other	262,696	268,129	272,655	276,514	278,952	16,256	6.2%	22,716	4,064	18,651
13-1161	Market Research Analysts and Marketing Specialists	120,101	123,770	126,824	129,452	131,633	11,532	9.6%	14,762	2,883	11,879
13-1199	Business Operations Specialists, All Other	171,496	174,126	176,228	177,983	179,372	7,876	4.6%	17,542	1,969	15,573
13-2011	Accountants and Auditors	217,297	220,497	223,127	225,346	227,149	9,852	4.5%	21,765	2,463	19,302
15-1121	Computer Systems Analysts	87,125	89,176	90,812	92,154	93,276	6,151	7.1%	7,239	1,538	5,702
15-1122	Information Security Analysts	9,960	10,452	10,884	11,268	11,610	1,650	16.6%	1,117	413	704
15-1133	Software Developers, Systems Software	89,674	91,596	93,067	94,239	95,202	5,527	6.2%	7,211	1,382	5,829
15-1142	Network and Computer Systems Administrators	45,032	45,943	46,668	47,265	47,768	2,737	6.1%	3,536	684	2,852
15-1143	Computer Network Architects	18,712	19,149	19,502	19,795	20,045	1,333	7.1%	1,570	333	1,236
15-1199	Computer Occupations, All Other	57,782	58,978	59,929	60,718	61,372	3,590	6.2%	4,825	898	3,928
17-1021	Cartographers and Photogrammetrists	1,783	1,826	1,864	1,899	1,929	146	8.2%	168	37	131
17-2051	Civil Engineers	50,872	51,605	52,222	52,757	53,227	2,354	4.6%	4,309	589	3,720
17-2071	Electrical Engineers	27,241	27,615	27,918	28,170	28,372	1,132	4.2%	2,064	283	1,781
17-2072	Electronics Engineers, Except Computer	31,223	31,259	31,243	31,206	31,153	-70	-0.2%	2,079	-17	2,096
17-2081	Environmental Engineers	8,453	8,539	8,604	8,657	8,700	247	2.9%	623	62	561
17-2112	Industrial Engineers	25,525	25,981	26,357	26,667	26,924	1,399	5.5%	2,051	350	1,701
17-2141	Mechanical Engineers	28,677	29,123	29,492	29,793	30,040	1,363	4.8%	2,192	341	1,851

SOC	Occupation	Employed in All Sectors (2018)	Employed in All Sectors (2019)	Employed in All Sectors (2020)	Employed in All Sectors (2021)	Employed in All Sectors (2022)	Change 2018 - 2022	% Change 2018 - 2022	AVG Annual Openings Total	AVG Annual Growth Openings	AVG Annual Replacement Openings
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	524	538	549	558	567	43	8.2%	51	11	41
17-2171	Petroleum Engineers	2,521	2,516	2,509	2,500	2,492	-29	-1.1%	181	-7	188
17-2199	Engineers, All Other	25,491	25,738	25,923	26,070	26,179	688	2.7%	1,833	172	1,661
17-3011	Architectural and Civil Drafters	18,694	18,972	19,196	19,383	19,536	842	4.5%	1,820	211	1,610
17-3012	Electrical and Electronics Drafters	4,844	4,906	4,954	4,994	5,024	180	3.7%	462	45	417
17-3013	Mechanical Drafters	5,313	5,411	5,491	5,558	5,610	297	5.6%	538	74	464
17-3023	Electrical and Electronics Engineering Technicians	24,715	24,818	24,871	24,897	24,898	183	0.7%	2,226	46	2,180
17-3029	Engineering Technicians, Except Drafters, All Other	11,411	11,515	11,593	11,653	11,699	288	2.5%	1,067	72	995
19-4041	Geological and Petroleum Technicians	1,746	1,743	1,737	1,730	1,723	-23	-1.3%	187	-6	193
41-3099	Sales Representatives, Services, All Other	164,891	168,195	170,884	173,147	175,007	10,116	6.1%	22,515	2,529	19,986
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	50,757	51,246	51,587	51,832	52,005	1,248	2.5%	5,588	312	5,276
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	179,662	180,019	180,179	180,193	180,109	447	0.2%	18,980	112	18,868
43-4051	Customer Service Representatives	238,517	243,221	247,048	250,178	252,616	14,099	5.9%	34,365	3,525	30,840
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	77,278	78,659	79,787	80,734	81,627	4,349	5.6%	8,882	1,087	7,795
47-2111	Electricians	81,242	83,383	85,146	86,647	87,892	6,649	8.2%	10,891	1,662	9,229
47-2152	Plumbers, Pipefitters, and Steamfitters	61,490	63,379	64,948	66,291	67,435	5,945	9.7%	8,119	1,486	6,633
47-2231	Solar Photovoltaic Installers	4,736	5,246	5,711	6,142	6,535	1,798	38.0%	1,017	450	568

SOC	Occupation	Employed in All Sectors (2018)	Employed in All Sectors (2019)	Employed in All Sectors (2020)	Employed in All Sectors (2021)	Employed in All Sectors (2022)	Change 2018 - 2022	% Change 2018 - 2022	AVG Annual Openings Total	AVG Annual Growth Openings	AVG Annual Replacement Openings
47-4098	Miscellaneous Construction and Related Workers	4,036	4,143	4,233	4,311	4,374	338	8.4%	524	85	439
47-5011	Derrick Operators, Oil and Gas	672	688	701	712	720	48	7.1%	95	12	83
47-5012	Rotary Drill Operators, Oil and Gas	1,296	1,322	1,343	1,363	1,377	81	6.3%	180	20	160
47-5013	Service Unit Operators, Oil, Gas, and Mining	2,941	3,006	3,062	3,112	3,144	203	6.9%	427	51	376
47-5071	Roustabouts, Oil and Gas	2,493	2,580	2,657	2,727	2,778	285	11.4%	390	71	319
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	45,250	46,210	47,011	47,688	48,231	2,982	6.6%	4,663	745	3,918
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	7,377	7,425	7,459	7,482	7,497	120	1.6%	685	30	655
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	2,787	2,803	2,814	2,821	2,828	41	1.5%	262	10	252
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	3,716	3,754	3,788	3,814	3,833	117	3.1%	328	29	299
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	34,468	35,582	36,513	37,314	38,000	3,532	10.2%	4,315	883	3,431
49-9041	Industrial Machinery Mechanics	30,670	31,128	31,495	31,788	32,014	1,344	4.4%	3,031	336	2,695
49-9051	Electrical Power-Line Installers and Repairers	7,834	8,111	8,344	8,543	8,715	881	11.2%	875	220	655
49-9052	Telecommunications Line Installers and Repairers	14,912	14,983	15,034	15,076	15,110	198	1.3%	1,579	49	1,530
49-9071	Maintenance and Repair Workers, General	156,364	159,572	162,198	164,388	166,166	9,802	6.3%	17,882	2,450	15,431
49-9081	Wind Turbine Service Technicians	1,256	1,347	1,430	1,507	1,575	320	25.5%	216	80	136
49-9099	Installation, Maintenance, and Repair Workers, All Other	40,167	40,615	40,978	41,284	41,504	1,337	3.3%	4,175	334	3,840

SOC	Occupation	Employed in All Sectors (2018)	Employed in All Sectors (2019)	Employed in All Sectors (2020)	Employed in All Sectors (2021)	Employed in All Sectors (2022)	Change 2018 - 2022	% Change 2018 - 2022	AVG Annual Openings Total	AVG Annual Growth Openings	AVG Annual Replacement Openings
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	36,636	36,094	35,515	34,908	34,284	-2,352	-6.4%	4,201	-588	4,789
51-8012	Power Distributors and Dispatchers	1,725	1,747	1,760	1,770	1,776	52	3.0%	176	13	163
51-8013	Power Plant Operators	3,394	3,454	3,504	3,548	3,592	198	5.8%	382	49	332
51-8021	Stationary Engineers and Boiler Operators	3,950	3,985	4,012	4,033	4,050	101	2.5%	440	25	415
51-8092	Gas Plant Operators	1,240	1,232	1,226	1,220	1,213	-27	-2.2%	139	-7	146
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	4,590	4,545	4,503	4,460	4,419	-171	-3.7%	470	-43	513
51-8099	Plant and System Operators, All Other	1,641	1,644	1,645	1,644	1,643	1	0.1%	168	0	167
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	64,735	64,541	64,265	63,928	63,511	-1,225	-1.9%	7,915	-306	8,221
53-7071	Gas Compressor and Gas Pumping Station Operators	1,176	1,128	1,085	1,046	1,016	-161	-13.7%	137	-40	177
53-7072	Pump Operators, Except Wellhead Pumpers	2,533	2,547	2,552	2,551	2,549	16	0.6%	323	4	319
53-7073	Wellhead Pumpers	6,974	7,164	7,331	7,480	7,571	597	8.6%	1,021	149	872
TOTAL		3,082,010	3,135,340	3,178,311	3,213,889	3,241,955	159,945	5.2%	325,663	39,986	285,677

Source: Emsi

Appendix G: Job Posting Data

SOC	Occupation	Unique Postings from Jun 2018 - May 2019	AVG Monthly Active Posting Jun 2018 - Aug 2018	AVG Monthly Active Posting Sep 2018 - Nov 2018	AVG Monthly Active Posting Dec 2018 - Feb 2019	AVG Monthly Active Posting Mar 2019 - May 2019	% Change (Jun 2018 - May 2019)
15-1199	Computer Occupations, All Other	120,746	21,117	25,172	26,440	27,333	32%
43-4051	Customer Service Representatives	120,220	21,563	24,886	25,034	26,393	27%
13-2011	Accountants and Auditors	89,395	15,186	18,098	18,952	19,262	32%
11-9199	Managers, All Other	61,985	11,542	12,567	13,215	15,075	40%
11-1021	General and Operations Managers	59,436	12,050	13,245	13,095	13,965	21%
15-1121	Computer Systems Analysts	58,940	9,972	11,510	11,891	13,052	37%
17-2112	Industrial Engineers	58,897	11,280	13,164	13,598	14,416	31%
15-1142	Network and Computer Systems Administrators	57,307	9,899	11,210	12,485	12,768	32%
41-3099	Sales Representatives, Services, All Other	56,542	10,202	11,770	12,490	12,661	24%
49-9071	Maintenance and Repair Workers, General	53,671	10,484	11,608	11,973	12,399	24%
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	53,661	9,708	10,282	11,151	11,511	16%
13-1161	Market Research Analysts and Marketing Specialists	49,507	9,365	10,237	10,494	11,593	24%
13-1199	Business Operations Specialists, All Other	36,376	6,375	7,147	7,218	8,032	26%
15-1133	Software Developers, Systems Software	34,439	6,298	7,964	9,023	8,258	36%
17-2141	Mechanical Engineers	32,929	6,192	7,402	7,969	8,051	35%
15-1122	Information Security Analysts	32,906	5,838	6,981	7,590	7,590	31%
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	32,573	5,774	6,746	7,529	7,955	37%
17-2071	Electrical Engineers	26,033	4,910	5,894	6,184	6,819	44%
11-9021	Construction Managers	25,281	5,190	5,847	5,612	5,692	14%
17-2051	Civil Engineers	21,598	3,889	4,849	5,155	5,303	43%
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	21,214	4,070	4,579	4,558	4,845	23%
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	14,964	3,048	2,864	2,622	2,773	22%
17-2072	Electronics Engineers, Except Computer	14,265	2,754	3,352	3,577	3,604	38%
11-3051	Industrial Production Managers	12,312	2,526	2,807	2,827	3,176	37%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	11,980	2,328	2,406	2,512	2,354	5%

SOC	Occupation	Unique Postings from Jun 2018 - May 2019	AVG Monthly Active Posting Jun 2018 - Aug 2018	AVG Monthly Active Posting Sep 2018 - Nov 2018	AVG Monthly Active Posting Dec 2018 - Feb 2019	AVG Monthly Active Posting Mar 2019 - May 2019	% Change (Jun 2018 - May 2019)
47-2111	Electricians	9,285	1,894	2,046	1,781	1,747	2%
17-3023	Electrical and Electronics Engineering Technicians	8,891	1,797	1,988	2,009	2,137	21%
11-3071	Transportation, Storage, and Distribution Managers	7,146	1,382	1,440	1,368	1,565	16%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	6,107	1,293	1,306	1,261	1,475	21%
49-9041	Industrial Machinery Mechanics	5,854	1,239	1,321	1,251	1,263	2%
17-2081	Environmental Engineers	4,688	922	1,007	1,070	1,245	33%
47-2152	Plumbers, Pipefitters, and Steamfitters	4,363	840	931	873	807	12%
17-2199	Engineers, All Other	4,362	775	959	998	1,069	38%
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	4,144	755	863	847	882	28%
15-1143	Computer Network Architects	4,082	751	852	832	868	21%
17-3011	Architectural and Civil Drafters	3,619	673	716	715	827	22%
17-3013	Mechanical Drafters	1,509	297	295	302	335	11%
17-3029	Engineering Technicians, Except Drafters, All Other	1,455	275	300	308	335	42%
47-2231	Solar Photovoltaic Installers	903	170	198	167	158	(5%)
49-9052	Telecommunications Line Installers and Repairers	720	151	117	119	123	(48%)
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	634	117	150	139	146	25%
51-8021	Stationary Engineers and Boiler Operators	541	84	103	137	161	67%
49-9099	Installation, Maintenance, and Repair Workers, All Other	502	93	101	100	108	5%
17-2171	Petroleum Engineers	471	85	112	97	116	16%
17-3012	Electrical and Electronics Drafters	361	68	67	68	84	21%
49-9051	Electrical Power-Line Installers and Repairers	321	87	96	93	92	10%
49-9081	Wind Turbine Service Technicians	319	74	93	63	62	(19%)
47-5013	Service Unit Operators, Oil, Gas, and Mining	263	70	66	48	58	(19%)
51-8013	Power Plant Operators	202	34	40	42	43	45%
19-4041	Geological and Petroleum Technicians	189	41	40	33	50	13%
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	153	25	37	37	37	71%

SOC	Occupation	Unique Postings from Jun 2018 - May 2019	AVG Monthly Active Posting Jun 2018 - Aug 2018	AVG Monthly Active Posting Sep 2018 - Nov 2018	AVG Monthly Active Posting Dec 2018 - Feb 2019	AVG Monthly Active Posting Mar 2019 - May 2019	% Change (Jun 2018 - May 2019)
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	113	18	20	34	27	56%
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	96	20	19	15	15	(42%)
47-5071	Roustabouts, Oil and Gas	78	14	18	17	25	41%
47-4098	Miscellaneous Construction and Related Workers	75	10	21	13	14	44%
51-8012	Power Distributors and Dispatchers	69	17	23	14	12	(7%)
47-5012	Rotary Drill Operators, Oil and Gas	68	22	21	16	16	(19%)
17-1021	Cartographers and Photogrammetrists	49	5	8	8	9	43%
51-8092	Gas Plant Operators	43	6	3	17	6	(17%)
51-8099	Plant and System Operators, All Other	38	8	9	8	9	71%
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	31	3	4	7	8	0%
53-7071	Gas Compressor and Gas Pumping Station Operators	2	0	1	0	0	0%
53-7072	Pump Operators, Except Wellhead Pumpers	2	0	1	0	0	0%
47-5011	Derrick Operators, Oil and Gas	1	0	0	0	0	0%
53-7073	Wellhead Pumpers	0	0	0	0	0	0%

Source: Emsi

Appendix H: Hires Data

SOC	Occupation	2016 Average Monthly Hires	2017 Average Monthly Hires	2018 Average Monthly Hires	2019 Average Monthly Hires	Percent Change 2016 - 2019
11-1021	General and Operations Managers	14,161	14,397	14,690	14,998	6%
43-4051	Customer Service Representatives	11,662	11,659	11,928	12,170	4%
13-2011	Accountants and Auditors	10,110	9,953	10,229	10,392	3%
41-3099	Sales Representatives, Services, All Other	7,871	8,308	8,480	8,649	10%
13-1199	Business Operations Specialists, All Other	6,708	7,143	7,226	7,337	9%
49-9071	Maintenance and Repair Workers, General	6,873	6,930	7,114	7,280	6%
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	6,787	6,742	6,564	6,597	-3%
13-1161	Market Research Analysts and Marketing Specialists	4,330	4,687	4,821	4,966	15%
47-2111	Electricians	4,132	4,325	4,456	4,580	11%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	3,721	3,847	4,057	4,183	12%
47-2152	Plumbers, Pipefitters, and Steamfitters	3,014	3,103	3,221	3,337	11%
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	2,955	3,158	3,169	3,181	8%
15-1121	Computer Systems Analysts	2,949	3,009	3,090	3,175	8%
15-1133	Software Developers, Systems Software	3,017	3,000	3,065	3,145	4%
11-9199	Managers, All Other	2,389	2,600	2,639	2,677	12%
11-9021	Construction Managers	2,201	2,363	2,474	2,544	16%
15-1199	Computer Occupations, All Other	1,838	2,153	2,191	2,240	22%
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	1,932	1,953	1,997	2,040	6%
15-1142	Network and Computer Systems Administrators	1,864	1,852	1,892	1,936	4%
17-2051	Civil Engineers	1,633	1,723	1,771	1,804	10%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	1,584	1,618	1,682	1,749	10%
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	1,660	1,662	1,627	1,645	-1%
49-9099	Installation, Maintenance, and Repair Workers, All Other	1,187	1,239	1,253	1,273	7%
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	1,287	1,227	1,238	1,233	-4%
49-9041	Industrial Machinery Mechanics	1,133	1,172	1,191	1,214	7%
17-2141	Mechanical Engineers	926	980	1,018	1,040	12%
17-2072	Electronics Engineers, Except Computer	934	966	973	978	5%

SOC	Occupation	2016 Average Monthly Hires	2017 Average Monthly Hires	2018 Average Monthly Hires	2019 Average Monthly Hires	Percent Change 2016 - 2019
11-3071	Transportation, Storage, and Distribution Managers	819	881	900	922	13%
17-2112	Industrial Engineers	768	813	847	869	13%
17-2071	Electrical Engineers	784	783	804	818	4%
15-1143	Computer Network Architects	727	756	776	798	10%
17-2199	Engineers, All Other	693	719	733	744	7%
17-3023	Electrical and Electronics Engineering Technicians	732	715	724	731	0%
11-3051	Industrial Production Managers	669	701	712	720	8%
17-3011	Architectural and Civil Drafters	649	649	667	679	5%
49-9052	Telecommunications Line Installers and Repairers	618	635	642	653	6%
15-1122	Information Security Analysts	381	433	455	476	25%
17-3029	Engineering Technicians, Except Drafters, All Other	448	430	438	444	-1%
49-9051	Electrical Power-Line Installers and Repairers	351	334	356	372	6%
17-2081	Environmental Engineers	324	334	341	345	6%
47-2231	Solar Photovoltaic Installers	245	258	290	321	31%
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	273	257	260	263	-4%
17-3013	Mechanical Drafters	201	196	204	210	5%
47-4098	Miscellaneous Construction and Related Workers	197	186	196	203	3%
17-3012	Electrical and Electronics Drafters	173	175	178	182	5%
51-8021	Stationary Engineers and Boiler Operators	127	132	132	134	5%
47-5071	Roustabouts, Oil and Gas	146	123	130	133	-9%
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	97	99	102	104	7%
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	105	105	104	103	-2%
47-5013	Service Unit Operators, Oil, Gas, and Mining	79	94	98	99	26%
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	83	94	95	96	16%
51-8013	Power Plant Operators	79	79	78	79	0%
17-2171	Petroleum Engineers	70	75	78	79	13%
53-7072	Pump Operators, Except Wellhead Pumpers	61	71	73	74	21%
51-8099	Plant and System Operators, All Other	65	68	68	68	6%
19-4041	Geological and Petroleum Technicians	53	63	64	65	21%

SOC	Occupation	2016 Average Monthly Hires	2017 Average Monthly Hires	2018 Average Monthly Hires	2019 Average Monthly Hires	Percent Change 2016 - 2019
47-5012	Rotary Drill Operators, Oil and Gas	61	60	61	62	2%
17-1021	Cartographers and Photogrammetrists	55	53	55	57	3%
49-9081	Wind Turbine Service Technicians	47	43	46	50	8%
51-8012	Power Distributors and Dispatchers	31	35	35	35	14%
47-5011	Derrick Operators, Oil and Gas	31	32	32	33	5%
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	21	18	19	19	-8%
53-7071	Gas Compressor and Gas Pumping Station Operators	16	19	19	19	18%
51-8092	Gas Plant Operators	20	17	17	17	-11%
53-7073	Wellhead Pumpers	6	5	5	5	-23%

Source: Emsi

Appendix I: Gap Analysis

SOC	Occupation	Avg. Annual Openings Energy (Demand)	Avg. Annual Openings Non-Energy (Demand)	Avg. Annual Openings All-Sectors (Total Demand)	Avg. Annual Completions	Gap	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
11-1021	General and Operations Managers	392	26,558	26,950	56,582	29,632	Bachelor's degree	5 years or more	None
11-3051	Industrial Production Managers	24	1,704	1,728	53,191	51,463	Bachelor's degree	5 years or more	None
11-3071	Transportation, Storage, and Distribution Managers	12	1,976	1,989	55,932	53,943	High school diploma or equivalent	5 years or more	None
11-9021	Construction Managers	134	5,379	5,513	53,596	48,084	Bachelor's degree	None	Moderate-term on-the-job training
11-9199	Managers, All Other	638	22,077	22,716	63,238	40,522	Bachelor's degree	Less than 5 years	None
13-1161	Market Research Analysts and Marketing Specialists	73	14,689	14,762	1,116	(13,646)	Bachelor's degree	None	None
13-1199	Business Operations Specialists, All Other	178	17,364	17,542	678	(16,864)	Bachelor's degree	None	None
13-2011	Accountants and Auditors	319	21,446	21,765	3,764	(18,001)	Bachelor's degree	None	None
15-1121	Computer Systems Analysts	42	7,197	7,239	3,406	(3,834)	Bachelor's degree	None	None
15-1122	Information Security Analysts	7	1,110	1,117	14,789	13,672	Bachelor's degree	Less than 5 years	None
15-1133	Software Developers, Systems Software	11	7,199	7,211	11,686	4,476	Bachelor's degree	None	None
15-1142	Network and Computer Systems Administrators	39	3,497	3,536	1,415	(2,122)	Bachelor's degree	None	None
15-1143	Computer Network Architects	11	1,558	1,570	14,789	13,219	Bachelor's degree	5 years or more	None
15-1199	Computer Occupations, All Other	21	4,804	4,825	7,890	3,065	Bachelor's degree	None	None
17-1021	Cartographers and Photogrammetrists	16	151	168	210	42	Bachelor's degree	None	None
17-2051	Civil Engineers	46	4,263	4,309	2,713	(1,595)	Bachelor's degree	None	None

SOC	Occupation	Avg. Annual Openings Energy (Demand)	Avg. Annual Openings Non-Energy (Demand)	Avg. Annual Openings All-Sectors (Total Demand)	Avg. Annual Completions	Gap	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
17-2071	Electrical Engineers	160	1,903	2,064	4,571	2,507	Bachelor's degree	None	None
17-2072	Electronics Engineers, Except Computer	9	2,070	2,079	4,693	2,614	Bachelor's degree	None	None
17-2081	Environmental Engineers	6	617	623	354	(269)	Bachelor's degree	None	None
17-2112	Industrial Engineers	25	2,026	2,051	560	(1,491)	Bachelor's degree	None	None
17-2141	Mechanical Engineers	27	2,165	2,192	4,140	1,948	Bachelor's degree	None	None
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	3	48	51	0	(51)	Bachelor's degree	None	None
17-2171	Petroleum Engineers	13	168	181	95	(86)	Bachelor's degree	None	None
17-2199	Engineers, All Other	30	1,804	1,833	2,089	255	Bachelor's degree	None	None
17-3011	Architectural and Civil Drafters	12	1,809	1,820	1,331	(489)	Associate's degree	None	None
17-3012	Electrical and Electronics Drafters	12	449	462	21	(441)	Associate's degree	None	None
17-3013	Mechanical Drafters	5	533	538	122	(416)	Associate's degree	None	None
17-3023	Electrical and Electronics Engineering Technicians	53	2,173	2,226	953	(1,273)	Associate's degree	None	None
17-3029	Engineering Technicians, Except Drafters, All Other	24	1,044	1,067	406	(661)	Associate's degree	None	None
19-4041	Geological and Petroleum Technicians	22	165	187	3	(184)	Associate's degree	None	Moderate-term on-the-job training
41-3099	Sales Representatives, Services, All Other	166	22,348	22,515	783	(21,732)	High school diploma or equivalent	None	Moderate-term on-the-job training
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	20	5,568	5,588	716	(4,872)	Bachelor's degree	None	Moderate-term on-the-job training
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	182	18,798	18,980	1,916	(17,064)	High school diploma or equivalent	None	Moderate-term on-the-job training

SOC	Occupation	Avg. Annual Openings Energy (Demand)	Avg. Annual Openings Non-Energy (Demand)	Avg. Annual Openings All-Sectors (Total Demand)	Avg. Annual Completions	Gap	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
43-4051	Customer Service Representatives	393	33,972	34,365	16	(34,350)	High school diploma or equivalent	None	Short-term on-the-job training
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	456	8,427	8,882	2,618	(6,265)	High school diploma or equivalent	5 years or more	None
47-2111	Electricians	284	10,607	10,891	2,338	(8,553)	High school diploma or equivalent	None	Apprenticeship
47-2152	Plumbers, Pipefitters, and Steamfitters	227	7,892	8,119	680	(7,439)	High school diploma or equivalent	None	Apprenticeship
47-2231	Solar Photovoltaic Installers	23	994	1,017	58	(960)	High school diploma or equivalent	None	Moderate-term on-the-job training
47-4098	Miscellaneous Construction and Related Workers	16	508	524	187	(337)	High school diploma or equivalent	None	Moderate-term on-the-job training
47-5011	Derrick Operators, Oil and Gas	83	12	95	0	(95)	No formal educational credential	None	Short-term on-the-job training
47-5012	Rotary Drill Operators, Oil and Gas	139	41	180	0	(180)	No formal educational credential	None	Moderate-term on-the-job training
47-5013	Service Unit Operators, Oil, Gas, and Mining	307	120	427	0	(427)	No formal educational credential	None	Moderate-term on-the-job training
47-5071	Roustabouts, Oil and Gas	224	166	390	0	(390)	No formal educational credential	None	Moderate-term on-the-job training
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	175	4,488	4,663	61	(4,603)	High school diploma or equivalent	Less than 5 years	None
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	21	664	685	597	(88)	Postsecondary nondegree award	None	Long-term on-the-job training
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	80	181	262	1,678	1,417	Postsecondary nondegree award	Less than 5 years	Moderate-term on-the-job training
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	152	176	328	125	(203)	High school diploma or equivalent	None	Moderate-term on-the-job training

SOC	Occupation	Avg. Annual Openings Energy (Demand)	Avg. Annual Openings Non-Energy (Demand)	Avg. Annual Openings All-Sectors (Total Demand)	Avg. Annual Completions	Gap	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	26	4,288	4,315	1,824	(2,491)	Postsecondary nondegree award	None	Long-term on-the-job training
49-9041	Industrial Machinery Mechanics	116	2,915	3,031	125	(2,906)	High school diploma or equivalent	None	Long-term on-the-job training
49-9051	Electrical Power-Line Installers and Repairers	569	306	875	305	(570)	High school diploma or equivalent	None	Long-term on-the-job training
49-9052	Telecommunications Line Installers and Repairers	296	1,283	1,579	204	(1,375)	High school diploma or equivalent	None	Long-term on-the-job training
49-9071	Maintenance and Repair Workers, General	77	17,804	17,882	0	(17,882)	High school diploma or equivalent	None	Moderate-term on-the-job training
49-9081	Wind Turbine Service Technicians	124	92	216	229	14	Postsecondary nondegree award	None	Long-term on-the-job training
49-9099	Installation, Maintenance, and Repair Workers, All Other	45	4,130	4,175	1,037	(3,138)	High school diploma or equivalent	None	Moderate-term on-the-job training
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	35	4,166	4,201	227	(3,975)	High school diploma or equivalent	None	Moderate-term on-the-job training
51-8012	Power Distributors and Dispatchers	101	75	176	61	(116)	High school diploma or equivalent	None	Long-term on-the-job training
51-8013	Power Plant Operators	227	155	382	61	(321)	High school diploma or equivalent	None	Long-term on-the-job training
51-8021	Stationary Engineers and Boiler Operators	8	432	440	4,410	3,970	High school diploma or equivalent	None	Long-term on-the-job training
51-8092	Gas Plant Operators	94	46	139	88	(52)	High school diploma or equivalent	None	Long-term on-the-job training
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	77	393	470	64	(407)	High school diploma or equivalent	None	Moderate-term on-the-job training
51-8099	Plant and System Operators, All Other	11	157	168	61	(107)	High school diploma or equivalent	None	Moderate-term on-the-job training

SOC	Occupation	Avg. Annual Openings Energy (Demand)	Avg. Annual Openings Non-Energy (Demand)	Avg. Annual Openings All-Sectors (Total Demand)	Avg. Annual Completions	Gap	Typical Entry Level Education	Work Experience Required	Typical On-The-Job Training
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	140	7,774	7,915	61	(7,854)	High school diploma or equivalent	None	Moderate-term on-the-job training
53-7071	Gas Compressor and Gas Pumping Station Operators	42	95	137	0	(137)	High school diploma or equivalent	None	Moderate-term on-the-job training
53-7072	Pump Operators, Except Wellhead Pumpers	128	194	323	0	(323)	High school diploma or equivalent	None	Moderate-term on-the-job training
53-7073	Wellhead Pumpers	1,005	16	1,021	0	(1,021)	High school diploma or equivalent	Less than 5 years	Moderate-term on-the-job training
TOTAL		**8,434**	**317,229**	**325,663**	**384,854**	**59,191**			

Note: Average annual completions for 1) electricians, 2) plumbers, pipefitters, and steamfitters, 3) HVAC, 4) telecommunication line installers and repairers, and 5) electrical power-line installers and repairers include Emsi reported completions and apprenticeships completions in 2017. All other average annual completions include Emsi reported completions and do not include any apprenticeship completions.
Source: Emsi, California Department of Industrial Relations/Division of Apprenticeship Standards, and ICF