C·O·E

CENTERS OF EXCELLENCE

Inform Connect Advance

INDUSTRIAL MAINTENANCE MECHANICS WORKFORCE NEEDS ASSESSMENT: SURVEY RESULTS FROM NORTHERN CALIFORNIA EMPLOYERS

June 2018

Prepared by:
California Community Colleges, Economic and Workforce Development
Aaron Wilcher, Director, North/Far North Region COE, Los Rios Community College District
John Carrese, Director, Bay Region COE, City College of San Francisco
Nora Seronello, Director, Central Valley/Mother Lode Region COE, Modesto Junior College

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Industrial maintenance mechanics and repair technicians apply an array of skills across a variety of businesses, on wide ranging equipment and machinery. They have job titles as diverse as Operations Manager, Cellar Worker, Production Technician, Mechatronics Technician, Machinist, and Plant Mechanic. They repair engines, electric motors, hydraulics, winemaking equipment, conveyors, and pumps. They perform testing and predictive maintenance, welding, and machining. These technicians are jacks of all trades.

These are high-road jobs. Most maintenance and repair work is done by full-time employees. The positions pay middle-income wages, and technicians tend to hang around once they are hired. Retention is not a problem for employers.

Training qualified, competent technicians would present any training provider with the challenge of the diversity of needed skills and equipment knowledge. Added to that, the arrival of state-of-the-art advanced manufacturing and distribution facilities, like Tesla and Amazon, in a number of California's regions presents additional challenges to workforce education and training providers. Career education (CE) programs in industrial electronics and industrial maintenance mechanics, for example, currently supply the state's manufacturing and industrial employers with trained technicians. Combined with other, more specialized programs in mechanical and electrical technology, mechatronics, and manufacturing technology, these programs have the potential to supply the next generation of manufacturing and industrial middle-skill technicians to keep facilities operating at full capacity.

But what, exactly, has been the effect of the arrival of high-tech automated facilities on technicians? Can these workers' diverse skillsets be applied to a digitalizing shop floor? Are new and emerging skills needed? Or, should workforce training and education providers be focused on opportunities through legacy facilities (i.e., small businesses) for technicians?

To better understand the technological and industrial trends that are impacting maintenance and repair technicians in Northern California's manufacturing, industrial, and logistics facilities, the Centers of Excellence for Labor Market Research (COE) conducted a survey of 86 businesses across Northern California to gather information directly from employers who hire maintenance and repair technicians. A focus group of employers in the Central Valley provided background information for the survey design.

The study sought to determine current and future labor market demand for maintenance and repair technicians, as well as preferences for skills, knowledge, abilities, credentials, and education levels that employers find most valuable.

What emerges from this study are findings not only about current maintenance and repair technician needs, but also employer needs for a technical workforce across an array of industrial, manufacturing, and distribution facility operations.

The main research findings include the following:

Demand projections for industrial maintenance and repair technicians are strong.
The employer survey found that demand for maintenance and repair technicians could be as high as 26 percent. However, other occupational projections suggest that the survey projection growth rate could be too high; economic data puts the growth projection at 7 percent. Still, 50 percent of employers surveyed said they would add to their technician workforce in the next two years. More than 80 percent of those surveyed said they have at least some difficulty hiring qualified maintenance and repair workers.

Comparing education and training awards to projected annual openings indicates an opportunity for the colleges to provide additional trained technicians.
Analysis of projections data shows there could be as many as 1,500 annual openings for maintenance and repair technicians in the three Northern California regions studied. The research shows the community colleges confer 385 awards on average each year. (The figure merits context, since the research suggests there are other sources for hiring besides formal education and training organizations.) Nonetheless, when added to other factors expressed by employers in the survey, such as the need for experience, the demand data indicates a broad need for adding trained technicians to the labor market.

Employers prefer experience over credentials or education level.

The most common reason employers have difficulty finding qualified candidates is that they lack skills and experience. The wage premium for workers with just three years of experience is dramatic, at least $7 per hour above the entry-level wage, the survey indicates. Open-ended questions about preferred or required skills, knowledge, and abilities suggests that more than anything else, employers want technicians with experience. "Trade credentials" and welding credentials were cited as preferred or required credentials by a minority of employers surveyed. Other employers said much of the training employees receive occurs informally inside the facility.

Employers use staff and third parties to perform maintenance and repair work, but the work is done mostly by full-time employees with an assortment of duties.

Full-time employees perform the majority of maintenance and repair work in the facilities surveyed. Some larger employers (those with more than 50 employees) said that perhaps a fifth of the maintenance and repair workforce is part-time. Most employers surveyed use a variety of methods to maintain equipment and machinery. These methods include the manufacturer of the machinery or equipment, and third-party service providers. Overall, the survey reveals that employees, especially employees performing a range of duties, do the bulk of the maintenance and repair work.

Breadth of skills, knowledge, and abilities matters.

Technicians most often perform a range of duties besides maintenance and repair. Several survey responses indicate that many technicians who repair equipment are performing a variety of duties and tasks, including machining, welding, electrical, and other operations and production activities. This suggests that employers prefer workers with a broad range of skills and abilities over workers with a narrow set of skills. Still, about 40 percent of respondents said they have employees whose sole duty is maintenance and repair of equipment and machinery, even when they use other employees and third parties to repair and maintain equipment.

The survey results reveal these are high-road jobs: Wages start low, but rise quickly to exceed living wages; however, wages pose a potential concern in the Bay Area.

The survey indicates that starting, entry-level wages are between $12 per hour and $18 per hour, but they rise quickly. With more than three years of experience, maintenance and repair technicians earn between $7 per hour and $8 per hour above their starting wage. Some experienced technicians can earn up to $30 per hour. A minority, perhaps 20 percent of experienced technicians, earn $30–$40 per hour. A few employers from the Bay Area indicated that the cost of living posed challenges for recruitment and retention of technicians. Otherwise, retention largely was not listed as a major challenge for employers. These appear to be high-road jobs: Once workers enter employment, their wages rise quickly, and they stay with the company.

Employers expressed a preference for staple and traditional skills. Skills associated with state-of-the art automation technology and equipment did not dominate the results.

Employer responses to open-ended questions about equipment, machinery, and skills reveal that employers need workers who can service a variety of traditional equipment using traditional, staple technical skills, such as electronics, hydraulics, and pneumatics. Specific questions that asked employers to rate a range of computerized, digital, and automated equipment and skills did not indicate a widespread need for these skills. In a few cases, about a third of employers expressed preferences ("prefer to have") for some skills and equipment involving digital, automated controls and equipment. Few employers said these skills were a "must have." This could mean that many or most employers have not made large-scale investments into complex, automated equipment and machinery that use remote sensing and centralized, digital controls, or robotics. A handful of responses about technology and skills suggest that some employers have hybrid systems combining digital and legacy equipment. Predictive maintenance, for example, emerges in the survey as a potential area for skills training. The list of equipment, machinery, skills, and knowledge compiled for the survey merits tracking in the future to measure employers' adoption of new and emerging technology.

INTRODUCTION

There is no shortage of reporting about innovations and disruptions in manufacturing, distribution, and industrial facilities. It is widely accepted that to be competitive in a global economy, companies must adopt new digital and automated equipment and operations to meet shifting and specialized consumer and client demands.

Manufacturing and industrial facilities are compelled to transition to a higher level of automation, but in many cases have not yet done so.

Cloud computing, internet of things (IoT), and big data analytics at the transaction level are increasingly assimilated with remote sensors and integrated, digital equipment, and rapidly sped-up production and distribution systems in the warehouse and on the shop floor.[1] The most competitive companies have adopted these technologies and quickly pivot to produce and distribute products worldwide.[2]

But many manufacturing and industrial employers are small businesses that have not made investments in automated, digitized equipment and machinery. A 2017 McKinsey Global Institute report on manufacturing notes that amid these global technological shifts, U.S. manufacturers have been slow to respond.[3] While vehicles and electronics product manufacturing is highly digital and automated, a number of industries, including food processing and metals, do not possess high levels of robotics, digitalization, and automation. The report suggests that the U.S. overall has lagged globally. It notes that a survey of 400 manufacturers revealed that half had no digital roadmap.

A number of issues "hinder digital adoption, including technology readiness among lower-tier suppliers; interoperability issues across legacy plants, equipment, and firms in the supply chain; and concerns around data privacy, ownership, and security," according to the report, which underscores the need for these legacy operations to make transitions to remain viable and competitive in the global marketplace.

Such investments would likely have impacts on workforce development prerogatives, but other research shows that these impacts have not yet reached fruition. A 2016 report on an employer survey from PwC and the Manufacturing Institute shows low to moderate workforce impacts from advanced manufacturing technology including IoT, robotics, and automation.[4] About a third of the respondents indicated little or no difficulty acquiring talent to leverage advanced manufacturing technology. More than 40 percent said they had "moderate difficulty"; just over 20 percent said they had "substantial" or "extreme difficulty."

Other studies paint a slightly different picture, showing that manufacturing activity may be in transition toward automation and advanced digital technology, even if full integration is not yet here. One Deloitte survey showed that 40 percent of manufacturing executives project that the introduction of advanced manufacturing technologies and automation will contribute to a talent shortage for skilled production workers in the future ("significant or high impact"); 40 percent said it would have moderate impact.[5]

[1] "Material Handling and Logistics U.S. Roadmap 2.0," MHI, April 2017, http://www.mhlroadmap.org.

[2] Aaron Parrot and Lane Warshaw, "Industry 4.0 and its digital twin," Deloitte, May 12, 2017, https://www2.deloitte.com/insights/us/en/focus/industry-4-0/digital-twin-technology-smart-factory.html?icid=dcom_promo_standard|us;en.

[3] "Making It in America: Revitalizing U.S. Manufacturing," McKinsey Global Institute, McKinsey&Company, November 2017, pp. 15-16, https://www.mckinsey.com/~/media/McKinsey/Global%20Themes/Americas/Making%20it%20in%20America%20Revitalizing%20US%20manufacturing/Making-it-in-America-Revitalizing-US-manufacturing-Full-report.ashx.

[4] "Upskilling Manufacturing: How Technology Is Disrupting America's Industrial Labor Force," PwC, June 2016, p. 4, http://www.themanufacturinginstitute.org/Research/Disruptive-Innovations-in-Manufacturing/~/media/E9F0B41DEC4F40B6AE4D74CBC794D26D.ashx.

[5] "The Skills Gap in U.S. Manufacturing: 2015 and beyond," Deloitte and the Manufacturing Institute, 2015, pp. 6-7, https://www2.deloitte.com/us/en/pages/manufacturing/articles/boiling-point-the-skills-gap-in-us-manufacturing.html.

[6] Mark Glover and Benjy Egel, "Amazon's Sacramento Center Is Up and Shipping; Plans for Inside Home Delivery in Works," The Sacramento Bee, October 25, 2017, http://www.sacbee.com/news/business/article180833111.html.

Another Deloitte survey of 400 global employers from a cross-section of industries examined Robotic Process Automation (RPA). The findings show that in many cases, automated tools enhance worker productivity, even if it creates worker redundancy in other cases. The survey also showed that a majority of global employers included in the study said they bring in third parties to manage the digital transition. The report suggests that just 3 percent of the businesses surveyed had scaled their digital workforce despite the efficiencies and cost saving promised.[6]

All of this points to industrial and manufacturing industries that are compelled to transition to a higher level of automation, but in many cases have not yet done so.

Irrespective of the digital divide between legacy and state-of-the-art facilities, several reports suggest the need for workforce training and education to maintain basic staffing needs to maintain full operational capacity. Increases in worker overtime, and operation cycle time and down time result from not having trained workers who can meet demand. A shortage of trained workers, and limited investment from employers on training is contributing to the workforce impacts on facility operations.[7]

Responding to requests by employer and other community partners, several community colleges across Northern California called for a study of the industrial maintenance mechanics (IMM) and repair technicians workforce. Colleges, employers and other partners sought to address a common call for skilled technicians, and reports about the digitalization and automation of industrial and manufacturing operations.

For the purpose of this report, industrial maintenance mechanics and repair technicians are referred to as maintenance and repair technicians.[8]

To investigate, the Centers of Excellence for Labor Market Research (COE) conducted a survey of 86 Northern California employers in industrial, manufacturing, logistics, and other industries related to maintenance and repair to determine the demand for maintenance and repair technicians with needed skills, and the challenges employers face in recruiting and hiring a skilled workforce.

The survey covered the following topics:

- Employer characteristics;
- Maintenance and repair technician characteristics;
- Employment and hiring projections;
- Hiring and retention;
- Wages;
- Education and credentials;
- Equipment, technology, and skills; and
- Partnership opportunities.

For maintenance and repair technicians, the study investigates job titles, preferred education level and credentials, and the types of skills, knowledge, and abilities related to digital and automated equipment technology. The report also provides a demand-and-supply picture for the labor market in the study regions. Together, these aspects of the research seek to provide a framework for guiding the community colleges in supporting manufacturing and industrial employers in Northern California.

[6] "The robots are ready. Are you?" Deloitte, 2017, pp. 15-17, https://www2.deloitte.com/uk/en/pages/consulting/articles/the-robots-are-ready-are-you.html.

[7] "Out of Inventory: Skills Shortage Threatens Growth for U.S. Manufacturing," Accenture and the Manufacturing Institute, 2014, p. 7 and p. 10, http://www.themanufacturinginstitute.org/Research/Skills-and-Training-Study/~/media/70965D0C4A944329894C96E0316DF336.ashx. The report notes that, on average, the surveyed employers spend about $1,000 on training per employee.

[8] "Summary Report for: 49-9041.00 - Industrial Machinery Mechanics," O*Net OnLine, site updated May 29, 2018, https://www.onetonline.org/link/summary/49-9041.00.

INDUSTRY OVERVIEW OF SURVEYED FIRMS

The COE identified the top industries across subregions in Northern California that employ maintenance and repair technicians using inverse-staffing pattern analysis for the principle occupation. The COE distributed a survey to a list of businesses in the top industries. Appendix A provides details on the study's methodology.

Small businesses make up the vast majority of survey respondents and more than half are manufacturing employers.

Exhibit 1 displays the top industries represented in the survey for respondents who completed the entire survey. The list shows the number of total employees and the number of maintenance and repair technicians employed by respondent firms by industry, according to the responses.

The table also provides the regional concentration for the responses in each industry, the total number of respondents, and the percentage of total employment represented by maintenance and repair technicians. (For a comparison of industries where maintenance and repair technicians work, Appendix B shows the top industries employing maintenance and repair technicians in inverse staffing patterns of each community college subregion.)

Food and beverage manufacturing industries represent the top industries in the survey responses. These include wineries, confectionary, bakeries, rice milling, fruit and vegetable canning, and several other industries.

Two wholesale (logistics and warehousing) industries, including industrial supplies, and industrial machinery and equipment are also among the top industries.

A miscellaneous category that includes manufacturing companies in a number of categories (nuts, semiconductors, videogame components, ophthalmic, and rail stock) represented the largest employers of maintenance and repair technicians.

In total, the survey respondents employ about 7,000 workers and 470 maintenance and repair technicians.

[9] The North/Far North subregion is split into two regions given the number of distinct responses between the rural Far North subregion and the more urban North (Greater Sacramento) subregion. The subregions in the Bay region are combined, as are the subregions in the Central Valley/Mother Lode region.

Exhibit 1. Top industries represented in the survey by total reported employment and number of maintenance and repair technicians employed (continued)

NAICS	NAICS Description	Total Emp.	Total M&R Techs	% M&R in industry	# of Responses	Regional Concentration
Misc. Manu.	Nuts, Insulation, Machinery Supply, Electronics, Ophthalmic, Rail stock	3755	151	4%	9	North
312130	Wineries	909	70	8%	18	Bay, North, Far North
311340	Nonchocolate Confectionery	465	16	3%	1	Central
423840	Industrial Supplies Merchant	303	8	3%	2	Bay, Central
423830	Industrial Machinery and Equipment Merchant Wholesalers	262	69	26%	18	Bay, Central, North, Far North
811310	Commercial & Industrial Machinery & Equipment ...Repair & Maintenance	176	65	37%	19	Bay, Central, North, Far North
311812	Commercial Bakeries	170	9	5%	1	Bay
311351	Chocolate and Confectionery Manufacturing From Cacao Beans	164	18	11%	1	Bay
311212	Rice Milling	128	4	3%	1	Far North
311513	Cheese Manufacturing	94	2	2%	1	Bay
423850	Service Establishment Equipment and Supplies Merchant Wholesalers	92	1	1%	1	Bay
333111	Farm Machinery and Equipment Manufacturing	76	5	7%	1	Far North
311423	Dried and Dehydrated Food Manufacturing	70	2	3%	2	Central, Far North
311811	Retail Bakeries	70	11	16%	2	Bay, North
311421	Fruit and Vegetable Canning	65	4	6%	2	Bay
311119	Other Animal Food Manufacturing	49	9	18%	1	Central
311824	Dry Pasta, Dough, And Flour Mixes Manufacturing from Purchased Flour	43	8	19%	1	Central
311911	Roasted Nuts and Peanut Butter Manufacturing	12	8	67%	1	Central
311225	Fats and Oils Refining and Blending	7	4	57%	2	North, Far North
312120	Breweries	6	1	17%	1	North
311920	Coffee and Tea Manufacturing	2	1	50%	1	Bay
	TOTAL	**6918**	**466**	**6.7%**	**86**	

INDUSTRY AND GEOGRAPHIC CONCENTRATION OF SURVEYED FIRMS

Although there is overlap in Exhibit 2 across the three subregions with respect to the top industries that employ industrial maintenance and repair technicians, there are also some industries unique to each subregion:

- In the Far North region, three of the five top industries are unique to the subregion: rice milling, dried and dehydrated food manufacturing, and farm machinery and equipment manufacturing.
- In the North region, two of the five top industries are unique to the subregion: railroad rolling stock manufacturing and ophthalmic goods manufacturing.
- In the Bay Area, three of the top five industries are unique to the subregion: chocolate and confectionary manufacturing, cheese manufacturing, and commercial bakeries.
- In the Central Valley/Mother Lode region, three of the top five industries are unique to the subregion: fruit and vegetable canning, pickling, drying; industrial supplies wholesalers; and non-chocolate confectionary manufacturing.

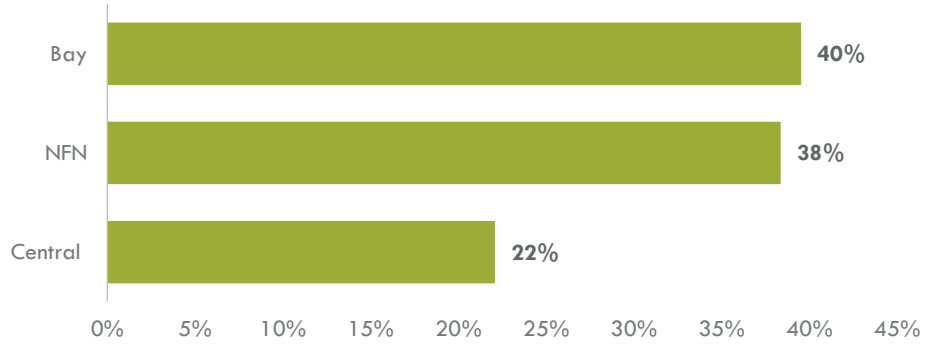
Rice milling, wineries, fruit and vegetable canning, and chocolate and confectionary manufacturing are some of the top industries in the subregions studied.

Exhibit 2. Top industries represented in the survey in each community college subregion

EMPLOYER CHARACTERISTICS

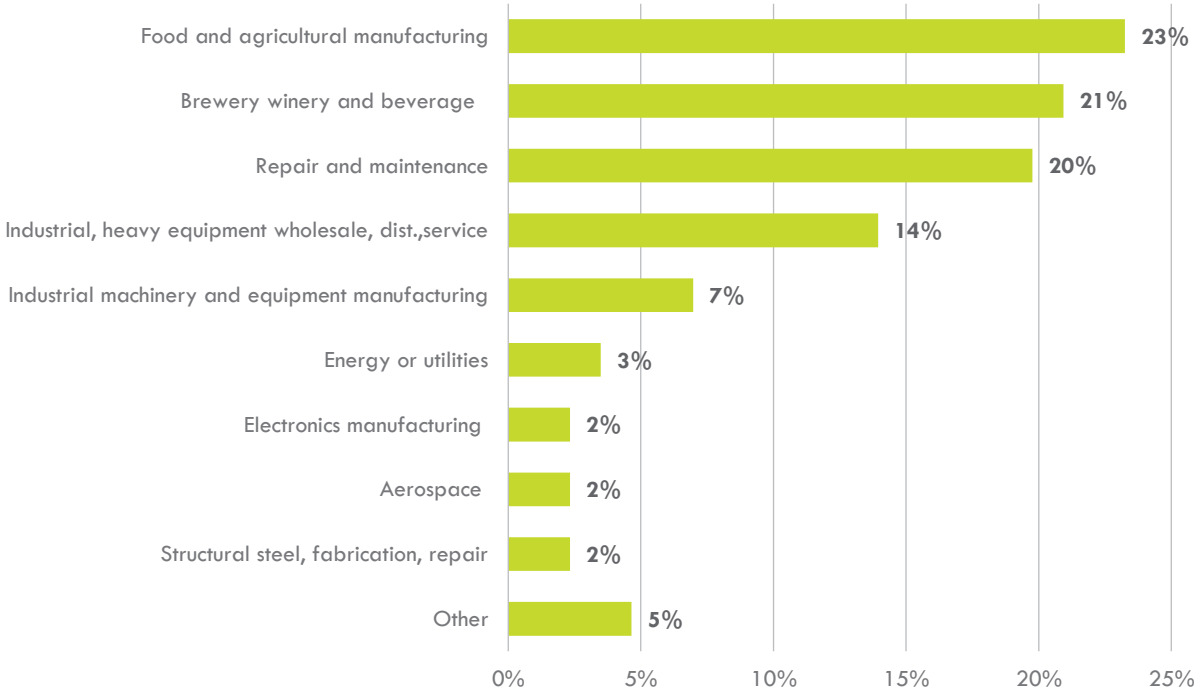
The survey asked employers to identify the physical location of their company. The Bay region and North/Far North region had nearly the same number of responses. The Central Valley/Mother Lode region accounted for about 20 percent of the responses (Exhibit 3). (Appendix C shows details of respondents' locations by county.)

Exhibit 3. Count of respondents by region (n=86)



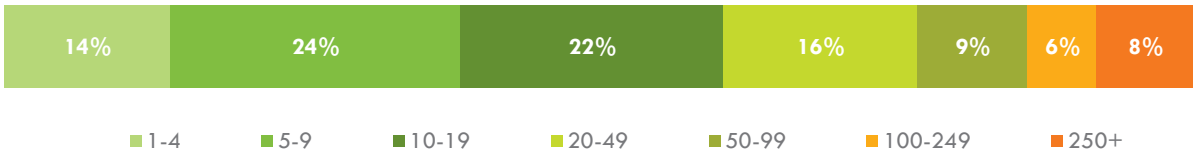
The survey asked respondents to identify the industries with which their company is most closely associated (Exhibit 4). The most common industries among respondents are: food and agricultural manufacturing; brewery, winery, and other beverage manufacturing; and industrial repair and maintenance. Other industries include industrial and heavy equipment wholesale and distribution, and industrial machinery and equipment manufacturing.

Exhibit 4. Respondent industry type (n=86)



Most people taking the survey (about 60 percent) represented small companies having fewer than 50 employees. A minority of respondents (about 15 percent) were from companies having more than 100 employees (Exhibit 5).

Exhibit 5. Respondents by size of firm (number of employees) (n=86)

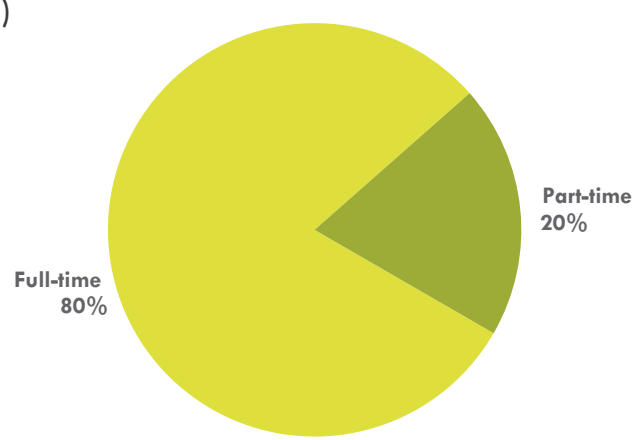


The survey asked employers the number of full-time and part-time employees, and whether they had hired the employees directly, or used an employment agency.

Irrespective of the size of the company, the employers surveyed indicated that about 80 percent of employees are full time, and 20 percent are part time (Exhibit 6). The survey characterized full time as at least 35 hours a week.

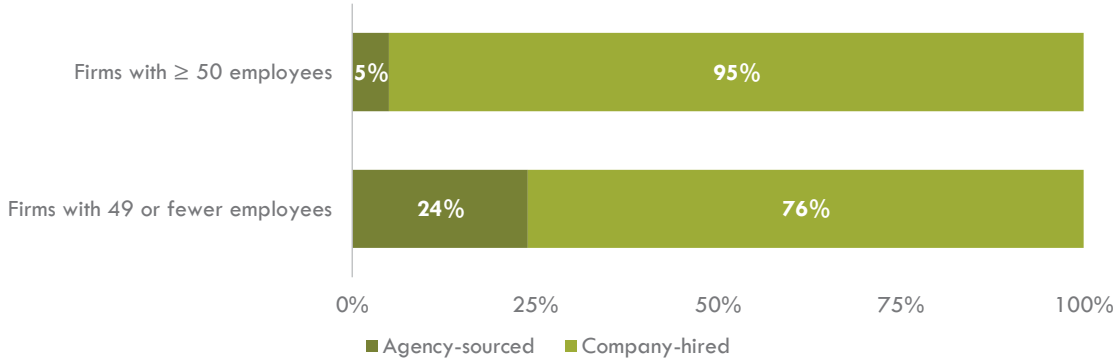
Altogether, the companies represented in the survey have more than 6,900 employees, including full-time and part-time workers.

Exhibit 6. Percentage of full-time and part-time workers (all employees in respondent firms) (n=86)



The size of the firm makes a difference when comparing whether employers do their hiring in house or through an agency. Smaller employers reported using an agency more commonly, but overall the firms mostly conduct hiring using company resources (Exhibit 7).

Exhibit 7. Total number of employees hired by agencies and by the company, by size of company (all employees in respondent firms) (n=86)



WORKER CHARACTERISTICS

The survey asked employers about the job title(s) held by maintenance and repair workers. The list includes a diverse array of specialties and roles, including management level, technicians, and basic and general assistants and helpers (Exhibit 8). Many respondents provided more than one response.

Exhibit 8. Employer-provided job titles for maintenance and repair technicians

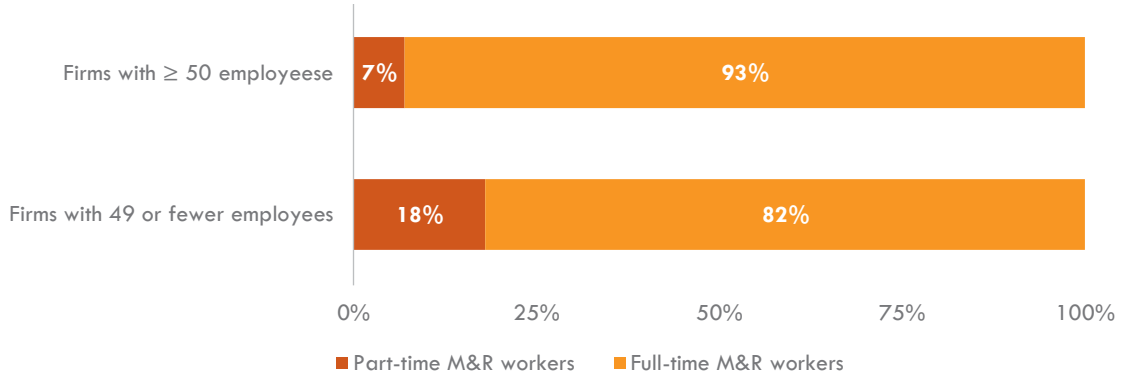
(n=86)

Title Keywords	Examples of Titles	Count
Maintenance	Maintenance mechanic; Maintenance technician; Maintenance Engineer; Industrial Maintenance Technician; Maintenance Assistant; Maintenance Manager; Assembly/Maintenance Technician	29
Technician	Electro-Mechanical Technician; Mechatronics Technician; Optical Maintenance Technician; Service Technician; Maintenance Technician; Facilities Technician; Compressor Technician; Conveyor Belt Technician; Electronic Technicians	27
Mechanic/Mechanical	Sheet Metal Mechanic; Mechanic; Equipment Mechanic; Mechanic Level I and Level II; Maintenance Mechanic; Plant Mechanic; Shop Mechanic; Field Mechanic; Winders	24
Manager	Maintenance Manager; Operations Manager; Shop Manager; Cellar Manage; Warehouse Manager; Bakery Manager; Vineyard Manager; Kitchen Manager; Warehouse Manager; Cellar Master; Ranch Manager; Production Supervisor	15
Service	Service Technician; Service Mechanic	8
Cellar	Cellar Worker; Cellar Master	5
Electronic/Electrical	Electrician; Electro-Mechanical Technician; Electrical Technician; Electric Motor Repair Tech	6
Mechanical	Mechanical Maintenance Repairman; Mechanical Assembly	4
Facility	Facilities Technician; Water Treatment Facilities Operator	4
Shop	Shop Manager; Shop Person; Shop Mechanic	4
Engineer	Maintenance Engineer; Quality Engineer; Equipment Engineer	4
Operator/Operations	Operations Manager; Director of Operations; Machine Operator; Water Treatment Facilities Operator	8
Vineyard	Vineyard Manager; Vineyard Worker; Vineyard Crew	3
Production	Production Technician; Production Supervisor; Production Worker	3
Laborer	Laborer	3
Machine	Machine Operator	2
Field	Field Technician; Senior Field Technician; Field Mechanic	3
Repair	Electric Motor Repair Technician; Maintenance Repairman	2
Machinist	Machinist	2
Millwright	Millwright	2
Handyman	Handyman	2
Welding	Welder	2

The survey specifically asked about the employment characteristics of maintenance and repair workers. There are about 470 maintenance and repair workers employed by the companies that responded to the survey. Comparing that number to the total number of full-time and part-time employees reveals that about 7 percent of the employees of the surveyed companies are maintenance and repair workers.

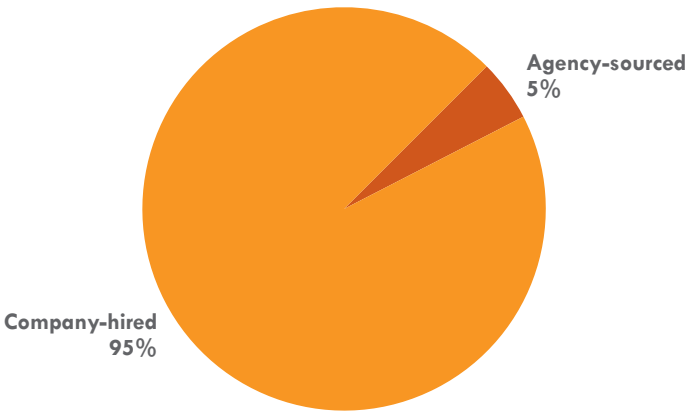
The vast majority of the maintenance and repair workers are full time (Exhibit 9). Part-time maintenance and repair technicians are more common at smaller firms according to the data. Nearly 20 percent of the maintenance and repair workers at companies with 49 or fewer employees are part time, compared to just 7 percent at the larger firms.

Exhibit 9. Share of part-time and full-time maintenance and repair workers, by size of company (n=86)



Maintenance and repair workers are nearly always hired by the company, according to the survey data. Just 5 percent of the workers employed by respondent firms were hired by an agency (Exhibit 10).

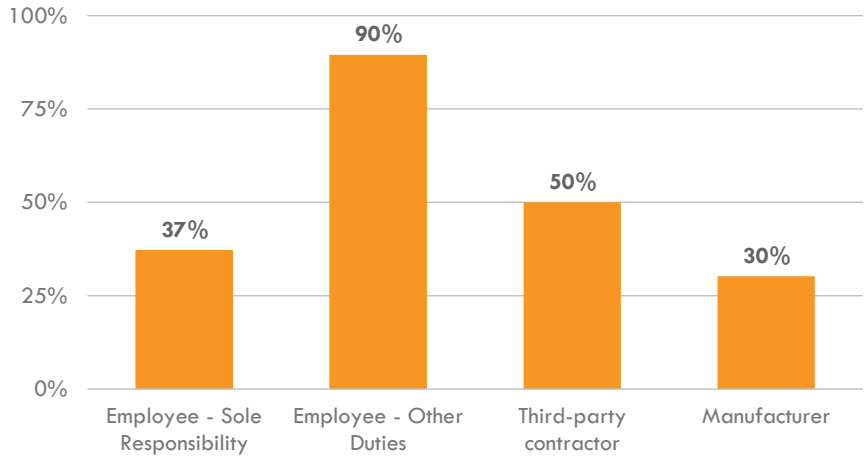
Exhibit 10. Share of maintenance and repair workers hired by company or sourced by agencies (n=86)



A majority of respondents indicate that maintenance and repair is done by employees who perform a variety of duties. This could be, for example, a production worker who also repairs and maintains the production equipment.

Similarly, employers use a combination of methods to repair and maintain equipment, including employees and third parties, such as a service company or the manufacturer. Just 20 of the 86 respondents use only one of the methods shown in Exhibit 11. More than half use a third-party or the manufacturer to perform repair and maintenance. Just over a third have employees whose sole responsibility it is to perform repair and maintenance.

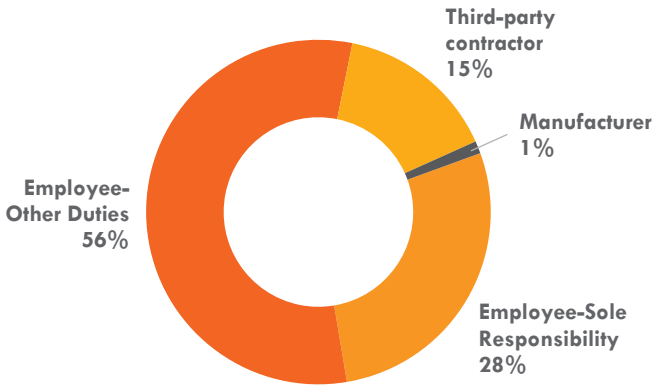
Exhibit 11. Responses to the survey question, who performs repair and maintenance? (n=86)



The survey asked employers to indicate the primary way they perform repair and maintenance. The responses echo the previous question, but highlight the importance of employees over third parties (Exhibit 12). Again, most respondents indicate that the primary mechanism for repair and maintenance is employees who have other duties. Nearly a third chose employees whose sole responsibility it is to repair and maintain equipment as the primary method. Third parties and manufacturers, the respondents indicated, are not the primary means for repair and maintenance.

Maintenance and repair work is performed by a wide spectrum of workers who most often perform other duties in addition to maintenance and repair work.

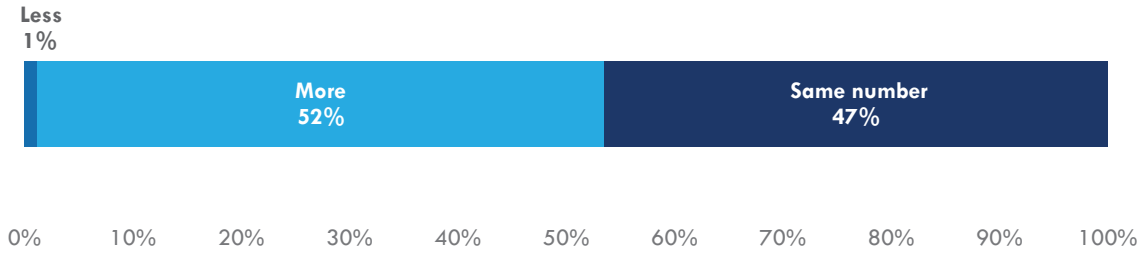
Exhibit 12. Primary way repair and maintenance is performed (n=86)



EMPLOYMENT AND HIRING PROJECTIONS

The survey asked employers about their projected hiring needs for maintenance and repair workers (Exhibit 13). Just one respondent expects a reduction. The remaining responses were split—employers project adding workers or maintaining the same number of maintenance and repair workers.

Exhibit 13. Share of employers projecting reducing, adding, or maintaining maintenance and repair workers (n=86)



The survey asked employers to project the number of maintenance and repair workers they would hire or let go over the next two years (Exhibit 14). Given the low number of projected reductions (-14), the total number of projected additions (+135) translates to a high growth rate: Employers project increasing their maintenance and repair workforce by more than 25 percent.

Exhibit 14. Two-year projected additions and reductions of maintenance and repair workers

2017 Employment	Additions	Reductions	Total	Growth Rate
466	+ 135	- 14	+ 121	26%

Employers anticipate a large retirement wave in the next two years. They suggest that more than a tenth of their maintenance and repair workforce will retire (Exhibit 15).

Exhibit 15. Two-year projected number of retiring maintenance and repair workers

Retirements	Rate
56	12 %

Exhibit 16 summarizes two-year maintenance and repair technician employment projections in the survey. Employers project 89 annual job openings, from both new jobs (26 percent growth) and replacement jobs due to retirements.

Exhibit 16. Current employment and projected occupational demand for the three Northern California regions based on survey responses (n=86)

	2017 Jobs	2019 Jobs	2017-2019 % Change	2017-2019 Change	Average Annual Openings, 2017-2019
All Survey Responses	466	587	26%	121	89

Comparing the growth rate from the survey responses to the Emsi occupational projections for the next two years suggests that employers' survey responses may be overly optimistic (Exhibit 17).

All three regions have experienced steady growth during the economic recovery since 2011 with greater increases in the Bay region and the Central Valley/Mother Lode region.

Two-year projections show that overall growth could be 7 percent above the 2017 baseline employment of maintenance and repair workers.

The projection is nearly 20 percentage points lower than what is projected by survey respondents. (See Appendix D for more details.)

Compared to employment projections from employers, economic projections are far lower, +7 percent, but this still amounts to 1,500 annual job openings in the three subregions.

Exhibit 17. Current employment and two-year projected occupational demand for the three Northern California regions based on Emsi data[10]

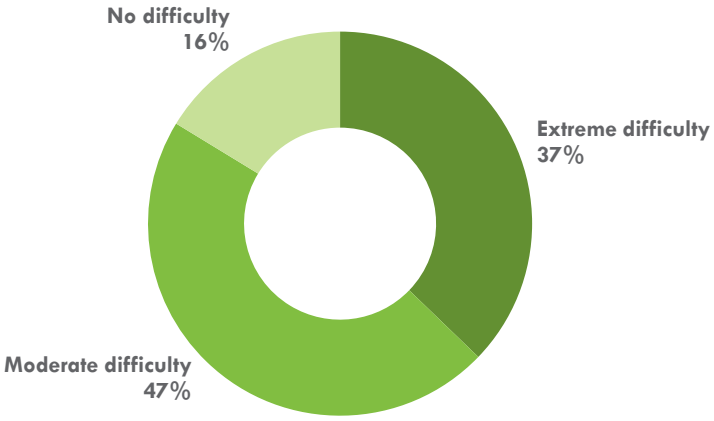
	2017 Jobs	2019 Jobs	2017-2019 % Change	2017-2019 Change	Average Annual Openings, 2017-2019
All Study Regions	12,158	13,048	7%	890	1,500

[10] Emsi 2018. The data uses the SOC code for Industrial Machinery Mechanics (SOC 49-9041). The comparison may not take into account workers who are counted in related occupational categories.

HIRING AND RETENTION

An overwhelming majority (more than 80 percent) of the employers surveyed reported at least some difficulty hiring maintenance and repair technicians who meet the company's hiring standards (Exhibit 18). Nearly 40 percent said they have extreme difficulty.

Exhibit 18. Difficulty hiring maintenance and repair technicians (n=86)



Eight out of 10 employers said they experience at least some difficulty hiring qualified maintenance and repair technicians.

The survey asked why respondents have difficulty hiring maintenance and repair technicians. More than 80 percent cited the lack of necessary skills to perform the job (Exhibit 19). They also indicate that applicants do not have enough work experience and there is strong competition for skilled workers.

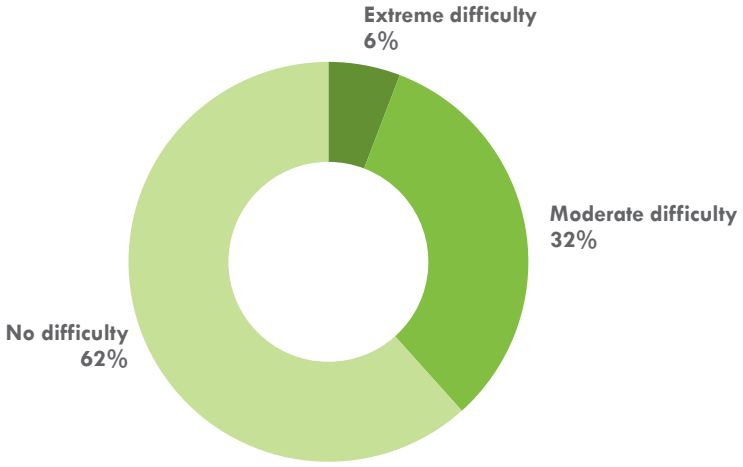
Other reasons cited included the high cost of living, small labor pool and rural location, and communication skills. Most, but not all, respondents provided an answer to the question.

Exhibit 19. Reasons why employers have difficulty hiring maintenance and repair technicians (n=72)

Reason	Count
Applicants lack the necessary skills to perform the job	58
Applicants do not have enough work experience	32
Strong competition for skilled workers	26
Other (M9b)	12
Not enough skilled workers	*5*
High cost of living	*3*
Lack of communication skills	*2*
Low work ethic	*1*
Inability to pass a drug test	*1*

By contrast, more than 60 percent of respondents reported no difficulty retaining maintenance and repair workers (Exhibit 20). Just 6 percent reported extreme difficulty with retention.

Exhibit 20. Difficulty retaining maintenance and repair technicians (n=86)



Respondents who reported moderate and extreme difficulty retaining maintenance and repair workers cited poor work ethic and competition for workers as the main reasons they have trouble retaining workers (Exhibit 21). Again, these respondents represent a minority of employers. Reasons cited in the "other" category include cost of living, relocation, and technicians' preference for focusing on one trade.

Exhibit 21. Reasons why employers have difficulty retaining maintenance and repair technicians (n=33)

Reason	Count
Poor work ethic	18
Strong competition for skilled workers	17
Other (M10b)	5
Cost of living	*2*
Relocation	*1*
Do not have desired skills/not willing to learn	*1*
Personal reasons	*1*

WAGES

The survey asked employers about the typical hourly wages for entry-level maintenance and repair technicians. The responses indicate that median entry-level wages range from $16 per hour in the North/Far North region to $18 per hour in the Bay Area; average wage ranges between the regions were slightly higher in the North Far/North and Central Valley, but skewed higher in the Bay Area due to several responses showing entry-level wages above $20 per hour.

Employer responses suggest that with just a few years of experience, technicians can earn a much higher wage (Exhibit 22). The median for experienced wages, for those workers with more than three years of experience, was generally higher than entry-level wages, from $7 per hour higher in the North/Far North region, to $8 per hour higher in the Central Valley/Mother Lode region. The average wage increase in the Bay region was similar. Again, the Bay region displayed a higher wage overall.

Exhibit 22. Survey findings for median and average wages for maintenance and repair workers (n=86)

	Median Wage	Average Wage
Entry-level	**$16.00**	**$17.71**
Bay Area	$18.00	$19.52
Central Valley	$17.00	$17.82
North/Far North	$16.00	$17.02
Experienced	**$23.00**	**$25.75**
Bay Area	$25.00	$28.65
Central Valley	$25.00	$26.88
North/Far North	$23.00	$23.18

Wages for maintenance and repair technicians rise dramatically with experience. Median wages quickly increase by $7 per hour to $8 per hour with more than three years of experience.

Exhibit 23 displays the responses by distribution for categories of wage levels. A majority of the employers (55 percent) in the survey said that entry-level maintenance and repair technicians earn between $12 per hour and $17 per hour. About a third of the entry-level technicians earn between $18 per hour and $24 per hour. A smaller number of employers said wages were $25 per hour and above.

The distribution skews upward for the experienced technicians. A third of the employers said experienced maintenance and repair technicians earn between $20 per hour and $24 per hour.

The distribution is relatively even for a range of wages at most levels from $15–$17 per hour to $35–$39 per hour; however, the upper part of the range is dominated by respondents from the Bay region. The Bay region had a large share at the lower end, as well.

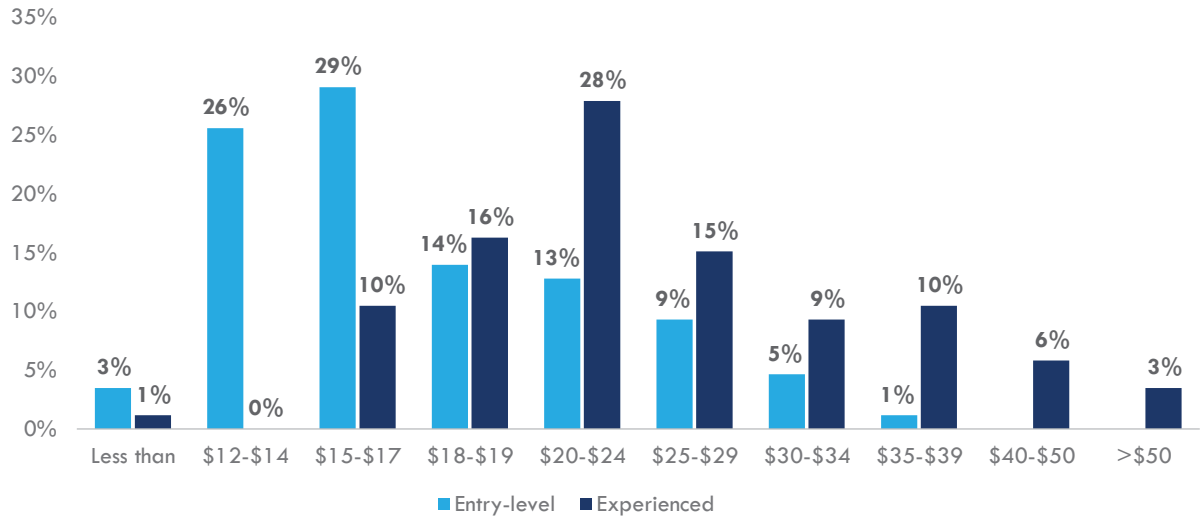
The data suggests that for maintenance and repair workers in the other two regions, the ceiling may be $25 per hour to $29 per hour.

The self-sufficiency wage for a one-adult, one child household in the Bay region is $28.12 per hour. In the Central Valley/Mother Lode region, it is $20.43 per hour. In the North/Far North, it is $20.92 per hour.[11]

[10] Living Insight, self-sufficiency tool.

Exhibit 23 displays the distribution of wages for entry-level and experienced maintenance and repair technicians. (Appendix E compares wage levels cited in the survey to the data collected by the Bureau of Labor Statistics and indicates the BLS wages are higher than those reported by surveyed employers.)

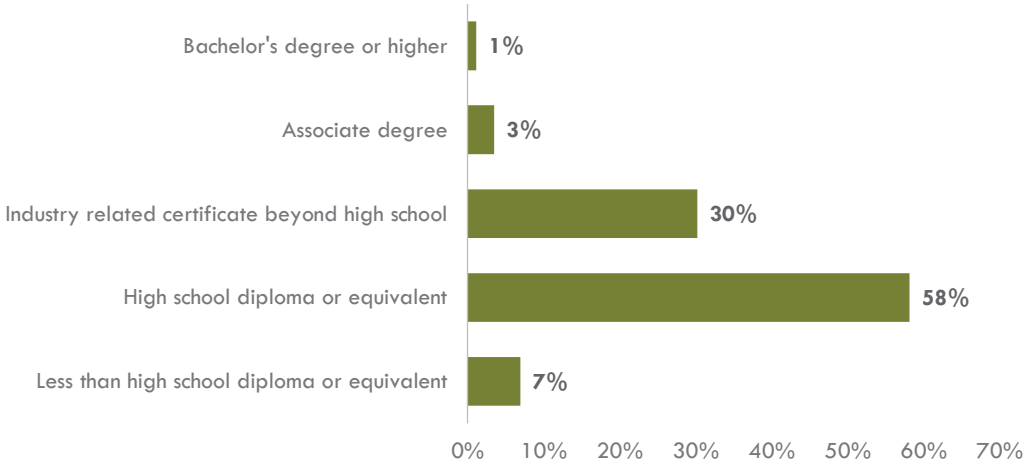
Exhibit 23. Wages for entry-level and experienced maintenance and repair technicians (n=86)



EDUCATION AND CREDENTIALS

The survey asked employers about their minimum education requirements for entry-level applicants. About a third said they require an industry-related certificate beyond high school (Exhibit 24). Nearly 60 percent said they require a high school diploma or equivalent. Just four respondents said formal degrees beyond high school, such as an associate or bachelor's degree, are required.

Exhibit 24. Respondents' education requirements for entry-level maintenance and repair applicants (n=86)



Employers were further asked in an open-ended question about the industry credentials or certificates they prefer or require for maintenance and repair workers at their companies. The respondents interpreted the question in various ways, but provided information that enabled coding into the categories shown in Exhibit 25. They often provided more than one response and, at times, elaborated on the response.

Most employers say a high school diploma is sufficient for an entry-level position, and experience is more important than credentials.

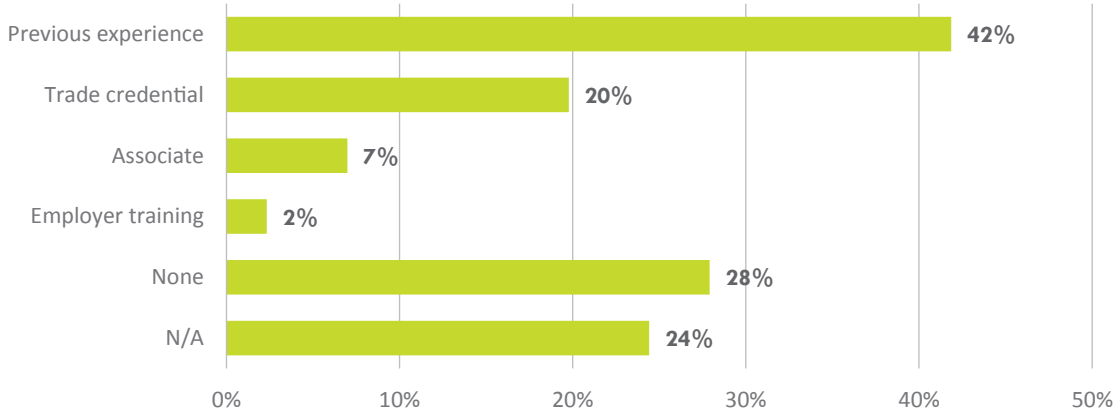
The most frequent response indicates that employers prefer previous experience, perhaps over or instead of a credential. Employers often articulated this in terms of valuing technicians who already have skills and abilities in certain areas in the open-ended responses.

The term "trade credentials" refers to employers looking for credentials in specific areas such as welding, electrical, mechanics, and HVAC. (Exhibit 26 highlights the specific skills cited in employer responses.)

Associate degree and certificate categories represent the employer responses that specifically said that employers prefer or require a formal credential from an accredited school, including community college programs. The responses here add additional data to the previous minimum education requirements by revealing that a minority of respondents prefer technical credentials.

A small number of employers said they primarily train in house. The "none" responses represent the number of employers who provided no response to the question; the N/A responses are for responses that were too general to categorize.

Exhibit 25. Preferred or required credentials or certificates for maintenance and repair workers (coded, open-ended responses) (n=86)

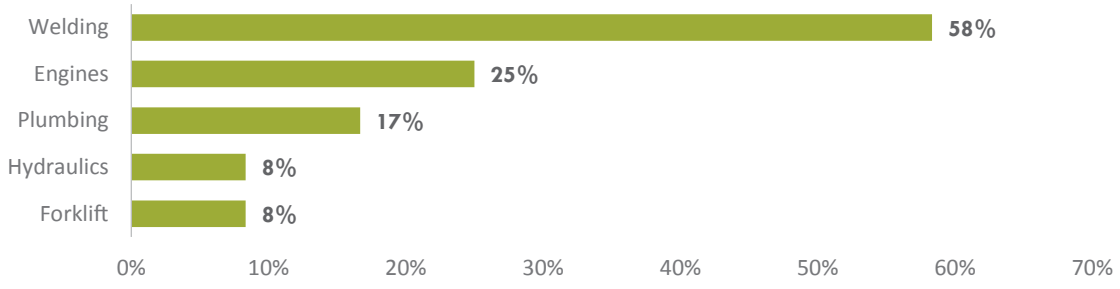


Some employers cited a specific skill, knowledge or ability for the credentials they prefer or require. These responses did not always refer to a specific credential, and so the value of credentials was not made clear by the responses. Nonetheless, the results presented below give a broad idea of the kinds of credentials and knowledge, skills, and abilities employers prefer and require (Exhibit 26).

Welding represents the most clearly articulated credential that employers cited as a specific credential they prefer or require, followed by engines and plumbing.

Appendix F shows an analysis of the equipment and technology knowledge needs for those employers who indicated high school or the equivalent as the preferred education level for entry-level maintenance and repair technicians.

Exhibit 26. Specific skills, knowledge, ability or credential type cited in coded, open-ended responses (n=12)



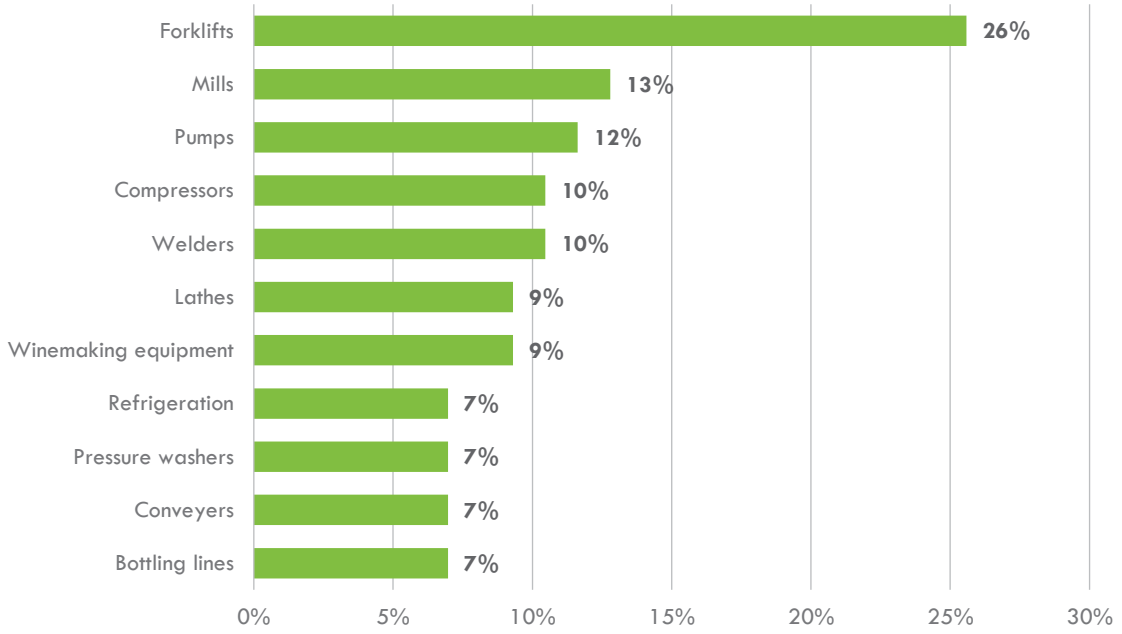
EQUIPMENT, TECHNOLOGY, SKILLS

Employers were asked specifically about the types of equipment that maintenance and repair technicians use at their facilities, and the skills, knowledge, and abilities employers prefer or require for candidates.

Responses to an open-ended question offer data on the types of equipment or machinery that employers use for production, manufacturing, or distribution for facility operations. The top responses show that traditional equipment and machinery predominate among respondents' operations.

Twenty-two respondents said they use forklifts, the most commonly cited equipment type in the survey. Mills, pumps, compressors, welders, lathes, and winemaking equipment were other top responses (Exhibit 27). An exhaustive list of the equipment and machinery used can be found in Appendix G. The list contains dozens of equipment and machinery types that did not fit into quantifiable categories.

Figure 27. Top types of equipment used for facility operations (n=86)



The following two questions sought information from employers about equipment and technology, and skills needed for maintenance and repair technicians at their locations. The questions asked employers to rate the level of importance for candidates for maintenance and repair positions.

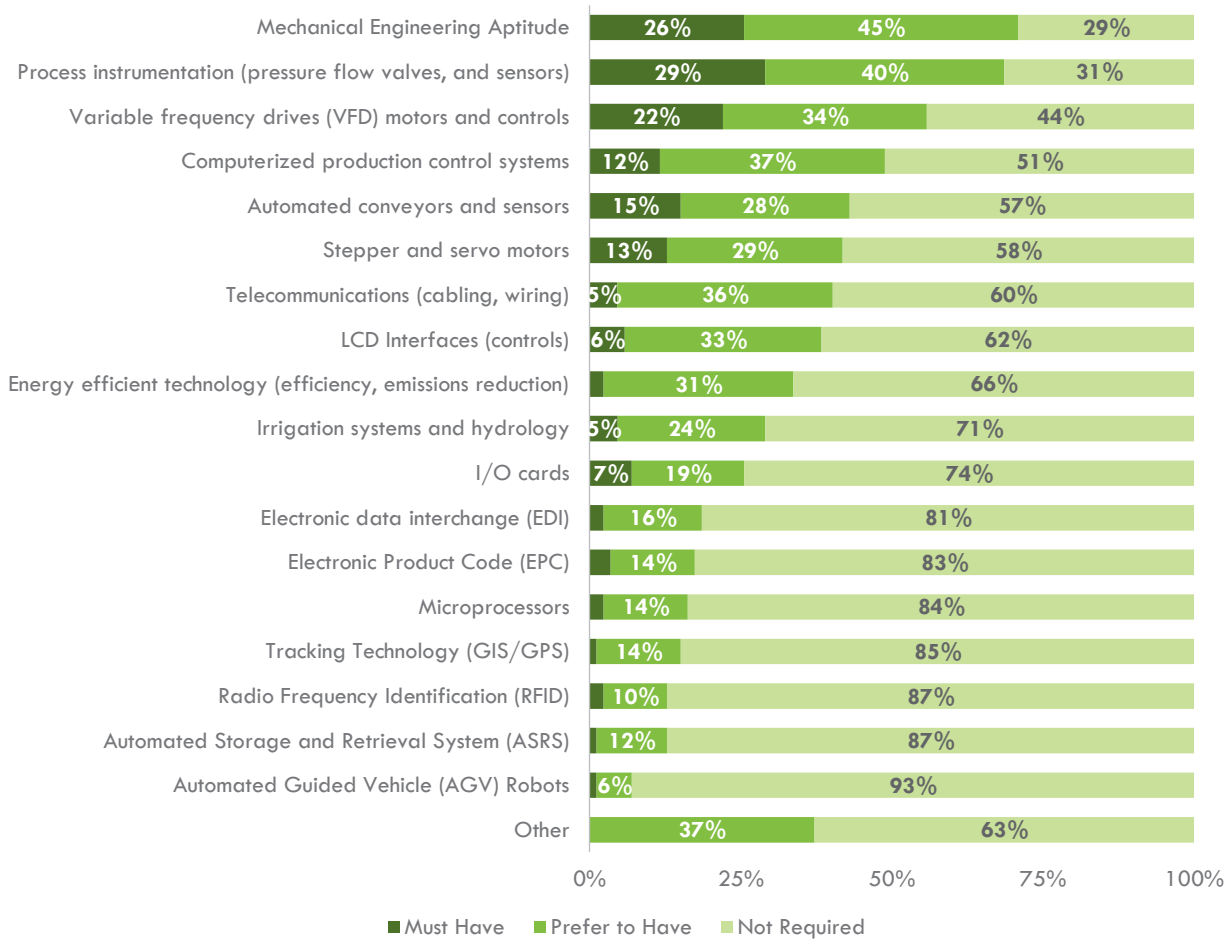
Questions were asked about technology and skills associated with automation—integrated, digital technology associated with equipment and machinery needing maintenance and repair. The list of answer choices grew out of engagement with industry observers and partners, review of industry and market reports, and other occupational research. Additionally, the research included a focus group with employers of maintenance and repair technicians. The focus group contributed to the list of choices. (Appendix H provides a summary of the focus group findings.)

The data reveals that some equipment and technology associated with automated or integrated equipment ranks high on the list. These include process instrumentation, computerized production control systems, automated conveyors and sensors, and telecommunications. Still, most of the responses do not indicate a requirement for these skills.

Other skills ranked highly, including mechanical engineering and variable frequency drives (VFD), and motors and controls (Exhibit 28).

Some equipment and technology associated with automation identified in preliminary research did not rank highly; a small minority of respondents prefer or require these skills for candidates. These included, I/O cards, electronic data interchange (EDI), electronic product codes (EPC), microprocessors, tracking technology (GIS/GPS), radio frequency identification (RFI), automated storage and retrieval (ASRS), and automated guided vehicle robots (AGVR).

Exhibit 28. Importance of applicant knowledge and experience with equipment and technology (n=86)



Those who responded "other" wrote in choices. Employers appear to prefer or require a variety of traditional technical skills and soft skills for maintenance and repair technicians (Exhibit 29).

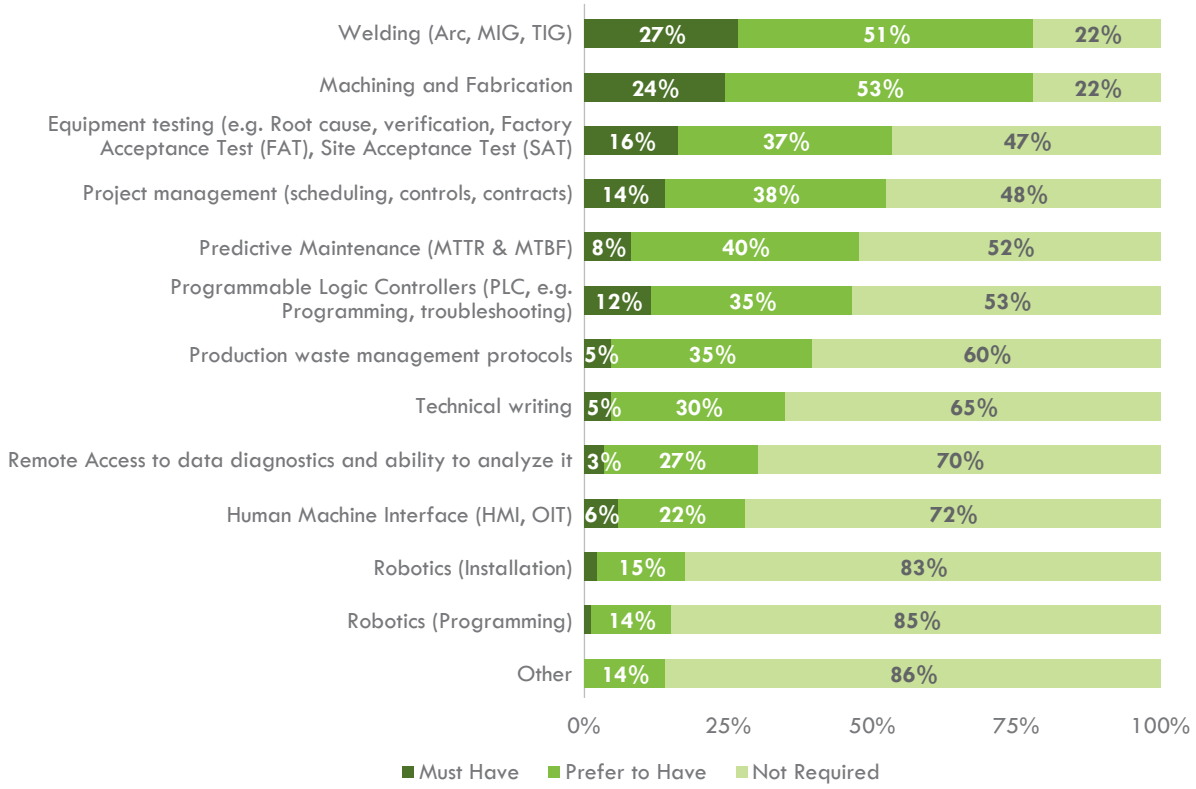
Exhibit 29. Other knowledge/experience preferred or required (n=32)

Basic Knowledge/Experience	Specialized Knowledge/Experience	
Math (4)	CAM software	Mechanics (3)
Food prep/safety (2)	Canning	Millwright
Provide own tools (2)	Chemistry/cryogenic liquids	Motorcycles
Safety (3)	Commercial kitchen equipment	PLC controls
Standard tools	Conveyors	Pneumatics (2)
Taking measurements	Diagnostics	Pressure gauges
Working with hands	[Electric] motors (5)	Programming
Adaptability	Electrical/electronics	Pumps (4)
Common sense	Engines	Reading schematics
Good work habits	Fabrication	Robotics
Willing and able to learn	Failure analysis	Sanitizing equipment
	Gearboxes	Small engines
	Heat treating	SOLIDWORKS
	Heavy Equipment	Tractor repair
	HVAC	Troubleshooting (2)
	Hydraulics	Welding (5)
	Lubrication	Wine equipment (2)
	Machine tool operators	
	Machining	
	Manifolds	

Employers were asked about skill and competency requirements for their entry-level and mid-level repair and maintenance technicians. Nearly 80 percent of respondents said they prefer or require welding and machining skills for maintenance and repair workers. Equipment testing, project management, and predictive maintenance, and skills associated with programmable logic controllers also topped the list (Exhibit 30).

Remote access to data diagnostics, Human Machine Interface, and robotics skills, i.e., skills associated with automation and centralized controls, ranked lower on the list of employer preferences for skills.

Exhibit 30. Respondents' preferences for applicant skills (n=86)



A few respondents wrote in answers for the "other" category, indicating a variety of skills and competencies, most of which are traditional technical skills and soft skills (Exhibit 31).

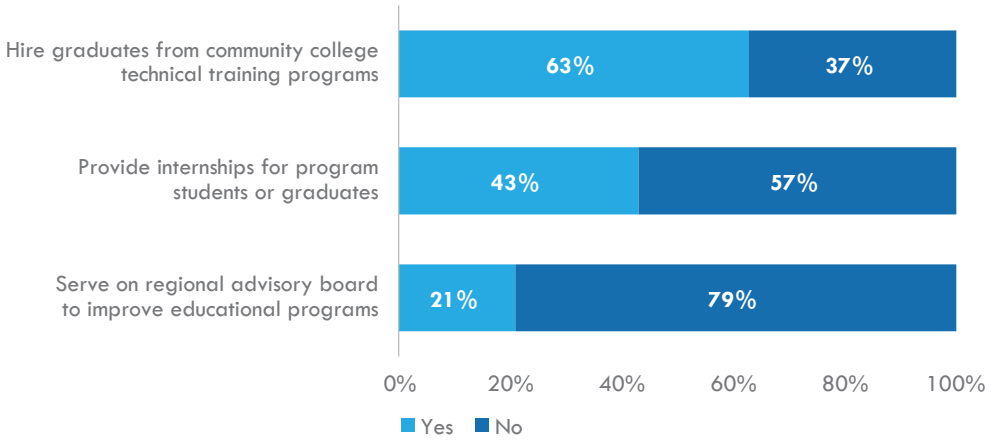
Exhibit 31. Other skills/competencies preferred or required (n=12)

Soft Skills/Competencies	Technical Skills/Competencies
Customer service	Knowledge of electric motors
Organizational skills	Predictive maintenance
Multitasking	Motorcycle diagnostics (traditional and electric)
Following directions	Kitchen skills (knife skills, cooking skills, kitchen equipment maintenance)
	Winemaking
	Taking measurements
	OSHA/LOTO (lock out, tag out)
	Safety/ sanitation
	Conveyor belt vulcanization

PARTNERSHIP OPPORTUNITIES

There is interest from surveyed employers in partnership opportunities with the community colleges. The most interest comes from employers looking to hire graduates from college technical training programs. Many are also willing to provide internships for students or graduates. A few are interested in serving on a regional advisory committee (Figure 32).

Figure 32. College-industry partnership opportunities (n=86)



COMMUNITY COLLEGE SUPPLY

There are 63 related training and education programs in the three study regions of Northern California.

Analysis of the California Community College Chancellor's Office curriculum inventory and Data Mart revealed there are 63 related training and education programs in the three regions of Northern California. The Central Valley/Mother Lode region has the greatest number of programs, 31, followed by the Bay Area, 19, and the North/Far North region, 12.

On average, over the last four years, these programs conferred 385 awards each year (283 certificates and 102 degrees) (Exhibit 33). Despite the varied number of programs, each of the three regions produce a similar number of certificate and degree completions annually. The North/Far North region has an annual average of 140 awards, while the Bay region has 115 awards. The Central Valley/Mother Lode region produces, on average, 130 awards.

Details on the programs and completions by region can be found in Appendix I.

COMMUNITY COLLEGE SUPPLY

Exhibit 33. Four-year annual average community college awards by program area in Northern California

TOP Title/Code	College	Certificate	Degree	Total
Electro-Mechanical Technology-093500	San Joaquin Delta	1		1
	SUBTOTAL	**1**		**1**
Industrial Electronics-093420	American River	4		4
	Fresno City	16		16
	Los Medanos	19	13	32
	Merced	2	2	4
	Modesto	2	10	12
	Sierra	55	28	83
	SUBTOTAL	**98**	**52**	**150**
Industrial Systems Technology and Maintenance-094500	Diablo Valley		1	1
	Fresno City	7		7
	Hartnell	2		2
	Laney	12		12
	Los Medanos	25	21	46
	Merced	1	1	2
	Modesto		1	1
	Sacramento City	32		32
	San Joaquin Delta	3		3
	San Jose City	3	4	7
	Sequoias	33	2	35
	Solano	2	2	4
	SUBTOTAL	**120**	**31**	**150**
Manufacturing and Industrial Technology-095600	Bakersfield	1	2	2
	Cerro Coso			
	De Anza	8	5	13
	Fresno City	26	2	28
	Modesto	2		2
	Porterville	18		18
	Redwoods	2	2	3
	San Francisco	1		1
	Shasta	2		2
	Sierra	7	9	16
	Solano			
	SUBTOTAL	**65**	**20**	**84**
TOTAL		**283**	**102**	**385**

CONCLUSION AND RECOMMENDATIONS

The employers surveyed for this study indicate that maintenance and repair technicians work in a variety of capacities, on an array of machinery and equipment. Many often perform other duties in addition to maintenance and repair work, including production work.

Demand for these technicians is strong, and employers report having difficulty recruiting and hiring them. Overall, employers seek technicians with experience and skills, but do not find value in formal credentials, except trade credentials, such as electronics and welding.

The businesses surveyed employ approximately 7,000 workers, including full-time and part-time workers. About 470 of these employees are maintenance and repair workers.

Noteworthy findings from the survey include an optimistic hiring outlook by employers. More than half of employers surveyed said they planned to hire additional maintenance and repair technicians in the next two years. Projected additions translate to a 26 percent growth rate over the next two years. However, an economic projection using Bureau of Labor Statistics data is far lower, a 7 percent growth rate, which translates to an estimated 1,500 openings in the three study subregions.

These are solidly middle-skill jobs, and wages increase dramatically with experience. Most employers indicate that a high school diploma is sufficient for entry-level maintenance and repair technicians, and experience is more important than credentials.

The community colleges should consider the following actions based on this study's findings:

Work with employers to increase award completions in related programs aligned with local demand.

Demand appears strong across Northern California in a variety of industries including industrial maintenance and repair services, wholesale distribution facilities, agriculture and food processing manufacturing operations, and utilities. Industry partnerships, and curriculum and programs aligned with a range of employer needs should result in students finding high-road employment upon graduation. Overall, the data indicates that employer hiring needs are robust in this area, and that the workforce education and training infrastructure should invest more to increase the available pool of qualified technicians. The community colleges should consider scaling programs that have successful placement rates related to the field of study.

Work with employers to identify suitable skill enhancement milestones for programs, and experienced technicians, with the goal of training technicians with a variety of skillsets.

The evidence from the survey and secondary literature suggests that employers mostly do not provide formal training in house, or rely on formal external training resources to train the technician workforce. Nonetheless, the survey results indicate they have high skill and experience standards for their entry-level workers. Given these findings, there appears to be an opportunity to train well-rounded technician candidates and to offer skill enhancement training for the existing workforce.

Employers emphasize a need for a wide spectrum of technician skills. Responses to questions on job titles, machinery and equipment repaired, and skills, knowledge, and ability preferences indicate that most maintenance and repair activity involves a wide range of activities. Candidates and entry-level technicians who possess a broader set of skills are likely to add the most value. Program participants should be encouraged to attain a breadth of skills by offering milestone credentials en route to an associate degree or other technical credential, or to add to existing skillsets. Short-term, alternatively scheduled, or on-site training offerings could accommodate existing workers.

Provide extensive work-based learning, on-the-job training, and other employer-led training to give trainees practical experience as part of formal training efforts.

Many employers in the survey expressed interest in partnering with the community colleges on hiring and internship efforts. The responses mirror major findings from equipment and credentials questions, in which employers expressed strong preferences for technicians with practical, hands-on experience. To meet the need, the community colleges should consider ways to provide work-based learning en route to earning college and other industry and trade credentials. These could include credit mechanisms for internships, or for projects undertaken on campus or in an employer's facility, or through another project. Similarly, the community colleges might consider providing incumbent worker training or on-the-job training for new hires.

Work closely with employers, and continue monitoring market reporting and industry research to follow digital roadmaps and investment plans for highly-automated equipment.

The market, industry, and policy literature highlights present and future market pressures to lower costs and reduce delivery time to meet shifting customer demands. All signs point to increasing pressure on manufacturing and distribution companies to automate and digitize their operations, even if many or most businesses have not yet made these investments. Pilot programs, train-the-trainer workshops, equipment and machinery manufacturer partnerships, and other innovative approaches could be appropriate interim steps for the community colleges to begin weighing opportunities to consider new curriculum.

The community colleges, and manufacturing and industrial technology program leads, could look to other technical programs that have added curriculum that addresses digital integration with traditional equipment. Innovations taking place in commercial heating, ventilation, and air conditioning (HVAC) programs are an example. Some community colleges nationally have responded to the increasing use of automated, digital building controls in commercial buildings. Some community colleges have begun offering both integrated and specialized curriculum for these purposes.

APPENDIX A: SURVEY METHODOLOGY

The Standard Occupational Classification (SOC) code that most closely captures the specific activity related to this study is Industrial Machinery Mechanics (SOC 49-9041). The survey data suggests that related maintenance and repair activity is probably also counted in several other occupational codes. Other codes are not exclusive to industrial and manufacturing operations, and so were not included in the report.

The O*NET description and sample job titles reads as follows: Repair, install, adjust, or maintain industrial production and processing machinery or refinery and pipeline distribution systems.

A sample of reported job titles includes: Fixer, Industrial Machinery Mechanic, Industrial Mechanic, Loom Fixer, Machine Adjuster, Maintenance Mechanic, Maintenance Technician, Master Mechanic, Mechanic, and Overhauler.

Inverse staffing patterns on the most closely related Standard Occupational Classification (SOC) title and code—Industrial Machinery Mechanics (SOC 49-9041)—yielded the top industries in each region that employ related workers.

The major North American Industry Classification System (NAICS) codes were identified for each region using the total number and concentration of industrial machinery mechanics in each industry for each region.

High ranking NAICS codes that were common to two or three regions were included in a final list. A handful of NAICS codes that ranked highly in individual regions were also included.

The NAICS list gave the criteria for buying a business list used by Davis research, a call-center, in the implementation of the survey.

The table below briefly outlines sample composition for the survey. In late Fall 2017, the COE and Davis Research conducted a survey of 86 businesses throughout Northern California. Only respondents that were familiar with their company's hiring and workforce needs participated in the survey. Additional screener questions asked if the business has industrial machinery and equipment, and if it employs technicians who perform maintenance and repair.

Technique	Telephone and online survey
Sample Pool Size	762
Number of Respondents	86
Field Dates	October 25, 2017 – December 20, 2017
Incidence Rate	11%
Confidence Level	90%
Margin of error	+/- 10%

For the purpose of asking respondents to self-identify an industry, the research team aggregated NAICS categories for the survey question. The analysis allowed for re-coding some open-ended responses by looking up the websites of the companies included.

The following descriptions provide a summary of the types of businesses included in each survey category:

- The food and agricultural manufacturing category includes producers of nuts, olive oil, bakeries, rice and pasta, coffee and other specialty foods producers.
- The brewery and winery category includes a distillery.
- The repair and maintenance category is diverse, including an air compressor and vacuum company, welding shops, motor and engine repair, crane rental, industrial equipment repair, industrial cleaning, and ophthalmic goods manufacturing.
- The wholesale and distribution category includes suppliers of industrial rubber products, machine tools, pipes and valves, industrial gasses, and industrial air compressors.
- The industrial machinery manufacturing category includes manufacturers of bakery equipment, insulation, air compressors, coffee roasting equipment, grain processing and storage equipment, machine shop, LCD gaming monitors, utilities tooling and parts, and welding and metal fabrication.
- Utilities respondents provide products and services for water and oil facilities.

The remaining categories, including "other," contain aerospace and electronics, steel fabrication and construction employers.

APPENDIX B: INVERSE STAFFING PATTERNS

Inverse staffing patterns for the occupation show the top industries in each region that employ Industrial Machinery Mechanics (SOC 49-9041). The process for selecting eligible businesses for the survey was done partly by using the process for inverse staffing patterns for each region. Exhibits B1, B2, and B3 display the top 10 industries for each region by the estimated number of industrial machinery mechanics employed in the industry. The middle column shows the number of establishments in each region for each industry. The rightmost column displays the percentage of total industry employment made up by industrial machinery mechanics.

The commercial and industrial machinery and equipment repair and maintenance industry contains the highest employment concentration and total employment number for the occupation for each region. Local government, wineries, natural gas distribution, and industrial machinery and equipment wholesalers are also common in the three regions' top lists. Each region has unique industries with concentrations of industrial machinery mechanics.

Overall, the inverse staffing patterns suggest a couple things about employment concentration:

- Industrial machinery mechanics represent between 1 percent and 2 percent of total industry employment on average for the industries that employ the occupation in the studied regions.
- The occupational concentration difference from the survey data indicates that maintenance and repair activity is probably counted in several other occupational categories.

For the Bay region, occupational data analysis reveals there are about 5,000 industrial machinery mechanics. Several unique industries make up maintenance and repair employment in the Bay region: pharmaceutical preparation; petroleum refineries; and semiconductor manufacturing and machinery manufacturing (Exhibit B1).

Subclusters labeled manufacturing and traded are generally export oriented. The long-haul trucking logistics subcluster is labeled "traded." Wholesale, services, retail and transportation are other categories of activities.

Exhibit B1. Top 10 industries employing industrial machinery mechanics in the 12-county Bay region

NAICS	Industry Description	2017 IMM Jobs	# Estab. in Region	M&R as % of Industry Emp.
811310	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	511	330	12.9%
312130	Wineries	319	974	1.5%
325412	Pharmaceutical Preparation Manufacturing	196	72	1.1%
221210	Natural Gas Distribution	185	17	1.4%
334413	Semiconductor and Related Device Manufacturing	181	340	0.6%
903999	Local Government, Excluding Education and Hospitals	176	967	0.1%
423830	Industrial Machinery and Equipment Merchant Wholesalers	170	375	3.2%
324110	Petroleum Refineries	116	20	2.4%
111000	Crop Production	112	1,419	0.3%
333242	Semiconductor Machinery Manufacturing	103	81	1.1%

There are about 5,200 maintenance and repair technicians in the Central Valley/Mother Lode region. Several unique industries are among the top 10 including fruit and vegetable canning, cheese manufacturing, poultry processing, and roasted nuts and peanut butter manufacturing (Exhibit B2).

Exhibit B2. Top 10 industries employing industrial machinery mechanics in the 15-county Central Valley/Mother Lode region

NAICS	Industry description	2017 IMM Jobs	#Estab. In Region	M&R as % of industry emp.
811310	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	796	345	18.7%
311421	Fruit and Vegetable Canning	355	38	4.4%
312130	Wineries	200	173	2.7%
903999	Local Government, Excluding Education and Hospitals	180	973	0.2%
111000	Crop Production	171	3,847	0.3%
311513	Cheese Manufacturing	169	23	3.9%
423830	Industrial Machinery and Equipment Merchant Wholesalers	157	223	5.7%
221210	Natural Gas Distribution	152	24	3.2%
311615	Poultry Processing	144	116	1.7%
311911	Roasted Nuts and Peanut Butter Manufacturing	134	22	3.0%

There are about 1,900 maintenance and repair technicians in the North/Far North region. Federal and local government employment ranks second (Exhibit B3). Rice milling, fruit and vegetable canning, sawmills and temporary help services are among the unique industries in the region employing maintenance and repair technicians.

Exhibit B3. Top 10 industries employing industrial machinery mechanics in the 22-county North/Far North region

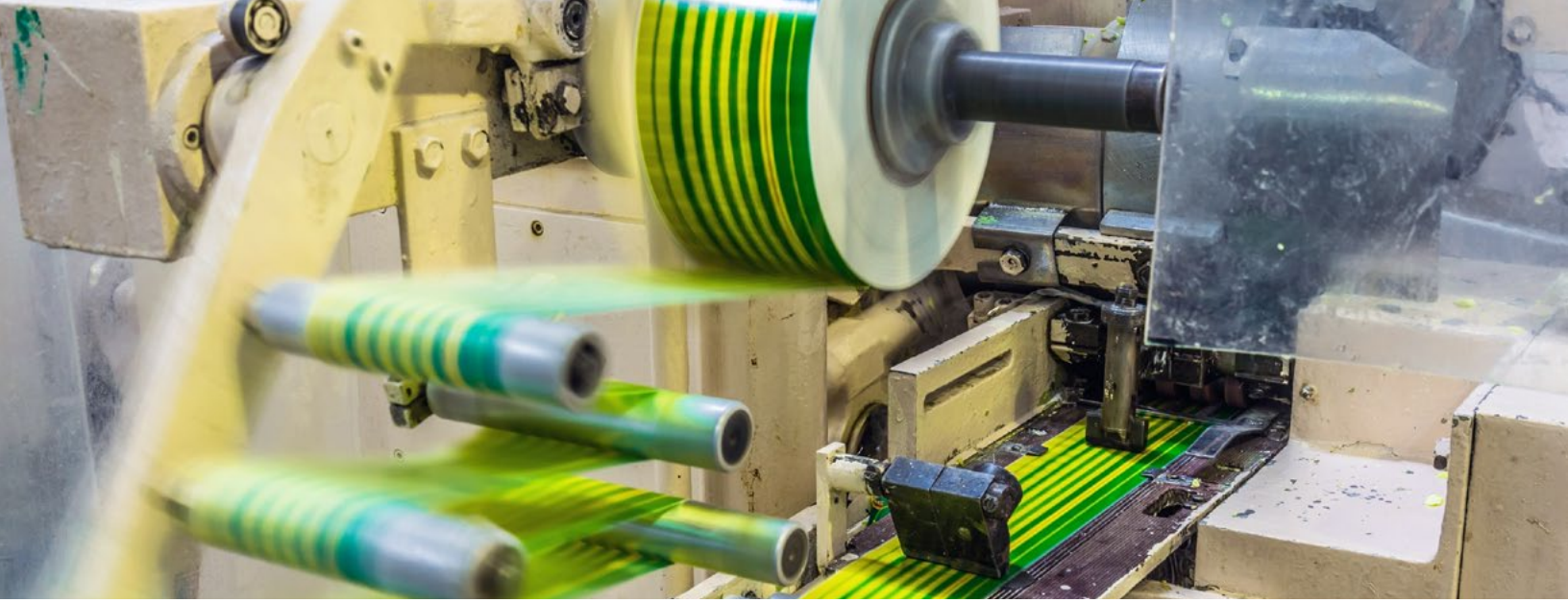
NAICS	Industry Description	2017 IMM Jobs	#Estab. in Region	M&R as % of Industry Emp.
811310	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	280	175	14.5%
903999	Local Government, Excluding Education and Hospitals	147	1,190	0.2%
423830	Industrial Machinery and Equipment Merchant Wholesalers	92	154	4.5%
221210	Natural Gas Distribution	59	301	2.2%
111000	Crop Production	45	1,899	0.3%
311212	Rice Milling	39	58	3.3%
311421	Fruit and Vegetable Canning	38	17	2.3%
321113	Sawmills	38	34	1.5%
561320	Temporary Help Services	34	286	0.1%
901199	Federal Government, Civilian, Excluding Postal Service	34	371	0.2%

APPENDIX C: SURVEY RESPONDENTS BY COUNTY

Survey respondents were asked to identify the county where their company is physically located. In the Bay region, Alameda and Sonoma counties have the largest number of responses; in the Central Valley region, Stanislaus and Fresno counties have the largest number of survey responses; in the North/Far North region, Yolo and Sacramento counties have the greatest number of respondents (Exhibit C1).

Exhibit C1. Number of survey respondents by county

Region	County	Count
Bay Area	Alameda	9
	Sonoma	8
	Napa	4
	Monterey	3
	San Francisco	3
	Santa Cruz	2
	Santa Clara	2
	Contra Costa	1
	San Mateo	1
	Solano	1
	Marin, San Benito, Sonoma	0
Central Valley	Stanislaus	6
	Fresno	5
	Tulare	3
	Kern	3
	San Joaquin	2
	Alpine, Amador, Calaveras, Inyo, Kings, Madera, Mariposa, Merced, Mono, Tuolumne	0
North/Far North	Yolo	7
	Sacramento	6
	Butte	4
	Shasta	4
	Mendocino	3
	Placer	3
	El Dorado	2
	Glenn	1
	Humboldt	1
	Colusa	1
	Siskiyou	1
	Del Norte, Lake, Lassen, Modoc, Nevada, Plumas, Sierra, Sutter, Tehama, Trinity, Yuba	0



APPENDIX D: EMPLOYMENT AND PROJECTED OCCUPATIONAL DEMAND

The following tables show current employment and projected occupational demand for industrial machinery mechanics (SOC 49-9041) in the three Northern California study regions.[12]

The survey asked employers about their hiring projections over the next two years. The occupational data for two-year and five-year projections, including annual openings are shown in Exhibits D1 and D2.

Exhibit D1. Employment and two-year projections for industrial machinery mechanics

Subregion	2017 Jobs	2019 Jobs	2-year % Change	2-year Change	Average Annual Openings, 2017–2019
Bay Area	5,001	5,383	8%	382	625
Central Valley/Mother Lode	5,258	5,605	7%	347	629
North/Far North	1,899	2,061	9%	162	246
All Study Regions	**12,158**	**13,048**	**7%**	**890**	**1,500**

Exhibit D2. Employment and five-year projections for industrial machinery mechanics

Subregion	2017 Jobs	2022 Jobs	5-year % Change	5-year Change	Average Annual Openings, 2017–2022
Bay Area	5,001	5,813	16%	812	619
Central Valley/Mother Lode	5,258	5,989	14%	731	621
North/Far North	1,899	2,240	18%	341	243
All Study Regions	**12,158**	**14,042**	**15%**	**1,884**	**1,483**

[12] Emsi 2018.1.

APPENDIX E: OCCUPATIONAL WAGE DATA COMPARED TO SURVEY WAGE DATA

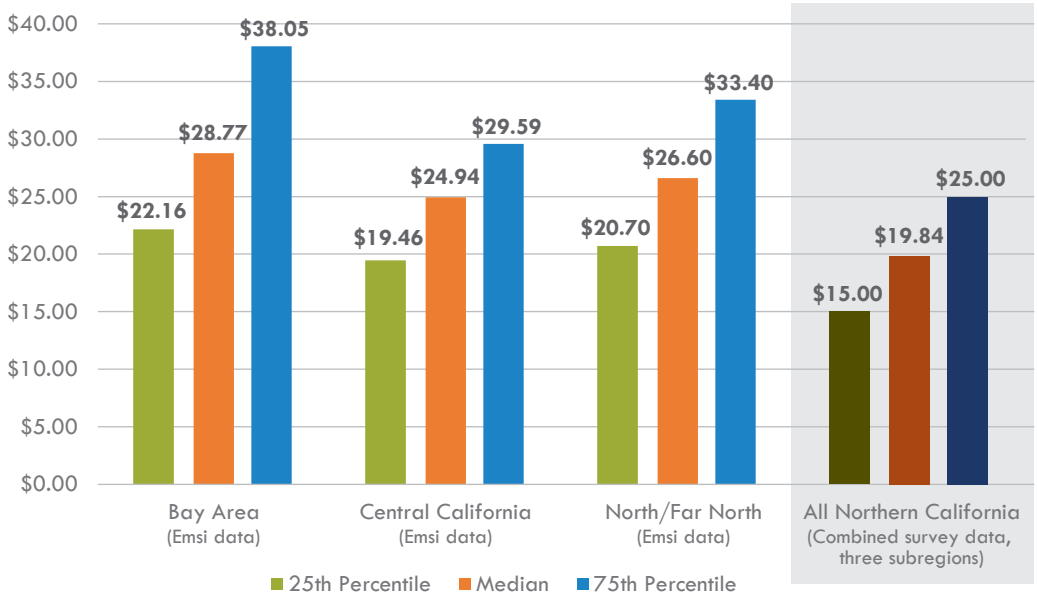
Exhibit E1 compares wage levels cited in the survey (the shaded bars in the exhibit below) to the data collected by the Bureau of Labor Statistics (BLS) provided by Emsi. The wage rates provided by surveyed employers is lower than wage rates collected by the BLS.

The BLS occupational wage data for the study regions shows wages are between $5 per hour and $15 per hour higher than the wage data collected by the survey.

One important difference in the data sources is the type of worker, and the way they are counted. It is possible that many of the workers analyzed in the survey would be counted under separate occupational categories, some that would typically pay less than what industrial machinery mechanics earn.

Nonetheless, the BLS occupational wage data indicates that at least some of the industrial maintenance technician workforce will be compensated at the upper end of the survey's wage range.

Exhibit E1. Wages for entry-level and experienced maintenance and repair technicians (compares Emsi data for each region to the survey data for all three regions combined [n=86])

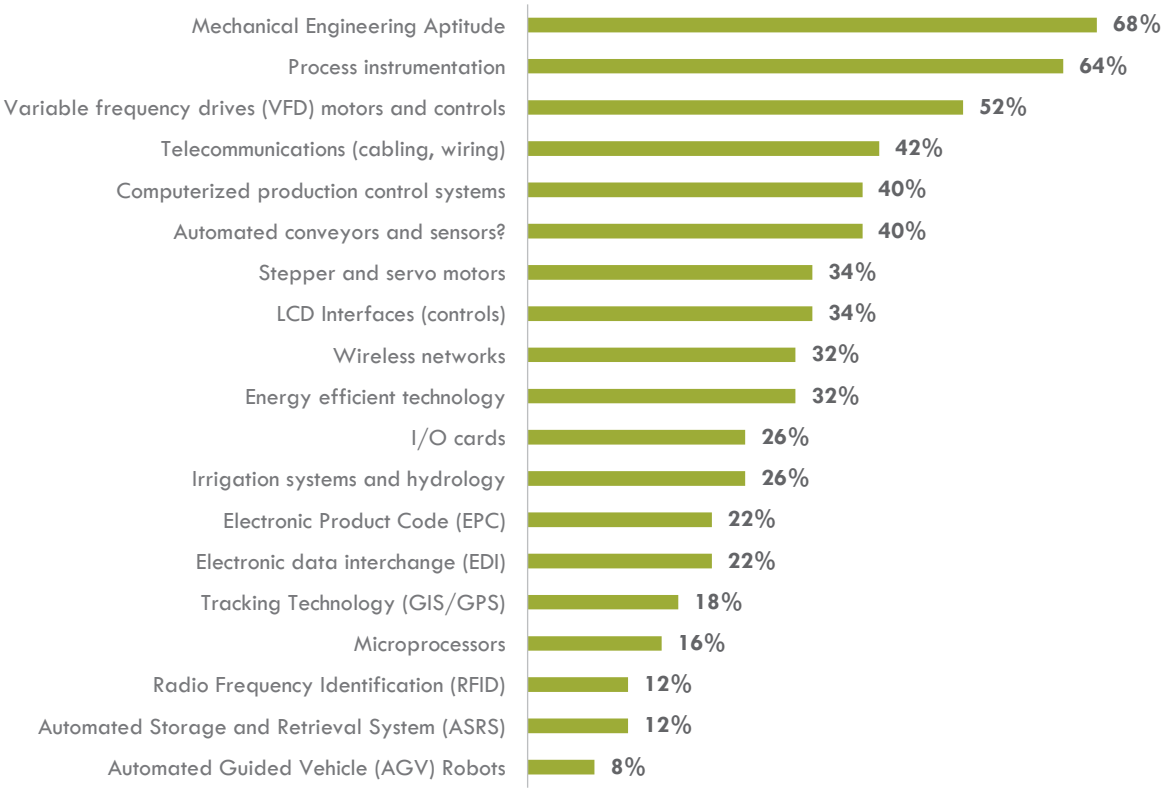


APPENDIX F: PREFERRED AND REQUIRED SKILLS, HIGH SCHOOL OR EQUIVALENT

The research team analyzed equipment and technology knowledge needs for those employers who indicated high school or equivalent as the preferred education level for entry-level maintenance and repair technicians (Exhibit F1).

The 50 responses gathered are similar to those displayed in Exhibit 26, highlighting mechanical engineering aptitude, process instrumentation, variable frequency drives, motors or controls. The responses suggest that skills rise above what students might learn in high school, raising potential opportunity for training and education providers to provide skills training in these areas.

Exhibit F1. Employer preferences for knowledge of equipment and technology for entry-level technicians, employers who responded that high school was the preferred education level for entry-level applicants (n=50)



APPENDIX G: ADDITIONAL EQUIPMENT TYPES USED IN EMPLOYER OPERATIONS

Some of the equipment and machinery listed by employers in their responses enabled coding analysis, but many of the open-ended responses were distinct. The list of open-ended responses are shown in Exhibits G1 and G2.

Exhibit G1. Open-ended responses, types of equipment and machinery used in facility operations

Destemmer (5)	Food processing equipment (3)	Filling equipment (2)
Ovens (5)	Fermentation equipment (3)	Electronic sorters (2)
Trucks (5)	Press brake (3)	Drill presses (2)
Tanks (4)	Glycol systems (3)	Food packaging equipment (2)
Presses (4)	Chillers (3)	Sealers (2)
Tractors (4)	Air conditioning machines (3)	Waste water equipment (2)
Bin dumpers/tippers (4)	Pneumatic equipment (3)	Lasers (2)
Mixers (4)	Agricultural machinery (3)	Packaging equipment (2)
Hydraulic equipment (4)	Boilers (3)	Band saws (2)
	Computers (3)	Paint systems (2)
	Bending machines (3)	Scales (2)
	Cranes (3)	Pallet jacks (2)
	Eyeglass lens equipment (3)	Loaders (2)
		Kitchen equipment (2)
		Hand tools (2)
		Choppers (2)
		Cutting machines (2)
		Heavy industrial equipment (2)
		Hoses (2)

Exhibit G1. Open-ended responses, types of equipment and machinery used in facility operations (continued)

Air lappers	CNC plasma table	Ingredient depositors	Retail bagging equipment
Alignment racks	Cookers	Ironman	Robots
Assembly lines	Crimping machines	Jar fillers	Roll grooving machines
Augers	Crushers	Laboratory equipment	Rolling
Auto lifts	Custom test fixtures	Large drills	Rolling stock
Autocad gasket cutting	Density gauges	Lifts	Sackline equipment
Autoclaves	Dicers	Load cell testers	Sanding power tools
Auto-insertion equipment	DMA TG testers	Mash kettles	Scalders
Automatic bag placers	Dough rollers & cutters	Metal cutting machines	Scissor lifts
Automatic packaging equipment	Drink dispensers	Motorized fork and clamp trucks	Scrubbers
Automatic screw feeders	Drip irrigation	Motors	Shaker tables
Automobiles	Dynamometer	NCM tooling centers	Shears
Bag sealers	Electrical panels	Nitrogen tanks	Skidsteers
Belt conveyor makers	Electrical testing equipment	Nut hulling equipment	Small power/hydraulic tools
Bench hogs	Electronic sensors	Nut shelling equipment	Soldering equipment
Blanchers	Electro-static precipitators	Optical sorter	Sorting equipment
Bobcats	Espresso machines	Pasteurization equipment	Spray rigs
Box sealers	Forming fans	Pipe threading machines	Steam kettle
Case erectors	Freezers	PLC control systems	Stretch wrappers
Case fillers	Fruit dehydration equipment	Pressure testers	Thermal oxidizers
Chamfers	Fryers	Printers	Trellis materials
Chief frame machines	Furnaces	Programmable band saws	Turntables
Clamps	Generators	Proof boxex	Ultrasonic C-Scan machines
Clean rooms	Grinders	Radiator tests	Vacuums
CMM	Hoe making machines	Registers	Vehicles
	Hose insulation		Warehouses
	Hot oil presses		Warewashing
	Hydrostatic testing devices		Weigh scales

APPENDIX H: FOCUS GROUP, TOPLINE REPORT

The Central Valley/Mother Lode Region Center of Excellence partnered with Davis Research to conduct a focus group on industrial maintenance mechanics (IMM). The section below contains the topline summary report produced by Davis Research.

I. Research objective & methodology

The main objective of the focus group was to understand how the skills sets of this occupation may be changing and evolving due to automation and introduction of new IT or other technologies. The new or changing skill requirements identified will be included in the upcoming employer survey.

One two-hour focus group was conducted on July 27, 2017 at Clovis Community College (Herndon Campus).

The focus group consisted of managers and executives from a diversity of companies/industries who employ IMMs or offer positions that are closely related in duties to IMM. A total of nine people participated. The industries represented:

- Manufacturing (drip irrigation; wheelchairs; tomato harvesters; tents/awnings; propane storage tanks),
- Water treatment,
- Waste management,
- Metal finishing and plating,
- Wholesale (industrial rubber products), and
- Automotive service.

All participants were recruited by Davis Research from a list of members of the San Joaquin Valley Industrial Manufacturing Alliance.

The focus group was moderated by Eric Johnston, who also authored the findings in this topline report.

Important Caveat/Projectability of Findings: These topline findings are qualitative in nature; no statistical projections cannot be made from qualitative research due to the very small sample size.

II. Technological trends & challenges

Participants note several evolving trends and changes in their industries and IMM-related positions due to the growing impact of automation and the integration of IT/technology with equipment; they often cite the following as becoming more prevalent:

- The use of PLCs to manage various systems and equipment... participants frequently state that it's a very big challenge to find applicants who have PLC programming skills and knowledge; this is a critical need
- More electronically sophisticated, advanced components and interfaces on industrial equipment... such as an LCD interface/display screen on plasma cutting table and plate rolling machine
- Remote access to equipment/remote diagnostics (requiring IT and Wi-Fi expertise)
- Vision systems
- Computerized production control systems
- More rapid production due to increasing use of robotics and automated equipment... equipment is faster, information/data is faster, expectations are greater throughout the company
- Computer-aided design
- ERP & MRP systems
- Environmentally-friendly equipment (relating to efficiency, emissions reduction systems, etc.)

There is frequent frustration expressed that as industrial equipment becomes more technologically advanced and specialized, it is becoming increasingly difficult to find prospective workers who possess the required skills sets and knowledge to operate, program and repair the equipment. Several employers report they send employees to training sessions on advanced/specialized equipment offered by the OEMs—or, in a couple of cases, certain companies will actually outsource their equipment repair.

III. Industrial maintenance mechanic job titles

Four participants in the focus group report that they specifically have a "Maintenance Mechanic" position at their company; the remaining participants reveal various other job titles at their company (often reflective of their specific industry) which they state are closely related to IMM/duties. These include:

- Service Technician
- Heavy Equipment Mechanic
- Mechanic
- Machine Technician
- Industrial Technician
- Extrusion Technician
- Shift Technician
- Refrigeration Operator
- Sewing Machine Mechanic
- Hydraulic Assembly Specialist
- Assembly Specialist
- Maintenance, Repair & Operations (MRO)
- Automotive Technician

Many report that it can be difficult to find qualified candidates for these positions: beyond not possessing the technological knowledge and skills which are becoming important with the advent of automation, applicants reportedly often do not have the traditional core competencies and skills expected for a "mechanic" position—such as an understanding of electrical principles/theory, mechanical/engineering aptitude, plumbing knowledge, etc.

IV. Future skill requirements for IMM occupation

Participants see the following skills for IMMs as being important requirements in the next three years due to the increasing use of automation and technology integration with industrial equipment:

- Ability to program PLCs... the most frequently cited skill
  - o HMI programming
- Understanding of information technology... including Wi-Fi networks, remote operation and diagnostics, phone apps
- Data analytics and interpretation... especially given how much data is collected due to the increased speed and automation of equipment
- Computer skills/computer programming... software and hardware... including the ability to program computerized maintenance software
- Proficiency in computer-aided design... SolidWorks is the most cited design program
- Understanding of robotics
- Ability to interact with computerized/LCD interfaces on equipment... CNC machine equipment
- MTTR & MTBF understanding
- Ability to read and interpret schematics/drawings
- Technical writing skills
- Familiarity with energy-efficient technology (specifically for heavy equipment and commercial vehicles)
- Ability to perform predictive maintenance
- Understanding of communication protocols
- Ability to collaborate with others/work well in a team

Beyond these skill requirements, participants also stress that core competencies and skills traditionally associated with the IMM occupation need to be taught in the future because they are lacking in today's workforce; the key skills cited are:

- Basic mechanical skills and knowledge
- Understanding of electrical principles/theory and electrical components/systems... able to work on circuits, read/interpret circuit drawings
- Ability to work with mechanical tools and electrical tools
- Familiarity with hydraulics... how a hydraulic system and its components work (e.g., pump, pressure gauge, etc.)
- Knowledge of plumbing systems
- Understanding of HVAC
- Ability to read a flowchart... an understanding of the flow process
- Analytical skills
- System diagnostics
- Fabrication
- Welding
- Critical thinking, problem-solving, trouble-shooting
- Understanding of business math

V. Partnerships with community colleges

Participants state that they are very receptive to partnering with local community colleges in the future to develop and train workers.

Many complain that students graduating from community colleges (and state schools) today do not receive much-needed hands-on training/experience in the field as part of their education; they believe that students' learning is largely confined to the classroom and computer, and this does not prepare them adequately for the workforce.

Participants believe that community college programs in the future should integrate on-the-job training (e.g. internships) into the curriculum so that students can gain hands-on experience with using tools and equipment as part of their education. These company representatives indicate that they would be willing to consider offering internships to local community colleges to help with this goal; such internships would also help companies identify and develop future employees.

Furthermore, participants are very interested in sending their workers to community college training classes/programs which would teach key skills such as PLC programming (other topics suggested: electrical; HVAC). Most believe that Monday or Wednesday evenings would be the best time for their employees to attend such classes.

APPENDIX I: COMMUNITY COLLEGE SUPPLY DETAIL, BY COLLEGE

For each of the study regions, community college programs related to industrial maintenance mechanics are summarized:

Bay Area

- Electro-mechanical technology – one college, one program and zero completions;
- Industrial electronics – one college, two programs and 32 completions;
- Industrial systems technology and maintenance – six colleges, 11 programs and 21 completions; and
- Manufacturing and industrial technology – two colleges, five programs and 13 completions.

Central Valley/Mother Lode

- Electro-mechanical technology – one college, one program and one completion;
- Industrial electronics – three colleges, eight programs and 32 completions;
- Industrial systems technology and maintenance – five colleges, 10 programs and 48 completions; and
- Manufacturing and industrial technology – five colleges, 12 programs and 50 completions.

North/Far North

- Industrial electronics – two colleges, five programs and 87 completions;
- Industrial systems technology and maintenance – one college, one program and 32 completions; and
- Manufacturing and industrial technology – three colleges, six programs and 21 completions.

Exhibit I1 shows the colleges in each of the three study regions, the related programs they offer and the average annual number of completions for each program.

Exhibit I1. Four-year annual average community college supply in the three regions, awards 2013–2017

Region/College	Program Name	Certificates	Degrees	Average Total
Bay Area				
De Anza	Manufacturing and Industrial Technology	8	5	13
Diablo Valley	Industrial Systems Technology and Maintenance		1	1
Hartnell	Industrial Systems Technology and Maintenance	2		2
Laney	Industrial Systems Technology and Maintenance	12		12
Los Medanos	Industrial Electronics	19	13	32
	Industrial Systems Technology and Maintenance	25	21	46
San Francisco	Manufacturing and Industrial Technology	1		1
San Jose City	Industrial Systems Technology and Maintenance	3	4	7
Skyline	Electro-Mechanical Technology			
Solano	Industrial Systems Technology and Maintenance	2	2	4
	Manufacturing and Industrial Technology			
	Sub-total	**71**	**45**	**116**
Central Valley				
Bakersfield	Manufacturing and Industrial Technology	1	2	2
Cerro Coso	Manufacturing and Industrial Technology			
Fresno City	Industrial Electronics	16		16
	Industrial Systems Technology and Maintenance	7		7
	Manufacturing and Industrial Technology	26	2	28
Merced	Industrial Electronics	2	2	4
	Industrial Systems Technology and Maintenance	1	1	2
Modesto	Industrial Electronics	2	10	12
	Industrial Systems Technology and Maintenance		1	1
	Manufacturing and Industrial Technology	2		2
Porterville	Manufacturing and Industrial Technology	18		18
San Joaquin Delta	Electro-Mechanical Technology	1		1
	Industrial Systems Technology and Maintenance	3		3
Sequoias	Industrial Systems Technology and Maintenance	33	2	35
	Sub-total	**111**	**19**	**130**
North/Far North				
American River	Industrial Electronics	4		4
Redwoods	Manufacturing and Industrial Technology	2	2	3
Sacramento City	Industrial Systems Technology and Maintenance	32		32
Shasta	Manufacturing and Industrial Technology	2		2
Sierra	Industrial Electronics	55	28	83
	Manufacturing and Industrial Technology	7	9	16
	Sub-total	**101**	**38**	**139**
	TOTAL	**283**	**102**	**385**

APPENDIX J: BIBLIOGRAPHY

"Making It in America: Revitalizing U.S. Manufacturing," McKinsey Global Institute, McKinsey&Company, November 2017, https://www.mckinsey.com/~/media/McKinsey/Global%20Themes/Americas/Making%20it%20in%20America%20Revitalizing%20US%20manufacturing/Making-it-in-America-Revitalizing-US-manufacturing-Full-report.ashx.

"Material Handling and Logistics U.S. Roadmap 2.0," MHI, April 2017, http://www.mhlroadmap.org.

"Out of Inventory: Skills Shortage Threatens Growth for U.S. Manufacturing," Accenture and the Manufacturing Institute, 2014, http://www.themanufacturinginstitute.org/Research/Skills-and-Training-Study/~/media/70965D0C4A944329894C96E0316DF336.ashx.

Parrot, Aaron and Lane Warshaw, "Industry 4.0 and its digital twin," Deloitte, May 12, 2017, https://www2.deloitte.com/insights/us/en/focus/industry-4-0/digital-twin-technology-smart-factory.html?icid=dcom_promo_standard|us;en.

"The robots are ready. Are you?" Deloitte, 2017, https://www2.deloitte.com/uk/en/pages/consulting/articles/the-robots-are-ready-are-you.html.

"Summary Report for: 49-9041.00 - Industrial Machinery Mechanics," O*Net OnLine, site updated May 29, 2018, https://www.onetonline.org/link/summary/49-9041.00.

"Upskilling Manufacturing: How Technology Is Disrupting America's Industrial Labor Force," PwC, June 2016, http://www.themanufacturinginstitute.org/Research/Disruptive-Innovations-in-Manufacturing/~/media/E9F0B41DEC4F40B6AE4D74CBC794D26D.ashx.

"The Skills Gap in U.S. Manufacturing: 2015 and beyond," Deloitte and the Manufacturing Institute, 2015, https://www2.deloitte.com/us/en/pages/manufacturing/articles/boiling-point-the-skills-gap-in-us-manufacturing.html.

MORE ABOUT THE CENTERS OF EXCELLENCE

The Centers of Excellence (COE) for Labor Market Research deliver regional workforce research and technical expertise to California Community Colleges for program decision making and resource development. This information has proven valuable to colleges in beginning, revising, or updating economic development and Career Education (CE) programs, strengthening grant applications, assisting in the accreditation process, and in supporting strategic planning efforts.

The Centers of Excellence Initiative is funded in part by the Chancellor's Office, California Community Colleges, Economic and Workforce Development Program. The Centers aspire to be the leading source of regional workforce information and insight for California Community Colleges. More information about the Centers of Excellence is available at **www.coeccc.net**.

For more information on this study, contact:

Aaron Wilcher, Director, North/Far North Region COE,
Los Rios Community College District
(916) 563-3233
wilchea@losrios.edu

John Carrese, Director, Bay Region COE,
City College of San Francisco
(415) 452-5529
jcarrese@ccsf.edu

Nora Seronello, Director, Central Valley/Mother Lode Region COE, Modesto Junior College
(209) 575-6894
seronellon@mjc.edu

Important Disclaimer

All representations included in this report have been produced from primary research and/or secondary review of publicly and/or privately available data and/or research reports. Efforts have been made to qualify and validate the accuracy of the data and the reported findings; however, neither the Centers of Excellence, COE host District, nor California Community Colleges Chancellor's Office are responsible for applications or decisions made by recipient community colleges or their representatives based upon components or recommendations contained in this study.

Please consider the environment before printing.
This document is designed for double-sided printing.

C·O·E
CENTERS OF EXCELLENCE
Inform Connect Advance