ELECTRIC UTILITY WORKFORCE DEVELOPMENT AND DECARBONIZATION

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Acknowledgments

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ABSTRACT

This report examines the craft-level professional skills required to support the U.S. energy transition, providing an initial look at some of the electric sector craft labor demand implied by a 50% reduction in economy-wide greenhouse gas emissions by 2030. The study starts by developing a regional characterization of the current state of the skilled workforce versus current demands. It then explores potential electric sector workforce gaps implied by rapid decarbonization of the power generation sector and accelerated economy-wide electrification. This report identifies potential strategies and policies the construction industry and electric companies could consider to help ensure that an adequately sized and skilled workforce is available to support interim decarbonization goals.

Keywords

Decarbonization
Energy transition
Labor risk
Skilled construction workforce
Work force demand

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EXECUTIVE SUMMARY

ELECTRIC UTILITY WORKFORCE DEVELOPMENT AND DECARBONIZATION

Research Overview

To achieve economy-wide decarbonization targets, existing and new low-carbon and low-carbon-enabling technologies must be deployed at an accelerated pace through the 2020s.

Analysis by the Electric Power Research Institute (EPRI), *Strategies and Actions for Achieving a 50% Reduction in U.S. Greenhouse Gas Emissions by 2030* (referred to as the *50x30 study*[1] henceforth), projects that over the next decade, economy-wide decarbonization will likely entail the following:

- A rapid scale-up of renewable energy, inter- and intra-state transmission infrastructure, grid modernization, electrification, distributed energy resources, storage, building efficiency, and electric vehicle (EV) charging infrastructure
- The closure and/or repurposing of existing fossil plants coupled with construction of new, lower emitting firm capacity
- The development/demonstration and start of construction of carbon capture and sequestration, hydrogen, and nuclear technologies to provide a pathway to meet longer term targets

As the demand for these technologies increases, a competent, capable construction workforce is needed to ensure a safe, reliable, and cost-effective energy transition. As the energy transition accelerates in the 2020s, there will be an inherent shift in trade skills and energy professional expertise required to build and support the system.

Key Findings

- The skilled construction trades face substantial workforce shortages assuming the levels of construction needed to build the grid and generating resources projected in all of the 50x30 study's scenarios: reference (assumes no new policies that are not on the books), 50% reduction in economy-wide emission from 2005 levels, and accelerated electrification scenarios. The accelerated electrification case modifies the 50% reduction scenario by allowing more rapid improvements in electricity-using technologies, giving end users additional reasons to adopt new products and technologies. Of the 20 skilled trades examined in this report, only 7 (carpenter, craft helper, elevator installer and repairer, laborer, heavy equipment operator, painter, and truck driver) appear to be adequately resourced through 2030.
- Shortages of workers are projected to be most pronounced in the Midwest, particularly in the MISO East, MISO Northwest, MISO South, Southeast, and Ohio Valley regions. The California, Mid-Atlantic, Mountain, New York, and Pacific Regions are comparatively well-off but still face worker shortages in key trades—boilermaker-welders, carpenters, instrument technicians, insulators, ironworkers, millwrights, and heavy crane operators.
- The differences in skilled trade requirements between the 50% decarbonization case and the accelerated electrification case are relatively small. Resource plans for utilities across the nation already include substantial additions of renewables to their electric grids, and a majority of states have programs that incentivize adding solar and wind to their generation mix.

[1] https://www.epri.com/research/products/000000003002023165

EXECUTIVE SUMMARY | Key Findings

- Trades that appear comparatively well-resourced are generally associated with higher average wages and/or lower skill requirements. For example, craft helpers, construction laborers, painters, and operators (truck drivers) are well-resourced across the regions, but these are among the occupations where entry is easiest. Among those trades where worker shortages are most likely are boilermakers, carpenters, insulators, ironworkers, and millwrights. Comparatively well-paid but more difficult to enter licensed trades like electricians and pipefitters fall in the middle.
- Although there is confidence in the estimates of the numbers of workers needed to build out the power system under the reference, 50% decarbonization case, and the high electrification scenarios, there is more uncertainty around estimates of current and future craft labor supply. The main source of supply information is the U.S. Occupational Employment and Wage Statistics,[2] published annually for states and major metropolitan areas. It does not provide direct measures of total supply, and there are considerable gaps in the data that it does supply.
- In the absence of focused efforts to expand them, craft labor forces are projected to decrease over time due to natural attrition and lack of adequate development pipelines. These declines have the potential to limit project development under scenarios with accelerated deployment of new energy assets, could lead to increased costs due to competition for qualified craft labor, and create safety, schedule, and work-quality risks. With the projected shift in labor needs driven by the energy transition, certain skills and trades could become obsolete, creating opportunities to transition those affected to support deployment and operation of expanding technologies.

After providing insights into potential staffing supply and demand, the report identifies seven potential strategies to help address projected shortfalls. Two of the strategies, derived from successful industry approaches that have improved workplace safety in recent decades, have the potential to produce near-term, meaningful change in workforce development and training:

1) using metrics and benchmarking to drive improvement and

2) standardizing workforce investment.

Also critical to addressing the skilled labor need of the future is closer collaboration among owners, contractors, and workers to better project specific labor needs and invest in workforce development and training.

[2] https://www.bls.gov/oes/

1. INTRODUCTION

In the last decade, the technology mix of electricity generation resources for bulk power systems in North America has changed. Natural gas and renewables have displaced coal and now jointly provide the majority of electricity generation resources. By 2020, natural gas was the energy source for 40% of bulk power generation in the United States. At 20% of the total, renewables were fast-growing, fueled by gains in utility-scale solar and wind. The recent trends are projected to continue. In the North American Reliability Corporation's Summer 2020 Long-Term Reliability Assessment, natural gas, solar, and wind dominated prospective Tier 1 additions through 2030; wind and solar resources nearly matched planned additions of natural gas–fired capacity.[3]

In January 2021, newly inaugurated President Joe Biden signed an executive order for the United States to rejoin the Paris Climate Accord, binding the U.S. to meet its original December 2015 pledge to reduce U.S. greenhouse gas emissions (GHG; additional acronyms listed in Appendix A) between 26% and 28% by 2025 using the nation's 2005 emissions as a baseline. And in April 2021, the U.S. announced a strengthened commitment to cut 2030 GHG emissions by 50–52% below the 2005 level.

A fundamental question that arises given the need for rapid acceleration of technology deployment to meet near-term targets is whether the United States has the material and labor resources to meet its Paris goals. The primary focus of this report is whether the U.S. labor force has sufficient skilled trade workers to meet the prospective needs of owners and contractors. Key questions include 1) Are there enough skilled tradesmen and women to meet the combined public and private infrastructure needs implied by the Infrastructure Investment and Jobs Act, which became law on November 15, 2021, and the needs driven by U.S. decarbonization goals; 2) Does the distribution of workers across trades match the regional needs of pending infrastructure projects, public and private; and 3) What are recent and projected wage trends for the skilled trades; that is, will workers be both available and affordable?[4]

The impacts of these policies over the next decade are unclear because implementation rules and guidelines are still to be developed. To provide early insights, this analysis compares regional skilled trade workforces to projected construction needs under two scenarios from the EPRI report *Strategies and Actions for Achieving a 50% Reduction in U.S. Greenhouse Gas Emissions by 2030*,[5] where the U.S. adds sufficient electric transmission and generation capacity

[3] See North American Reliability Corporation. 2020. "2020 Long-Term Reliability Assessment," Capacity Additions, p. 26 at https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2020.pdf. Tier 2 solar and wind additions exceed natural gas additions.

[4] There are also important differences in worker skill and experience that are harder to address but presumably are reflected in the differences in wage rates paid to individual tradesmen.

[5] *Strategies and Actions for Achieving a 50% Reduction in U.S. Greenhouse Gas Emissions by 2030*. EPRI, Palo Alto, CA: 2021. 3002023165.

to meet its 2030 Paris targets while meeting the labor needs implied by an initial interpretation of the public infrastructure program. Figure 1-1 summarizes findings of the report with respect to the expected capacity additions required to meet the targets. Projected capacity additions in the 2020s total around half the capacity of the current U.S. grid in both 50x30 scenarios. Annual wind and solar capacity additions would be two to three times their historical rates. Capacity additions—including renewables, storage, and natural gas—would exceed on average the historical maximum annual deployment in each year through 2030. In most instances, local transmission additions are needed to connect these new resources to the grid. In addition, inter-regional transmission is projected to increase by 20% relative to current levels to help balance hourly supplies with demands economically. Deployment of this generation and grid equipment depends critically upon rapidly expanded equipment and labor supply. This study examines how these additions could influence labor demand required to support construction of these energy assets.

The analysis examines the needs for 20 construction skilled trades in each of 16 U.S. regions (depicted in Figure 1-2). The occupations correspond to 20 key skilled trades for building, upgrading, and repairing power generation, electricity distribution lines, and telecommunication networks. The occupational analysis is based on state-level data aggregated to be consistent with the 16 regions for which EPRI provided construction buildouts.

The skilled trades examined roughly correspond to the Bureau of Labor Statistics (BLS) Standard Occupational Classification Codes, a system of 867 detailed occupations designed to cover all workers in the United States. The skilled trades examined in this report are as follows with additional detail for each discipline provided in Appendix B:

- Boilermaker
- Carpenter (Pile Driver/Operator)
- Carpenter (Scaffold Builder)
- Concrete Finisher-Cement Mason
- Craft Helper
- Electrician
- Elevator Installer and Repairer
- Instrumentation Technician
- Insulator
- Ironworker (Reinforcing)
- Ironworker-Welder
- Laborer
- Lineman
- Millwright
- Operator (Heavy Crane)
- Operator (Heavy Equipment)
- Operator (Truck Driver)
- Painter
- Pipefitter
- Sheet Metal Worker[6]

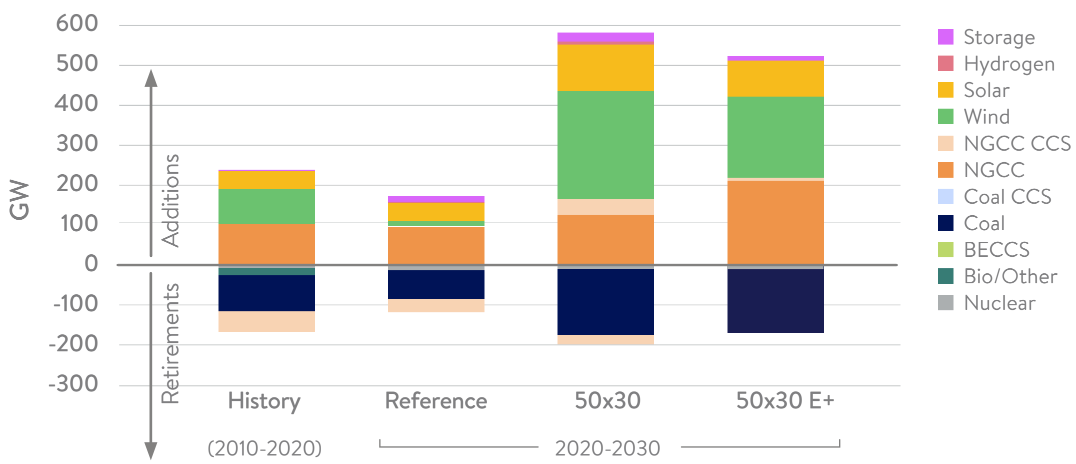

Figure 1-1. *Historical and projected capacity additions and retirements by technology, comparing decadal rates of change*

[6] See Appendix B for a listing of the skilled trades and standard occupational codes for their roles in the workplace.

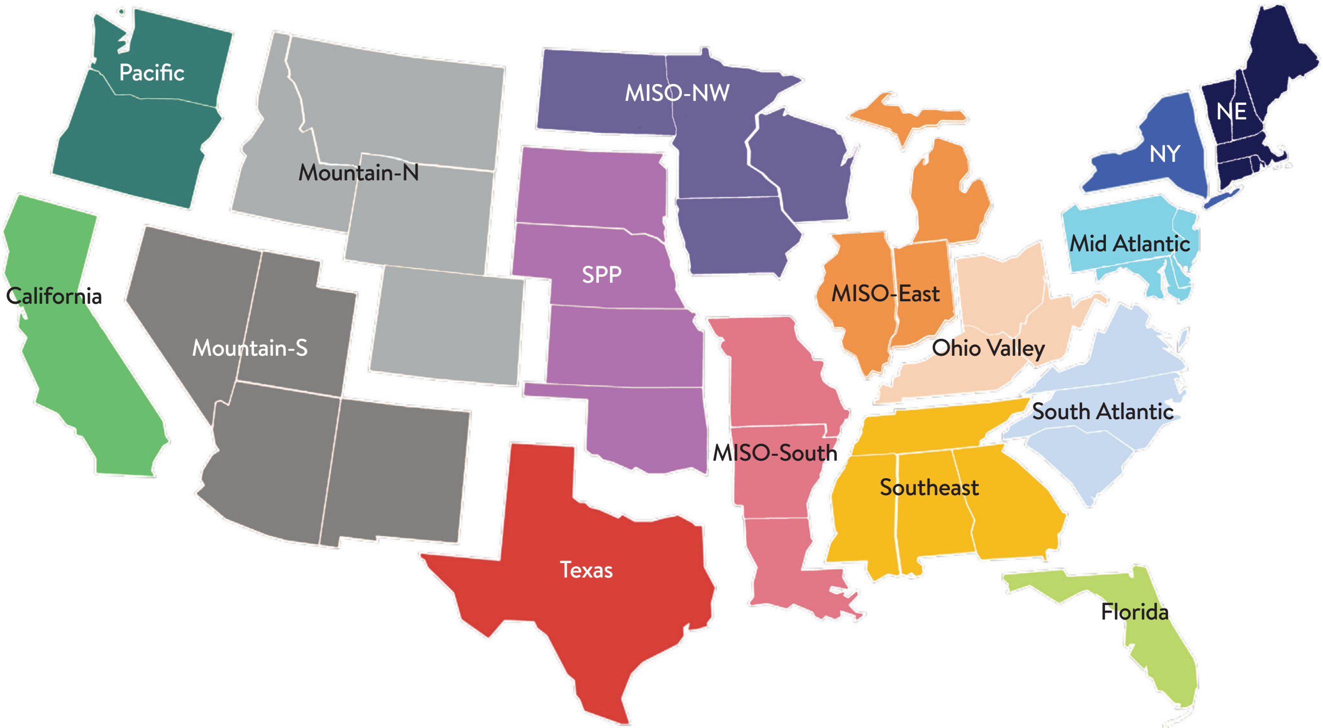

Figure 1-2. *The 16 U.S. regions covered in this analysis*

The three cases examined in this study are a reference case (no new climate policies other than those on the books), a 50% decarbonization case with moderate electrification, and a 50% decarbonization case with high electrification. The results are projected using the EPRI's US-REGEN Model,[7] which simulates interactions between the U.S. economy and the energy sector.

- **Reference Case:** The reference case includes existing, on-the-books federal and state legislation. Current legislation, regulations, and existing incentives at both federal and state levels are assumed to remain in place until their expiration.
- **50% Reduction in Greenhouse Gas Emissions Case:** The 50% reduction case cuts U.S. greenhouse gas emissions by one-half using 2005 as a base year. It assumes improvements in electric end-use technologies consistent with existing trends as outlined in previous EPRI studies.
- **50% Reduction with Rapid Electrification Case:** The rapid electrification case modifies the 50% reduction scenario by allowing more rapid improvements in electricity-using technologies, giving end users additional reasons to adopt new products and technologies.

[7] For model documentation and recent analyses, see https://esca.epri.com/models.html#tab=0.

2. THE SKILLED TRADES LABOR MARKET

Among the most challenging aspects of understanding the skilled trades marketplace and its risks is assessing the supply of skilled trade workers. Construction workers are segmented by geographical region, by the type of buildings they work on, by their construction trade, and by the level of their skills and experience. Laws affecting unionization and wages vary across the nation.

Once a new grid investment project has been permitted, a utility, independent power producer, or other market participant typically contracts with a set of design, engineering, and construction firms to build the project. Responsibility passes to those companies to produce detailed drawings, plan the project, and hire the workers to construct it. The contractors set schedules and strive to meet deadlines. Detailed schedules include careful planning for the numbers and types of skilled trade workers that will be needed as well as when they will be needed. Budgets guide and limit what a project manager can pay workers. In some circumstances, a project labor agreement sets pay scales and defines ways to settle grievances and deal with other issues that may arise.

Differences in required skills between construction projects and the diversity of tasks required at a worksite, in addition to variation in worker skills and experience, make hiring a workforce challenging. Construction managers have discretion about whom to hire and what to offer for wages and benefits unless they have been negotiated under a project labor agreement. Project managers consider whether the worker has the skills needed for the type of project to be built, if the worker's experience is recent, and whether the training an applicant has received is sufficient to maintain or extend their competency.

If local trades workers are not sufficient in number, a project manager may hire "travelers," who are highly skilled individuals who take jobs often far away from their homes. They find temporary accommodations near the worksite and often are paid per diems to cover additional expenses. The worker must decide if whether the pay rate, additional compensation, and the length of time he or she will be employed justifies accepting an offered job.

Characteristics of the U.S. Construction Workforce

In August 2021, the construction industry workforce in the United States consisted of approximately 7.5 million people working within the construction industry on many types of structures and specializing in different types of tasks, either as individual contractors or as members of a construction firm.[8] After a marked decline in construction during and following the Great Recession (December 2007 to June 2009), the construction industry and construction job market recovered in early 2020 to very near its levels pre-2008.[9] More recently, construction has rebounded strongly from a sharp 2020 drop driven by the COVID-19 pandemic. The unemployment rate for the construction industry of 4.0% as of October 2021 is down more than 3% from the previous year, although current construction employment is still

[8] In the BLS system, industries are defined by the firms that compose it, even though many of the firm's employees will not be construction workers.

[9] The National Bureau of Economic Research dates business cycles, often revising the dates of peaks and troughs in light of additional information. The 18-month "Great Recession" was the longest since the 43-month Great Depression, August 1929. through March 1933. See NBER. 2021. U.S. Business Cycle Expansions and Contractions at https://www.nber.org/research/data/us-business-cycle-expansions-and-contractions.

lower than its February 2020 peak.[10] In its October 2021 release, the BLS reported approximately 2.6 million employees in the non-residential specialty trades industry.[11]

The construction industry can be broadly divided based on the type of structure being built, whether construction activity is aimed at renovating, repairing, expanding, or building new. Structures include residential buildings, nonresidential buildings (commercial and public buildings), heavy construction (roadways, bridges, and other structures), and industrial buildings (manufacturing plants, power, and refineries, among other building types).

Except for dams, the power category includes all types of electric generation plants in addition to transmission and distribution lines, and related facilities. The construction industry workforce includes individuals who primarily support construction of these specific structures—residential, non-residential, and heavy construction—as well as a broad group of workers who are part of the "skilled construction trades." Of the skilled construction trades, approximately 40 occupations are those that general contractors and construction firms hire to perform specialized construction work.

Examining employment by occupation provides a different perspective than examining employment by industry. Skilled trades workers are spread throughout the U.S. economy. For example, painters may be employed by the Veterans Administration for maintaining existing structures. Individual skilled trade workers, who are directly employed by companies not classified as part of the construction industry (for example, a staff electrician employed by a hotel) do "force account" work, supporting day-to-day operations in some form. The focus in this report is instead on skilled trade workers within the construction industry.

Skilled trade workers undertake specialized tasks throughout the construction sector[12] to varying degrees. Tradesmen and women are hired by residential and nonresidential builders and by heavy and industrial construction companies to perform tasks ranging from working on high pressure vessels (boilermakers), masonry and brick laying (bricklayers), building air vents for heating and cooling systems (sheet metal workers), to setting up factory floors (millwrights).

Many nonresidential skilled tradesmen and women are self-employed or are employed by subcontractors, who are hired by general contractors to perform specific high-skill tasks. Both large general contractors and design, engineering, development, and construction firms have sets of subcontractors with whom their project managers have developed working relationships and who may be "pre-qualified" to bid on subcontracts.

Measuring the Supply of Skilled Trades Workers

Given the diversity of construction types, worker competencies, availability, and other characteristics, measuring the supply of skilled construction workers is challenging. Supply varies over time because individuals have gaps in employment between jobs or even enter and leave the labor force. Supply may change with the seasons because inclement weather makes it difficult to work at job sites. Beyond conceptual questions in measuring labor supply are empirical issues. The BLS collects occupational information for over 800 different jobs through its Occupational Employment and Wage Survey, which is administered under its Occupational Employment Statistics (OES) program.[13] The survey is published annually and is available for states, selected metropolitan areas, and the nation. It provides both summary and detailed views of historical wages and employment over time, but the OES job titles do not always correspond to the actual field work being executed.

An important aspect of the OES data is that individuals who work in each of the more than 800 occupations are spread across industries. As noted, even if most skilled trade workers hold jobs in the construction sector, skilled construction trades jobs are often located outside of the construction sector—that is, they are part of the staff in federal government agencies, industrial companies, real estate firms, and in other industries throughout the economy.

The converse is also true. Many jobs that are technically not "construction jobs" are important to the construction industry. Line installers and repairers, more colloquially known as "linemen," are not classified as a construction occupation, but as an installation, maintenance, and repair occupation. (See discussion of "Line Repairers and Installers: A Special Case" in Section 3.)

Supply estimates for the skilled trades in this study are based on OES data, adjusted first to exclude the portion of tradesmen and women who work on residential buildings. The resulting labor supply numbers are subsequently adjusted again to include only the more highly skilled workers. This approach presumes that those who work at high wage rates—that is, those with wage rates at or above the 75th percentile within a trade—constitute industrial tradesmen with skills and competency suited to the complex industrial work an electric utility might undertake.

[10] Unemployment for the construction industry is available from Table A-14 (Household Data) in the Bureau of Labor Statistics' monthly Employment Situation Report. See https://www.bls.gov/news.release/pdf/empsit.pdf.

[11] See The Employment Situation -- September 2021, Table B-1, line for Nonresidential Specialty Trade Contractors, Bureau of Labor Statistics at https://www.bls.gov/news.release/pdf/empsit.pdf

[12] See https://uploads-ssl.webflow.com/5daf5292fcdc19033b1c9448/5f97499abbe7266ad80d82cd_Algorithm%20List%20in%20CLMA%202020Oct26.pdf

[13] The collection and publication of the OES data have shortcomings such as being annual rather than quarterly, including some multi-year gaps in both jobs and wage rates gaps at smaller geographies. See the general discussion of the surveys on the Bureau of Labor Statistics program page at https://www.bls.gov/oes/. Links to additional methodological information can be found there as well.

Skilled trade workers are highly specialized due to various certification processes, training requirements, and/or direct experience. They often work on multiple types of projects, performing jobs that require a mix of talents at potentially dangerous worksites. In the case of industrial construction, their ability, training, and experience are crucial to completing projects safely, on-schedule, and within budget.

Estimating Industrial Supply

The current supply of high-skill industrial trade workers is estimated to be approximately 820,000. Construction Industry Resources, LLC (CIR) uses the number of individuals in the top two wage rate brackets, those at or above the 75th percentile, to estimate the pool of skilled trade workers capable of meeting requirements for industrial construction projects.[14] Changes in observed employment levels over time raise difficult questions about estimating supply. Conceptually, supply is not a single number of skilled trade workers in a specific labor market but a curve in which the supply of workers depends on multiple factors, such as the local cost of living and most importantly, the wages being offered. Wage levels are in turn influenced by the competitiveness of the labor market. As illustrated in Figure 2-1, labor supply in the market for a given job/trade is depicted as a positively sloped curve, where the quantity of workers willing to supply labor to a firm or firms (X-axis) increases as wages (Y-axis) increase but at a decreasing rate.

A benefit of using the adjusted OES survey data is that estimates of the supply of potential skilled trade workers on industrial projects are tied to the number of actual skilled trade workers employed in a given year. A difficulty with using this approach is that employment levels for skilled tradesmen vary from year to year. Between 2012 and 2020, estimated industrial supply for the 20 skilled trades examined in this study ranged from 1.49 million workers (2012) to 820,000 (2020) workers. The large variation in employment levels over the course of a construction cycle is characteristic of the industry. The variation in the construction sector is greater than in other sectors in the U.S. economy.

In this report, estimates of the supply of industrial trade workers are proprietary estimates of regional supply at the outset of the forecast period. These numbers are comparatively low, but they do represent the skilled trade workers who were employed and represent a lower bound for supply. The approach has the advantage of simplicity, but it does not address an important conceptual issue.

The supply elasticity is a ratio of the percentage change in the number of workers willing to work at a higher wage rate to the percentage change in the wage rate. Inelastic supply is the case in which larger percentage changes in wages have smaller percentage changes in the number of workers. Effectively, a ratio below one indicates inelastic supply; that is, for each percentage increase in wages, the employer gains less than a percentage increase in workers.

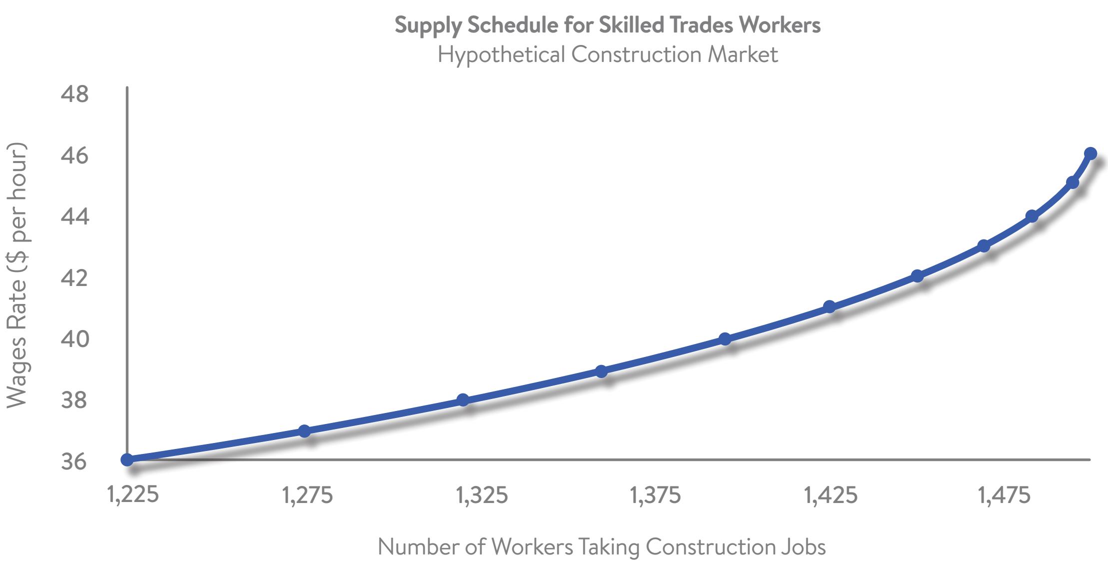

Figure 2-1. *Supply schedule for skilled trades workers*

[14] The conclusion that industrial jobs are particularly desirable stems from the eagerness with which trade unions and similar organizations lobby for large construction projects. They are built by contractors with contacts within the industry and who understand that project delays and workplace accidents lift costs and challenge construction schedules. Major construction projects are planned and managed by experienced individuals who are knowledgeable about labor markets and have extensive contacts among subcontractors and others. They also have budgets for per diems.

Typical estimates for elasticities of supply for U.S. workers range from 0.20 to 0.30.[15] Estimates for skilled tradesmen and women may be higher, showing a greater sensitivity to wage rates, because of the short-term nature of most skilled trades jobs. In between jobs, skilled trade workers may take breaks, temporary jobs in other industries, or even drop out of the labor force for periods of time.

Wage scales are an important consideration in worker choice, but increasing wage offers alone may not be adequate to attract the required supply of skilled tradesmen and women.[16] Anecdotal evidence indicates that both project owners and employers feel they are often paying higher wages for lower competency or no experience. This can result in increased safety incidents, lower productivity, and lower quality work. In addition to competitive wages, increasing the supply of qualified skilled trade workers requires lifting levels of both training and field experience.[17]

The key point is that the supply of the skilled construction trades is almost certainly inelastic with respect to wages. Doubling the number of skilled tradesmen and women willing to take construction jobs in a labor market will require more than doubling wage rates. Inelastic supply is particularly problematic for companies, such as utilities and power producers, that often plan major construction projects in what are often remote locations where the existing supply of skilled trade workers is either small or already fully utilized.

Demand for Skilled Trades in Industrial Construction

In this study, the estimated demand for skilled trade workers is based on data collected from projects under construction or nearing start in the construction queue. Construction managers create detailed schedules based on their expectations of specific labor needs over the course of a project. CIR researchers collect information on individual construction projects, then use project profiles distilled from the plans and experiences of project managers to estimate the types, percentages, and timing of skilled trade needs for the project. By creating schedules for different types of projects, scaling the schedules to project timelines, and summing demand over projects, CIR economists and researchers profile the time pattern of demand for different trades by region and occupation.

This methodology and level of detail, however, lead to relatively large increases and decreases in the demand for various trades year-over-year as projects start, stop, or experience delays. For example, CIR estimates of demand for electricians from construction projects in California during 2012 through 2020 are shown in Figure 2-2. The estimated demand for electricians was derived from **construction projects planned or under construction**. In California, between 2012 and 2020, the demand ranges from under

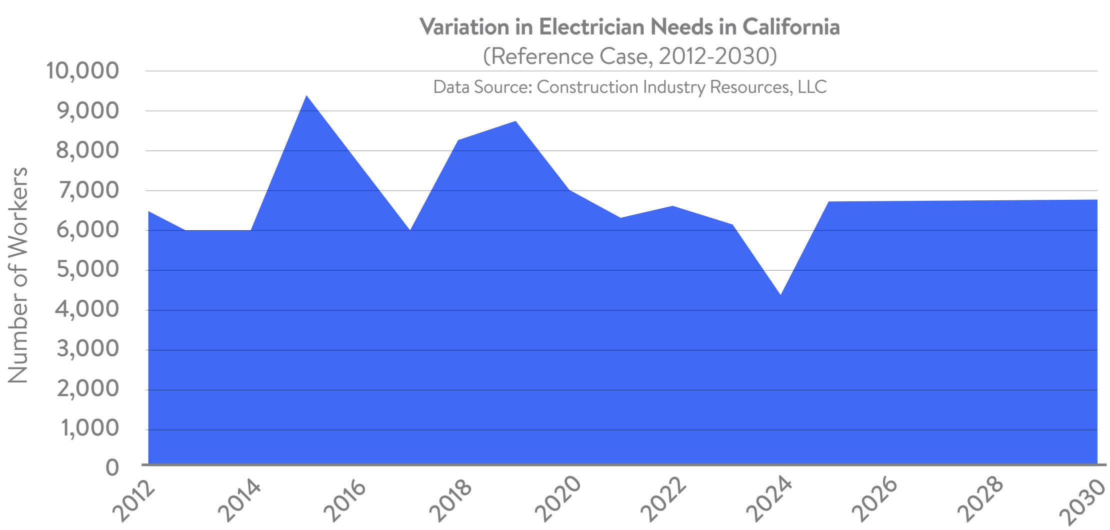

Figure 2-2. *Variation in electrician needs in California*

[15] McClelland, Robert and Shannon Mok. 2012. "A Review of Recent Research on Labor Supply Elasticities," Congressional Budget Office Working Paper Series, Washington, D.C. See opening pages, particularly page 3. More recent literature on labor supply focuses on elasticities under narrower conditions.

[16] One of the authors of this report has estimated supply for 14 of the skilled trades as a part of forecasting wage escalation using a combination of OES and CIR data wage. The general finding is wage elasticities of 0.2 and modestly higher. Gaps in both the OES series, however, limit the reliability of the results, even when using panel data—that is, combining cross-sectional and time series data when estimating the supply schedules.

[17] See Section 4 of this study for a more extensive discussion of the roles of training and experience in the skilled construction trades.

6,000 workers in some years to over 9,000 workers in others. Labor demand estimates were derived from planned and/or under-construction projects through 2023. Beyond 2024, the demand has been derived from the capacity additions presented in EPRI report *Strategies and Actions for Achieving a 50% Reduction in U.S. Greenhouse Gas Emissions by 2030*.

The link between the skilled trades and industrial construction suggests an upward trend in the need for construction jobs over the next decade as the United States continues to increase investments in renewable technologies and overall energy infrastructure.[18]

Shifts in Skilled Trades Requirements Due to Decarbonization

Meeting greenhouse gas targets under the Paris Agreement will require an overall increase in the availability of skilled construction workers. Across the different types of electric generation technologies, the relative demand intensity varies by trade. Electricians, for example, are needed in construction projects across the board but are particularly prominent in transmission and distribution projects. In contrast, millwrights make up a significant percentage of skilled trade workers for new solar and wind construction projects. A shift toward renewables and away from fossil fuels changes worker demand across the trades because different trades are used more intensively in some types of projects than in others. This results in demand for each skilled trade varying across regions and time; summaries of these variations are shown later in the study.

Of interest to both construction managers and workers are ways in which demand for individual trades changes with shifts in project mix among types of power plants. Utilization rates are the percentage of total skilled trade hours that each trade contributes to each type of power plant construction. Although the actual shift in the numbers and types of skilled workers employed in electric power plant construction depends on the mix of electricity projects in any given region and time period, an examination of some selected skilled trade utilization rates can provide perspective.

Figure 2-3 illustrates the variation in skilled trade utilization rates across different types of new electric power projects. It focuses on six selected skilled trades—boilermakers, concrete finishers and cement masons, electricians, laborers, millwrights, and pipefitters—and compares utilization rates for these skilled trades across five types of electricity generation projects. (See Appendix D for a listing of the 10 different electric generation technology categories.) Examining the graphs helps clarify which trades are likely to increase in demand and which are likely to undergo demand reductions within the electric sector during the energy transition.

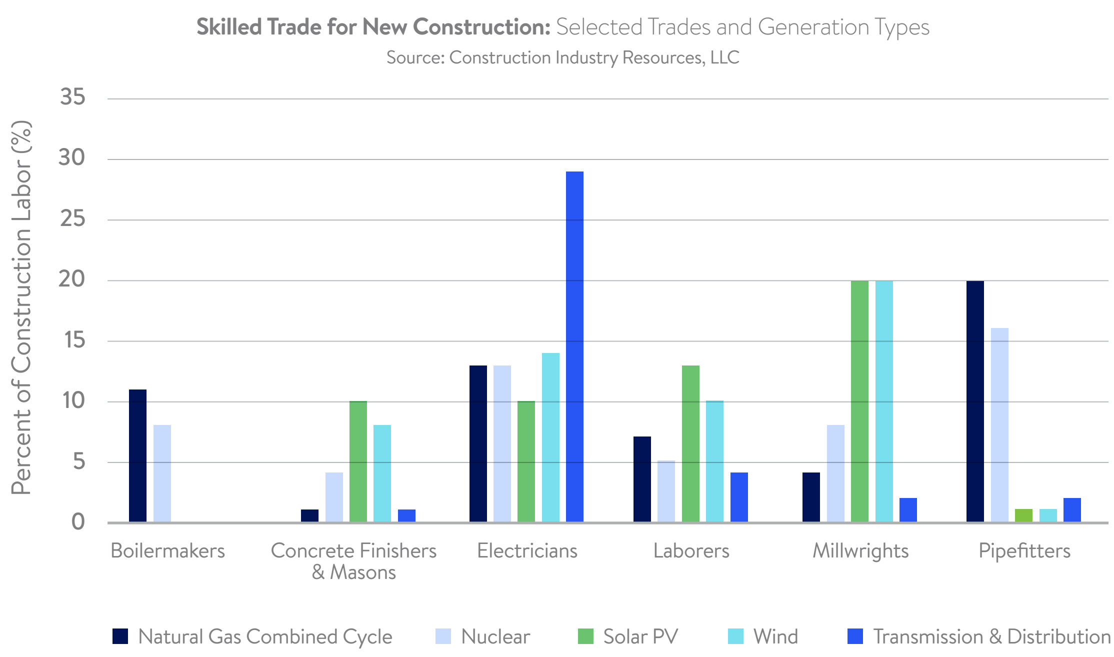

Figure 2-3. *Skilled trade intensities for new construction: Selected trades and generation types*

[18] The pattern is due to theories of industry life cycles, The concept is widely used and was prominently discussed in detail in Michael Porter. 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. Free Press.

In the near term, natural gas is expected to maintain a significant role in the energy system, which translates to continued demand for boilermakers. They work over 10% of the total skilled trades hours at single- and combined-cycle natural gas plants and slightly less than 10% of all skilled trades hours at nuclear plants but do not have a role at construction sites for solar, wind, and transmission and distribution projects. New solar and wind plants are also expected to play a critical role in the near-term energy mix. This continued increasing demand for solar and wind could result in even higher demand for concrete finishers and cement masons and millwright trades given the high percentage of labor demand for those trades required for solar and wind construction projects. Pipefitters are similar to boilermakers in that they are intensely used at combined cycle–natural gas projects and nuclear projects, contributing over 15% of skilled trades hours.

Electricians are unique with a high proportion of skilled trade hours across all types of power projects. They provide more than 10% of skilled trade worker hours at combined cycle–natural gas plants, nuclear plants, solar plants, and wind power projects and are responsible for nearly 30% of skilled trade hours at transmission and distribution projects.

Boilermakers, pipefitters, and laborers are expected to maintain high demand in the near term while electricians and laborers, which are already high-demand trades, are expected to increase in demand given the prominent role these trades play across the energy technology construction projects included in this study. Millwrights and concrete trades are expected to increase dramatically as the demand for new solar and wind projects increases. Although these trends may shift over time as future energy resource mixes evolve, ensuring a reliable near-term supply of these key trades could be vital to ensuring successful construction projects during the energy transition.

3. SKILLED TRADE REQUIREMENTS FOR DECARBONIZATION

The current outlook for the skilled trades in the United States appears to be strained—there are imbalances between the number of skilled trade workers likely to be available in the workforce and the expected levels of construction activity overall, and particularly the requirements for deploying future renewable energy resources and new transmission infrastructure. This conclusion is based on the three different scenarios that project the electricity generation, transmission, and distribution resources that need to be added to the regional grids. Differences in requirements for skilled trade workers across the three scenarios are comparatively modest because substantial increases in renewable energy generation are already planned by individual utilities, either independently or as a part of state mandates (see Figure 3-1).

The first scenario—the reference case—is based on existing, on-the-books federal and state legislation. Current legislation, regulations, and existing incentives, are assumed to remain in place until their expiration. Skilled trade demand under the reference case exceeds supply by 15,000 workers at the beginning of the projections in 2025, rising to 82,000 by 2030.

The second scenario—the 50% reduction in greenhouse gas emissions—cuts U.S. emissions by one-half using 2005 as a base year. It assumes improvements in electric end-use technologies consistent with existing trends. Skilled trade demand under the reference case exceeds supply by 107,000 workers at the beginning of the projections in 2025, rising to 174,000 by 2030.

The third scenario—the rapid electrification case—modifies the high electrification scenario by allowing more rapid improvements in electricity-using technologies, giving end users additional reasons to adopt new products and technologies. Skilled trade demand under the 50% reduction case exceeds supply by 135,000 workers at the beginning of the projections in 2025, rising to 202,000 by the close of the forecast.

The estimated shortfalls are significant for both decarbonization scenarios, ranging from 20% to 23% of the employed skilled trade workers as of 2030. Supply is expected to decrease over time due to steady workforce attrition. These results depend on workforce estimates of supply that use calendar year 2020 as the base year, which is reasonable given that, historically, the entire workforce has not returned to the industry following a major economic downturn exodus.[19]

The aggregate totals for the number of workers required to meet construction, however, severely understate shortfalls for individual trades. Ten of the sixteen trades have deficits in a majority of the 16 EPRI regions. Assuming a larger potential supply at the outset of the forecast or that the skilled trade workforce increases during the years 2021 through 2030 would mitigate the shortfall.

[19] The decision to use current supply numbers based on OES estimates of the number of employed workers in the skilled trades as of 2020 is the conservative estimate discussed earlier. Please recall the importance of supply fluctuations discussed in Section 2, "Estimating Industrial Supply."

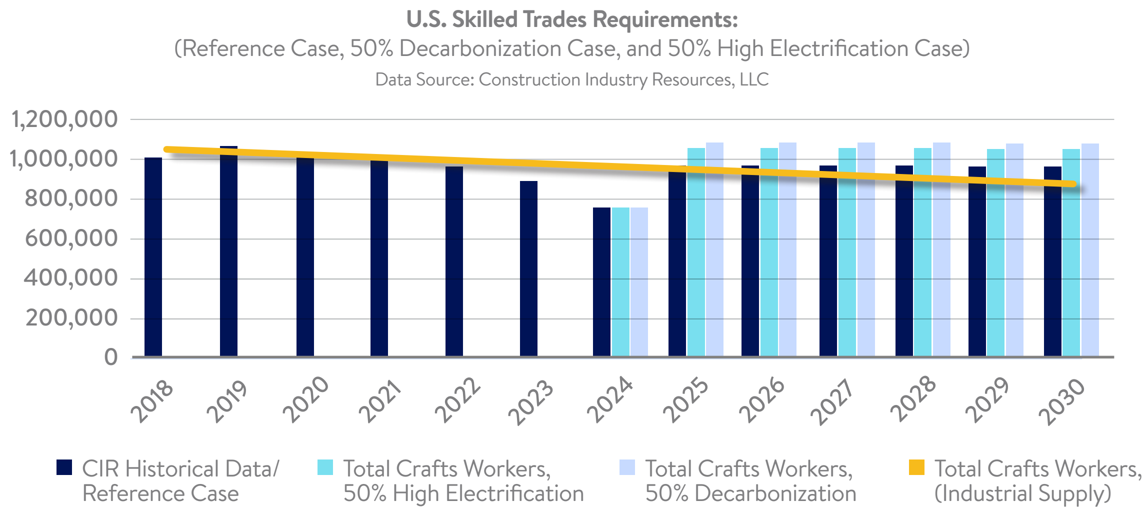

Figure 3-1. *U.S. skilled trades requirements: reference case, 50% decarbonization case, 50% and high electrification case*

To illustrate these demand-supply relationships by trade, the ratio of the number of full-time workers needed for a given trade in any given year can be divided by the corresponding estimate of the number of available workers, providing a measure of the tightness of the individual labor markets. A demand-supply ratio greater than one implies a supply shortage. When the demand-supply ratio is less than one, there is a surplus. The ratios in Table 3-1 are for the first year of the forecast interval. The most severe shortages are highlighted in red; other shortages are portrayed in orange and yellow. For boilermakers in the first year of the forecast, the construction demand is almost six times the estimated industrial supply.

Regional Surpluses and Shortages of Trade Workers

The national picture is a composition of 16 regions with different mixes of forecasted installed capacity, different resource endowments, and different rates of electricity demand growth. Some regions have abundant solar resources, while others are better endowed with wind capacity; still others are contemplating expanding nuclear generation. Table 3-1 can be constructed for each of the years 2021 through 2030.

Table 3-1 shows that many regions face challenges in procuring various skilled trades and could have difficulty meeting the construction needs for many of the 20 different trades across the 16 regions. Of these challenges, the prospective shortages of workers are estimated to be most pronounced in the Midwest, particularly in the MISO-East, MISO-Northwest, MISO-South, Southeast, and Ohio Valley regions. In the California, Mid-Atlantic, Mountain, and Pacific Regions, skilled trade workers will be in greater supply. Even these regions, however, will still face worker shortages in key trades such as boilermaker, carpenter (pile driver/operator), carpenter (scaffold-builder), instrument technician, insulator, ironworker (reinforcing), millwright, and operator (heavy crane).

Table 3-1. *Ratio of skilled trades need to worker availability*

(Regions: California Through Mountain-S)

Skilled Trade	California	Florida	Mid Atlantic	MISO-East	MISO-NW	MISO-South	Mountain-N	Mountain-S
Boilermakers	5.96	12.04	6.86	5.34	11.58	1.97	10.11	8.65
Carpenter (Pile Driver / Operator)	9.68	5.06	47.50	NA*	144.25	11.03	NA*	NA*
Carpenter (Scaffold Builder)	0.08	0.19	0.16	0.57	0.48	0.49	0.18	0.20
Concrete Finisher - Cement Mason	0.87	1.09	1.20	2.14	1.67	2.83	1.40	0.91
Craft Helper	0.66	0.38	0.78	1.76	1.13	1.04	0.71	0.74
Electrician	0.74	0.86	0.83	1.70	2.08	1.94	0.83	1.02
Elevator Installer and Repairer	0.07	0.11	0.13	0.24	0.11	0.15	0.05	0.06
Instrumentation Technician	1.46	2.36	0.93	1.92	3.27	2.05	1.85	2.01
Insulator	NA*	3.90	2.07	6.23	3.90	2.90	2.43	10.50
Ironworker (Reinforcing)	3.19	1.92	2.98	12.07	20.55	14.41	6.34	4.80
Ironworker - Welder (Structural)	0.51	1.01	0.47	1.10	1.27	1.28	0.67	0.56
Laborer	0.42	0.26	0.44	0.81	0.88	0.71	0.51	0.35
Lineman	0.43	0.28	0.48	0.37	0.39	0.15	0.15	0.32
Millwright	5.14	9.29	2.54	3.35	4.82	2.69	5.49	9.56
Operator (Heavy Crane)	1.49	0.81	1.29	3.68	4.59	1.54	7.81	5.49
Operator (Heavy Equipment)	0.40	0.22	0.37	0.72	0.44	0.46	0.22	0.24
Operator (Truck Driver)	0.26	0.26	0.75	0.54	0.77	0.75	0.97	0.66
Painter	0.32	0.35	0.46	1.38	1.43	1.20	0.63	0.62
Pipefitter	0.86	1.05	0.96	1.56	1.56	2.19	0.90	0.92
Sheet Metal Worker	0.61	0.69	0.56	1.13	1.15	1.73	1.26	0.71

(Regions: Northeast Through Texas)

Skilled Trade	NE	NY	Ohio Valley	Pacific	South Atlantic	Southeast	SPP	Texas
Boilermakers	18.54	2.91	5.19	30.10	14.21	6.54	7.69	1.09
Carpenter (Pile Driver / Operator)	27.46	NA*	NA*	8.33	24.12	45.96	NA*	3.05
Carpenter (Scaffold Builder)	0.47	0.16	0.68	0.12	0.40	0.94	0.27	0.48
Concrete Finisher - Cement Mason	2.14	2.12	2.33	0.88	1.75	2.85	1.09	1.56
Craft Helper	0.95	0.50	1.75	0.77	0.45	1.24	0.63	0.54
Electrician	1.55	0.83	1.77	0.61	1.12	2.10	1.51	1.11
Elevator Installer and Repairer	0.04	0.01	0.57	0.14	2.09	1.20	0.09	0.07
Instrumentation Technician	2.68	0.70	2.12	1.16	0.86	2.07	1.73	1.40
Insulator	2.55	4.14	9.02	1.38	1.75	7.68	4.08	1.40
Ironworker (Reinforcing)	17.39	3.80	32.05	5.58	5.80	9.16	NA*	1.31
Ironworker-Welder (Structural)	1.10	0.40	1.33	0.41	0.95	1.57	0.35	0.61
Laborer	0.73	0.35	0.61	0.29	0.51	0.70	1.05	0.32
Lineman	0.51	0.46	0.37	0.16	0.20	0.36	0.23	0.12
Millwright	8.25	5.33	2.57	1.94	3.12	3.46	7.63	2.60
Operator (Heavy Crane)	4.55	3.92	2.27	1.05	0.97	1.85	2.12	0.68
Operator (Heavy Equipment)	0.52	0.39	0.42	0.32	0.35	0.53	0.36	0.21
Operator (Truck Driver)	1.10	0.85	0.74	0.22	0.52	0.49	0.75	0.47
Painter	0.85	0.41	1.64	0.38	0.94	1.90	1.07	0.96
Pipefitter	1.12	0.64	2.40	0.76	1.14	2.31	1.18	1.36
Sheet Metal Worker	0.97	0.58	1.74	0.41	0.74	1.53	0.60	1.48

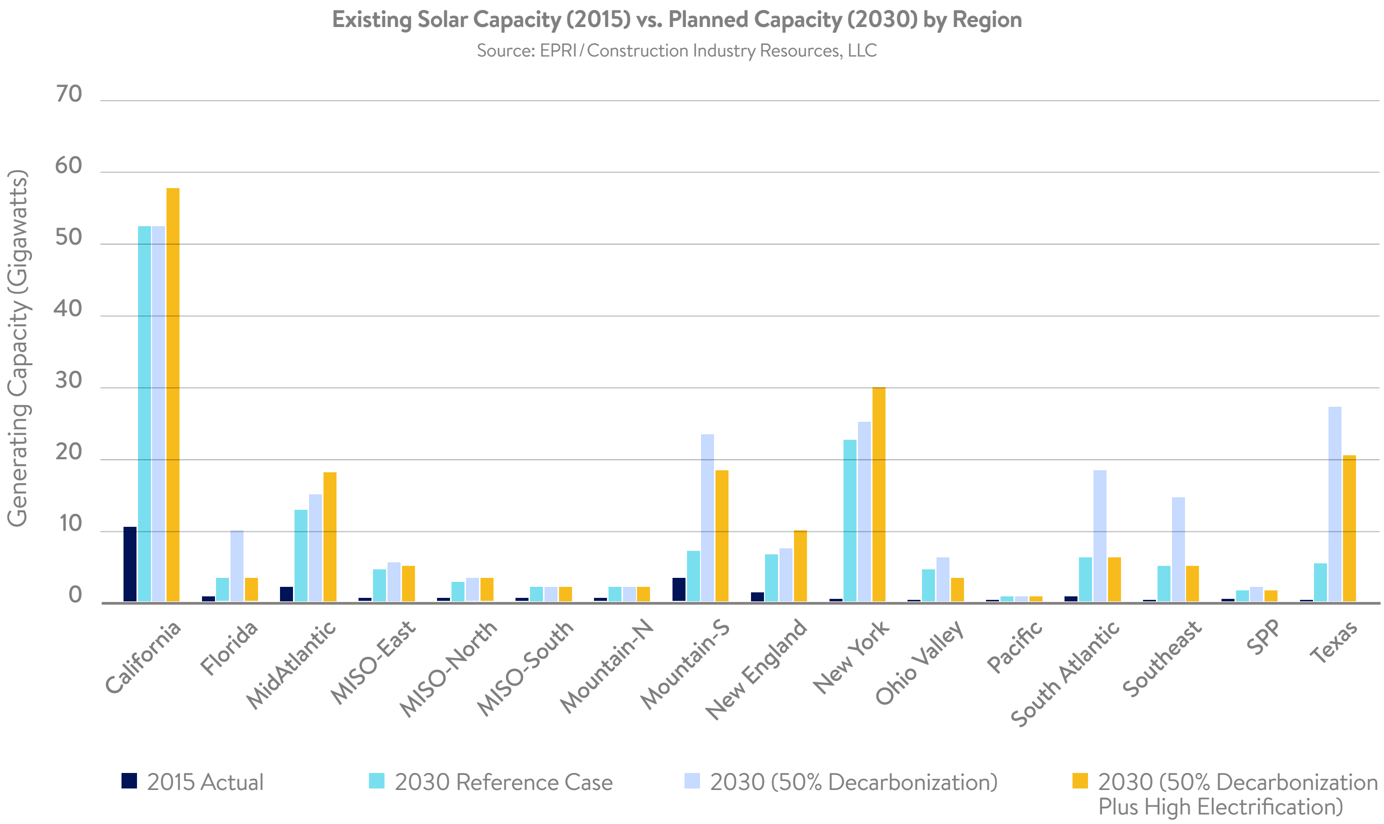

Figure 3-2. *Existing solar capacity (2015) vs. planned capacity (2030) by region*

A profile of solar electric generating capacity in 2015 versus planned solar capacity expansion in 2030 for the three different scenarios suggests that recent differences in regional labor demand will likely persist. For example, Figure 3-2 shows that additions to solar generation will be large under all three scenarios—reference case, 50% decarbonization case, and high electrification case—especially in California and New York regions. Both regions have public policy measures that require renewable electricity generation.

Evaluating the labor supply-demand ratios at the regional and state levels highlights that the supply of skilled trade workers is not evenly distributed across all geographic areas. For example, a surplus of workers in the pipefitters trade in the New York region is unlikely to help Texas projects, unless a large proportion of New York pipefitters is willing to travel. Regional wage differentials can be important in the willingness of a skilled trades worker to take a job in another region, and skilled trade wages in the Northeast are typically high. An increasing concern is that the willingness of the workforce to travel appears to be declining, further straining construction projects in locations with inadequate local supply. (The trend is discussed in more detail later in Section 4.)

Individual Skilled Trade Markets

In this section of the report, labor supply-demand relationships are discussed for specific trades within specific regions as a function of EPRI's projected build-out scenarios. Examples discussed next are from a sample of the 320 individual markets (20 skilled trades and 16 EPRI REGEN regions) evaluated in this study.

When examined individually, the tables and graphs for each region for each skilled trade provide an overview of the prospective balance between the need for the skilled trades and the availability of skilled trade workers in a specific region, including the data and charts for the various labor supply-demand relationships.

The labor supply-demand relationships can pinpoint stressed markets. Some trades, such as boilermakers, have estimated shortages across most regions because they are in short supply regardless of the shift toward renewable energy sources, which decreases their demand. Other trades like pipefitters are closer to balance in most of the 16 EPRI-REGEN regions, while others are mixed with skilled trade markets in some regions in surplus and others in deficit.

Among the 50 states, California, New Mexico, Hawaii, and Washington are perhaps the best known for their decision to mandate that all electricity be produced from renewable sources by or before 2050. Governor Jerry Brown signed California Senate Bill 100 in September 2018, setting a 100% clean energy goal for the state by 2045.[20] Many other states, including New York and New Jersey, have also passed bills supporting the transition to renewables.

[20] Office of the Governor. 2018. "Governor Brown Signs 100% Clean Electricity Bill." Press Release Sept. 10, 2018.

Figure 3-3 shows an example of the labor market for California pipefitters. The figure displays a near balance between the projected needs and estimated industrial supply. Differences between the requirements for pipefitters under the reference case, the 50% decarbonization case and high electrification demand, and the 50% decarbonization demand for pipefitters are already small—a reflection of the decarbonization already in place in California. Pipefitters have important roles in building, repairing, and maintaining natural gas and fossil fuel power plants, but they have limited roles, if any, in renewables such as solar and wind. In contrast, millwrights have a prominent role in the construction of new solar and wind plants. In the case of California, millwright demand has historically exceeded supply and is expected to continue as new solar plants are constructed in the region as shown in Figure 3-4. Approaches used to address persistent labor shortages, where historical demand has exceeded local labor supplies, are discussed later in this report.

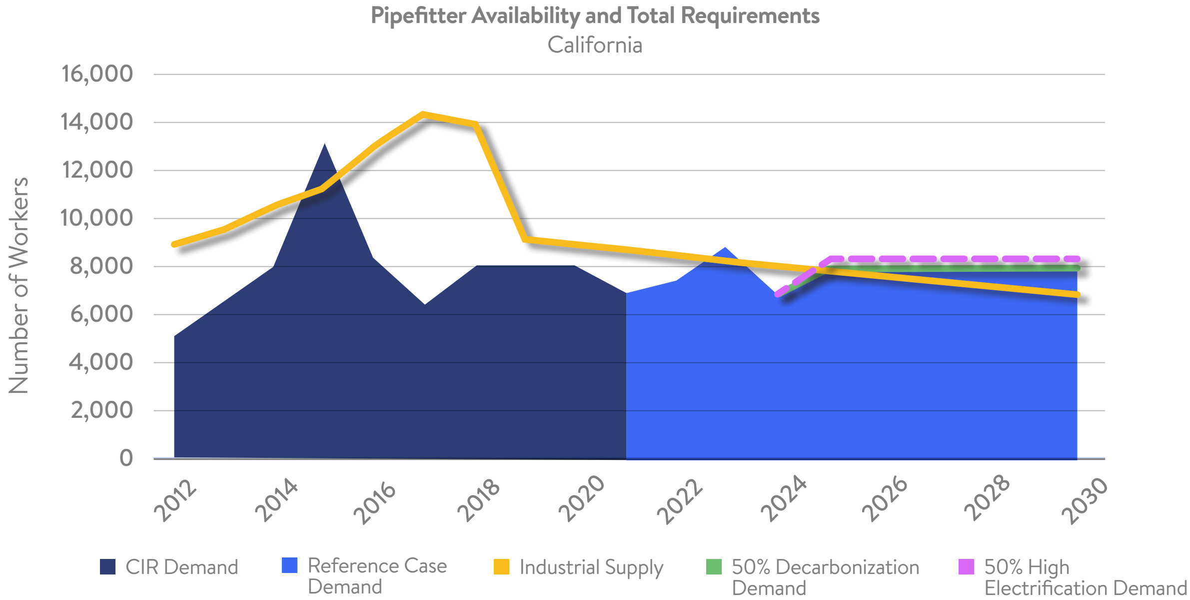

Figure 3-3. *Pipefitter availability and total requirements: California*

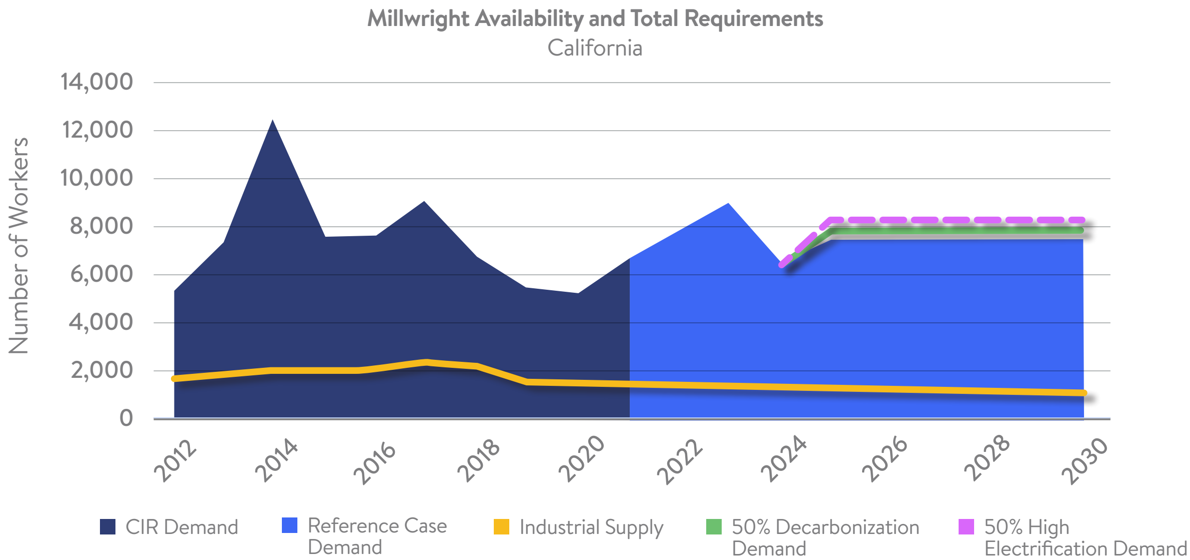

Figure 3-4. *Millwright availability and total requirements*

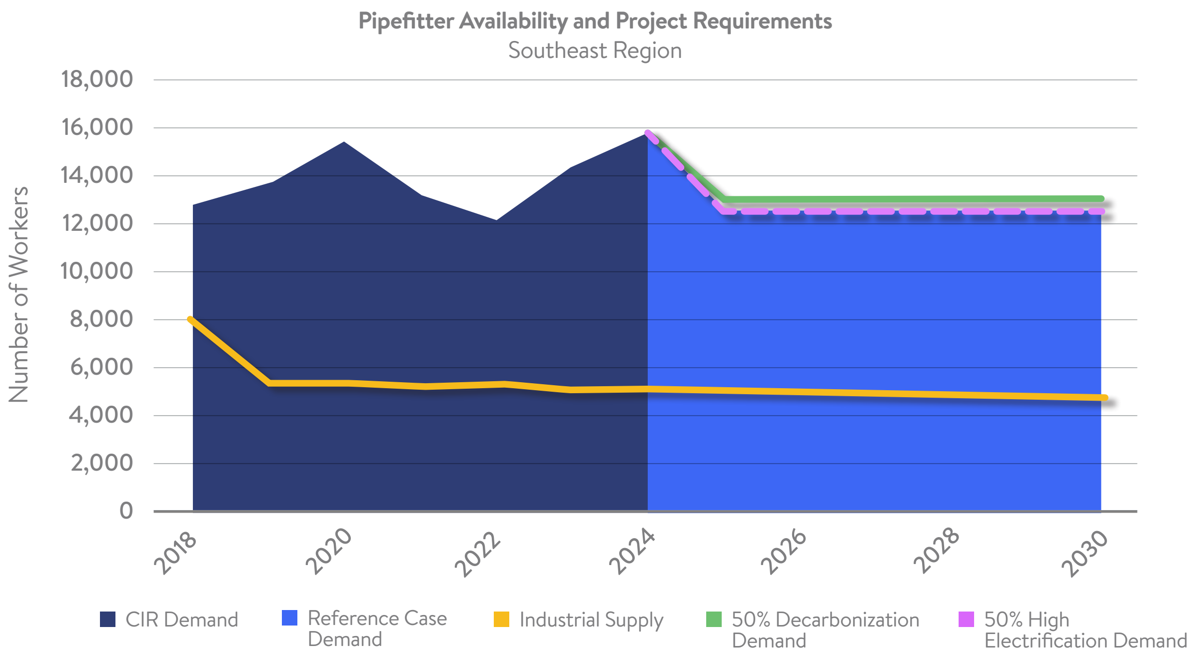

***Figure 3-5.** Pipefitter availability and project requirements: Southeast region*

In contrast to the California pipefitters example, the Southeast region presents the same modest increments but a sustained shortage in workers associated with both the base electrification and the high electrification cases. Requirements for pipefitters remain high throughout the historical and forecast periods, relative to the regional supply. CIR estimates of pipefitter requirements in the Southeast region rose to 15,300 in 2015, have remained above 12,000 in recent years, and will continue to do so into the forecast interval. This pattern differs from most other regions in which there was a sharp decline in demand in 2020 at the onset of the COVID-19 pandemic. The second difference between the regions lies in the modest supply of skilled trade workers—less than 50% of expected demand throughout the forecast years.

Finally, as shown in Figure 3-5, the Southeast has experienced a historical supply-demand imbalance, raising the question, "How did construction managers meet their needs for pipefitters during 2015 through 2020?" There are multiple possible explanations: construction firms may have employed traveling tradesmen and women from other regions and/or paid wage and per diem incentives to recruit workers from competing projects. Another key labor risk mitigation strategy for project owners is to prefabricate and modularize large project components offshore or in off-site locations.

Wage Escalation in the Skilled Construction Trades

This study also projects wage escalation rates for the years 2020 through 2030 using historical data beginning in 2012. These projections are not meant to substitute for detailed multi-equation forecasts or advanced time-series techniques, but rather to provide a directionally indicative perspective on recent trends as well as offer insight into how wages could be expected to escalate in the future. Associated with the trendlines are confidence intervals that provide a measure of statistical uncertainty associated with historical trends.

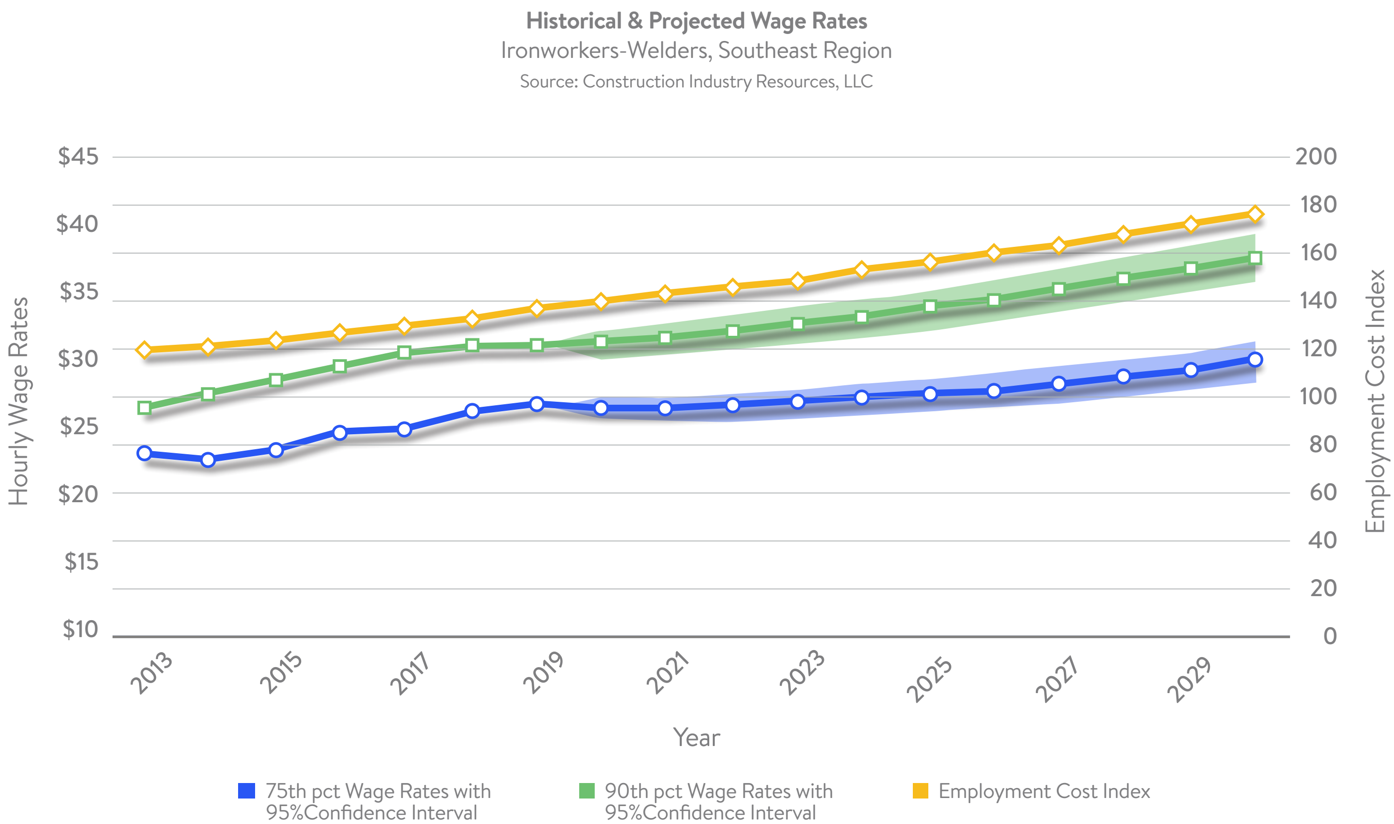

Figure 3-6. *Historical and projected wage rates: Ironworkers-welders, Southeast region*

Figure 3-6 presents an example of ironworker and ironworker-welder wage rates in the Southeast region between 2013 and 2030. The accompanying graph displays historical wage trajectories for workers paid at the 75th and 90th percentiles of the wage distribution. There appears to be an increasing premium for the highest skilled workers, as seen with the 90th percentile wages. Compound growth for the 75th percentile worker during 2020 through 2030 is 12.2% versus growth of 20.7% for the 90th percentile worker. These projected cumulative growth rates are modest when stated as annual averages, but they are historically consistent with the U.S. Employment Cost Index over the same period.

Line Installers and Repairers: A Special Case

Certain skilled construction disciplines present anomalies within the data—line installers and repairmen, in particular. Although they are vital to electric construction, they are not technically classified as a construction trade. Line installers and repairmen (Standard Occupation Code 49-9050), usually referred to as linemen, install, maintain, and repair electrical and telecommunication lines. By installing electrical and communication lines, they play an important role in building electrical transmission and distribution infrastructure. Linemen, however, are not classified among the BLS Construction and Extraction Occupations category but as part of another broad occupational grouping: Installation, Maintenance, and Repair Occupations.

One consequence of the mix of installation, repair, and maintenance tasks linemen undertake is that they mostly hold jobs in other industries. As reflected in Table 3-2, approximately 32% of linemen are employed in the construction industry, 25% in utility industries—particularly electric power generation and transmission—and 33% in telecommunication industries. The result is that nearly two-thirds of linemen are unlikely to be part of the construction workforce, and the resulting pool of workers from which general and specialty contractors can hire is significantly reduced.

The high proportion of linemen employed outside the construction industry will almost certainly hinder efforts to increase construction of new power plants and electricity transmission and distribution resources. Linemen with stable jobs at electric utilities or communications companies are unlikely to eagerly enter a new industry where employment is less stable and responsibilities differ. This means that two-thirds of linemen are unavailable for construction work. Under such circumstances, staffing linemen for power generation, transmission, and distribution projects would be time-consuming and require large wage incentives.

Impact of Federal Infrastructure Spending

President Biden signed into law the "Infrastructure and Jobs Act" (H.R. 3684) on November 15, 2021, which funds major increases in public infrastructure spending. The Administration is also seeking passage of the "Build Back Better" (H.R. 5376) Act, which focuses on 1) reskilling Americans for the 21st century, 2) meeting U.S. pledges under the Paris Accords of 2015, and 3) reviving U.S. competitiveness and leadership. The Administration projects that the two spending bills will jointly create two million new, well-paying jobs when direct, indirect, and tertiary effects of the legislation are considered.[21]

Table 3-2. *Distribution of line installers and repairers by industry (2020)*

Standard Occupational Code 49-9050			
Sectors & Industries	**Linemen**	**Sector Totals**	**Percentage**
Utilities			
Electric Power Generation, Transmission and Distribution	55,520		
Natural Gas Distribution	3,040		
Water, Sewage and Other Systems	70	58,630	25%
Construction			
Nonresidential Building Construction	30		
Utility System Construction	50,770		
Highway, Street, and Bridge Construction	190		
Building Equipment Contractors	23,450		
Building Finishing Contractors	40		
Other Specialty Trade Contractors	600	75,080	32%
Telecommunications			
Cable and Other Subscription Programming	1,720		
Telecommunications	75,890	77,610	33%
Other Industries			
All Other	24,530	24,530	10%
ALL WORKERS	**235,850**	**235,850**	**100%**

[21] The President claims that the two bills will jointly create two million jobs per year, which may be true if all the secondary and tertiary impacts of the legislation are considered. Restricting the focus to the direct impacts on construction workers of an additional $550 billion spread over 10 years, the increase is more modest. White House Briefing Room. 2021. Updated Fact Sheet: Bipartisan Infrastructure and Jobs Act (August 2, 2021) at https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/02/updated-fact-sheet-bipartisan-infrastructure-investment-and-jobs-act/.

***Table 3-3.** Additional funding from the Infrastructure Investment and Jobs Act (H.R. 3684)*

Additional Funding from the Infrastructure Investment and Jobs Act (H.R. 3684)*							
Infrastructure Type	**$Billions**	**Construction Worker Share**	**Spending on Construction Labor ($Billions)**	**Spending per Year Over 10 Years ($Billions)**	**Average Annual Compensation ($2017)**	**Inflation Adjusted Compensation ($000s)***	**Annual Need, Construction Workers**
Roads and Bridges	110.0	29.4%	32.34	3.23	95.89	105.48	30,660
Major Projects	16.0	29.4%	4.70	0.47	95.89	105.48	4,460
Transportation Safety	11.0	29.4%	3.23	0.32	95.89	105.48	3,066
Reconnect Communities	1.0	32.3%	0.32	0.03	94.04	103.45	312
Transit Programs	39.0	29.4%	11.47	1.15	95.89	105.48	10,870
Railway Programs	66.0	30.7%	20.25	2.02	94.04	103.45	19,575
Broadband and Internet	65.0	40.1%	26.04	2.60	96.24	105.86	24,601
Ports, Dams, Rivers, etc.	17.0	32.7%	5.56	0.56	81.70	89.87	6,187
Airports and Air Transportation	25.0	30.7%	7.67	0.77	94.04	103.45	7,415
Electrics Vehicles & Charging Stations	15.0	40.1%	6.01	0.60	94.52	103.97	5,780
Power Lines, Grid Upgrades	115.0	40.1%	46.08	4.61	96.24	105.86	43,525
Wastewater & Drinking Water Systems	55.0	32.7%	17.99	1.80	81.70	89.87	20,018
Environmental Remediation	21.0	32.3%	6.78	0.68	94.52	103.97	6,525
TOTALS	**556**		**188.45**	**37.69**			**182,996**

*Calculations based on Census of Construction (2017)

The direct effect on the industrial construction trades of these bills will likely be moderate because the skill levels required for industrial construction projects only partly overlap the skill levels required for public works projects. Focusing on the Infrastructure Investment and Jobs Act, the bill would reauthorize the current federal surface transportation legislation as well as authorize an additional $550 billion in spending. As reflected in Table 3-3, the increase includes $110 billion for roads, bridges, and other transportation infrastructure along with $39 billion for transit, $66 billion for passenger and freight rail, and $65 billion for improving broadband infrastructure. Also included is funding for wastewater and drinking water systems and for environmental remediation.

These projects will require many skilled tradesmen and women and could have significant impact on overall skilled labor balances across the 16 regions, although the impact for industrial construction is more moderate. Annual wages and benefits, adjusted for inflation, are expected to average between $90,000 and $105,000 in 2021,[22] producing the need for 183,000 trade workers per year during 2021–2030.

Skilled trade workers needed by the Infrastructure Investment and Jobs Act potentially constitute a large portion of trained skilled trade workers, particularly if the number of available tradesmen and women is limited to 820,000 high-skill trades workers. The impact of the pending Infrastructure Investment and Jobs Act on labor markets for skilled construction trades could be substantial for certain trades. As noted previously, however, the overlap between the types of trade workers needed for industrial construction and those needed for building public infrastructure is expected to be minimal.

The analyses performed in this study indicate that shortages of skilled trade workers are already present and could continue at various rates within different regions and for different trades. Federal legislation aimed at improving U.S. public infrastructure plays a substantial role in those shortages. Subsequent sections of this report discuss how the next generation of skilled trade workers could be recruited and developed to support industrial construction projects, including those that support decarbonization of the electric sector and the economy.

[22] Construction Industry Resources estimate.

4. THE EFFICACY OF WORKFORCE TRAINING AND RELATED SOLUTIONS

Over the past three to four decades, the U.S. construction industry has consistently faced shortages of skilled trade workers as evidenced by CIR analyses and numerous surveys by the Associated General Contractors, the Associated Builders and Contractors, and other organizations. During periods of economic expansion, wages for skilled trade workers typically increase, but the average quality of the workforce decreases as less-qualified workers enter the industry to take advantage of wage opportunities. During periods of economic contraction, many skilled trade workers are forced to leave the industry because of less project spending. The process repeats itself every economic cycle, so the phenomenon is well-understood by experienced construction personnel.

Since the Great Recession, however, construction stakeholders have observed fundamental structural changes to the construction workforce development system and society that pose a significant risk to the construction industry.[23] The issue of having a qualified workforce is not unique to union or open-shop operations, but rather a challenge for the entire industry.

In 2015, Construction Industry Institute Research Team 318 (CII RT-318)[24] identified several significant issues facing the North American construction industry, which are discussed in more detail later in this report:

- The average age of skilled trade workers within the construction industry is increasing, and the rate of this increase is four times the national average for all other industry sectors. Most of this is because younger workers are not entering the skilled trades.
- Despite significant declines in real construction wages and widespread use of per diem to attract the needed workforce, rather than being driven by pride in their work, skilled trade workers seem to be motivated by higher wages.
- Although there have been pockets of success in some U.S. geographic locations, immigrant skilled trade workers have not penetrated the more industrial-focused trades (for example, welder, pipefitter, and electrician) in-part due to relatively low educational attainment at the high school level.
- Over the past 30 years, the U.S. education system has incentivized younger generations away from vocational training and into four-year colleges and universities.

Historically, developing and maintaining a skilled labor workforce for the construction industry has demonstrated unique and complex challenges. The challenges experienced include inefficient and inadequate training programs, imbalance between trade skills and compensation rates, and the risk of seasonal unemployment or intermittent periods of unemployment due to the cyclical nature of the construction industry.

[23] Associated General Contractors 2020 Construction Outlook Survey Results National Results – https://www.agc.org/sites/default/files/Files/Communications/2020_Outlook_Survey_National.pdf

[24] Construction Industry Institute. 2016. "Is There a Demographic Labor Cliff that Will Affect Project Performance?" (RT318-11). University of Texas, Austin. See https://www.construction-institute.org/resources/knowledgebase/knowledge-areas/general-cii-information/topics/rt-318.

Except for COVID-19-induced shutdowns, the decline in skilled trade workforce availability has rarely produced a sudden impact on the construction industry. As such, the construction industry has habituated to the cyclical labor challenge and typically assumed that a workforce would be available when required and would be motivated by compensation increases if necessary. Potential issues that could compound these challenges include the following:

- Lack of engagement in the trade workforce by project owners
- Inconsistent recruitment and development performed by construction firms
- Lack of industry strategy to adapt to changes in the workforce and the increasing reluctance of workers to travel for project employment
- Changing culture of the workforce related to work-life balance and multiskilling

The practical consequences of a failure to address the structural challenges of the skilled trade workforce could lead to consequences such as:

- Labor shortage–induced project delays
- Decreased productivity and quality of work
- Higher project costs
- Inefficient deployment of human and physical resources
- Increased rate of safety-related events

The result of these and other factors is that the construction industry is shifting from the long-standing problem of not having enough qualified skilled trade workers to a new problem: not having enough workers at all, regardless of competency. The result is a direct linkage between worker availability and construction project safety, cost, and schedule performance.[25]

Costs of Skilled Trades Labor Shortages

Alleviating skilled labor shortages is broadly beneficial. Inadequate supplies of well-trained, experienced skilled trade workers threaten the ability of owners and contractors to meet project objectives such as safety, cost, schedule, and quality. The CII research project (CII RT-318) demonstrated that labor shortages cause an increase in safety incidents and missed project objectives, directly proportional to the severity of the shortage realized.

That research presented empirical, project-based evidence that workforce shortages are directly correlated with at least three key elements of project execution, and Table 4-1 further illustrates the correlation between labor risk and project challenges.

1. Safety – A labor shortage could cause Occupational Safety and Health Administration (OSHA) Total Recordable Incident Rates (TRIR) on projects to increase by 3–4 times, depending on the severity of the shortage.
2. Cost – A labor shortage could cause project cost escalations of more than 17%, depending on the severity of the shortage.
3. Schedule – A labor shortage could cause projects to experience schedule delays of more than 22%, depending on the severity of the shortage.

Table 4-1. *Impact of staffing difficulty on contractors*

Craft Labor Challenges Threaten Contractors' Capacity to Meet the Primary Objectives of Owner Clients (Cost | Schedule | Safety | Quality)			
Craft Labor Staffing Difficulty	**Average Cost Change**	**Average Schedule Change**	**OSHA Recordable Incident Cases** (Per 200,000 Hours)
Moderate-Severe	17.3% (8.4%, 26.2%)	22.5% (11.5%, 33.4%)	0.94 (0, 2.84)
Slight	3.2% (-0.9%, 7.3%)	12.8% (7.7%, 17.9%)	0.43 (0, 1.72)
No Difficulty	-6.2% (-10.7%, -1.8%)	6.4% (1%, 11.8%)	0.26 (0, 1.25)

CII RT+318, August 2015

[25] Associated General Contractors 2020 Construction Outlook Survey Results National Results – https://www.agc.org/sites/default/files/Files/Communications/2020_Outlook_Survey_National.pdf

Skilled Trade Worker Attrition and Replacement

As has been established throughout this report, the construction industry continues to face numerous obstacles—skilled workforce availability, aging workers, the need for craft training, and challenges in attracting and maintaining skilled trade workers, among others. Current forecasts indicate that skilled labor shortages will increase with a growing economy and aging construction workforce. Historically, the industry has survived the ups and downs of the national economy, but over the past few decades, its ability to retain workers during economic downturns and/or rehire them as the economy improves has declined precipitously. Complicating this steady decline is the looming exodus of retiring workers, which will create significant pressure on all projects but particularly for the power generation industry and electric utility companies as they work to meet the electric grid demands of electric vehicle growth and decarbonization.

Although the construction industry is not alone in confronting an aging labor force, it is failing to replenish the supply with younger workers. As a result, growth in the nation's working age population is slowing within the industry and was down in 2020. Concurrently, older Americans are retiring in record numbers. In 2020, for instance, 9% of those employed in construction (residential and nonresidential) were under the age of 25, which not only was down from 14% early in the 2000s, but also compares to an overall rate of nearly 12% for all industries. In addition, 31% were under the age of 35, which compares to an all-industry rate of 34%. The share of under-35-year-olds was also lower in 2020 than it was in the previous year, making it unsurprising that construction's median age of 42.9 exceeded the all-industry median age of 42.5, up from 42.6 in 2019.

More concerning, with 69% of construction workers above the age of 34 and 22% over 54, as many as 29% of construction workers will retire within the next ten years, which is up from 24% in 2011, and up to 19% will leave within the next five (assuming an average retirement age of 62). Furthermore, 40% will retire within the next 15. To avoid this situation, the industry must work harder to attract and train a younger workforce.

The BLS reported the age group of 16- to 19-year-old construction workers (the age group traditionally seen as entering the labor force) to be about 4% of the workforce in the early 2000s, while the share was just 2% in 2020 (summarized in Table 4-2). At the other end of the spectrum, the age group of workers 55 and older was only 10% in 2000, yet nearly 23% in 2020. This trend is shown in Figure 4-1.

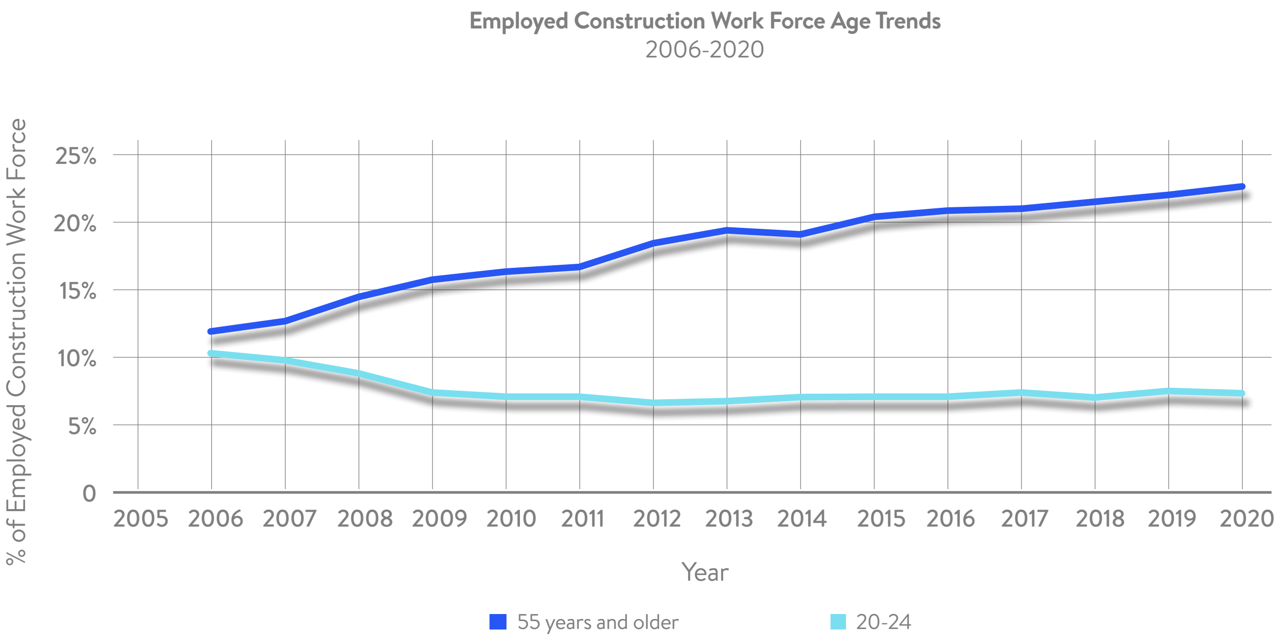

Figure 4 1. *Percent of employed construction workforce over 55 from 2006 to 2020*

Table 4-2. *Age distribution of employed construction workers*

Age Group	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total, 16 +	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
16-19	2.7%	2.6%	1.8%	1.6%	1.4%	1.4%	1.7%	1.6%	1.5%	1.5%	1.7%	1.8%	1.7%	1.7%	1.8%
20-24	10.5%	9.9%	9.0%	7.5%	7.2%	7.2%	6.7%	7.0%	7.2%	7.3%	7.3%	7.5%	7.3%	7.7%	7.6%
25-34							23.5%	22.9%	23.4%	22.7%	22.3%	22.1%	22.5%	22%	21.5%
35-44							24.0%	24.1%	24.3%	24.7%	24.3%	24.3%	25.3%	24.9%	24.6%
45-54							25.5%	24.9%	24.3%	23.4%	23.5%	23.2%	21.4%	21.6%	21.8%
25-54	74.7%	74.6%	74.7%	75.0%	74.9%	74.6%	73.1%	72.0%	72.0%	70.7%	70.1%	69.6%	69.3%	68.5%	67.9%
55 years +	12.0%	12.9%	14.6%	15.9%	16.5%	16.8%	18.6%	19.5%	19.3%	20.5%	21.0%	21.1%	21.7%	22.1%	22.7%
55-64							15.1%	15.5%	15.4%	16.4%	16.6%	16.6%	16.7%	16.8%	17.2%
65 years +							3.5%	3.9%	3.9%	4.0%	4.4%	4.5%	5.0%	5.4%	5.5%

Data Source: U.S. Department of Labor & Bureau of Labor Statistics

Alternatively, tracking new construction workforce entrants in the 16- to 24-year-old age groups shows a 31% reduction since 2007 (the year prior to the Great Recession). There was a 60% increase in the number of workers aged 55 and older. Again, this is further evidence that growth in the working age population is slowing while the Baby Boomer generation is rapidly reaching retirement age. These trends over the past decade and more demonstrate an aging workforce and declining labor pipeline growth that is problematic for industry leaders who rely on skilled tradesmen for project completions. As construction users continue to demand a skilled workforce, skill level, willingness to travel, and an aging workforce will undoubtedly shape project outcomes.

CIR supply data (imported directly from contractor and labor provider payroll information) shows attrition to be more significant for the most highly skilled industrial crafts because they tend to be older, having been in the construction industry for many years or decades. As shown in Figure 4 2, with an overall average retirement age of 59 years old, the age attrition rates for select highly skilled industrial trades—which are most likely to be used on power generation projects—is expected to be 20% in two years, 27% in five, 40% in ten, and 53% within fifteen years.

This challenge is particularly daunting because the overall all-industry labor participation rate for all age groups averaged just 62% in 2015, a 38-year annual low. Although the participation rate improved in subsequent years, increases were negligible; furthermore, it dropped precipitously in 2020. In fact, it averaged only about 61% in 2020. Though there were some encouraging signs before 2020, rates remain well below those seen prior to the Great Recession, which were upwards of 66% and more than 67% at the beginning of the 21st century. The COVID-19 pandemic caused participation to fall even more, plunging to 60% in April 2020, and although it slowly inched upward, averaging nearly 62% in August 2021, it remains far below pre-pandemic levels.

It takes a significant amount of time to train and develop a new hire to be a seasoned, productive professional. Meanwhile, the calendar is working against the industry as the most highly skilled workforce is retiring at a rapid rate and the construction industry's efforts to replace them are lacking.

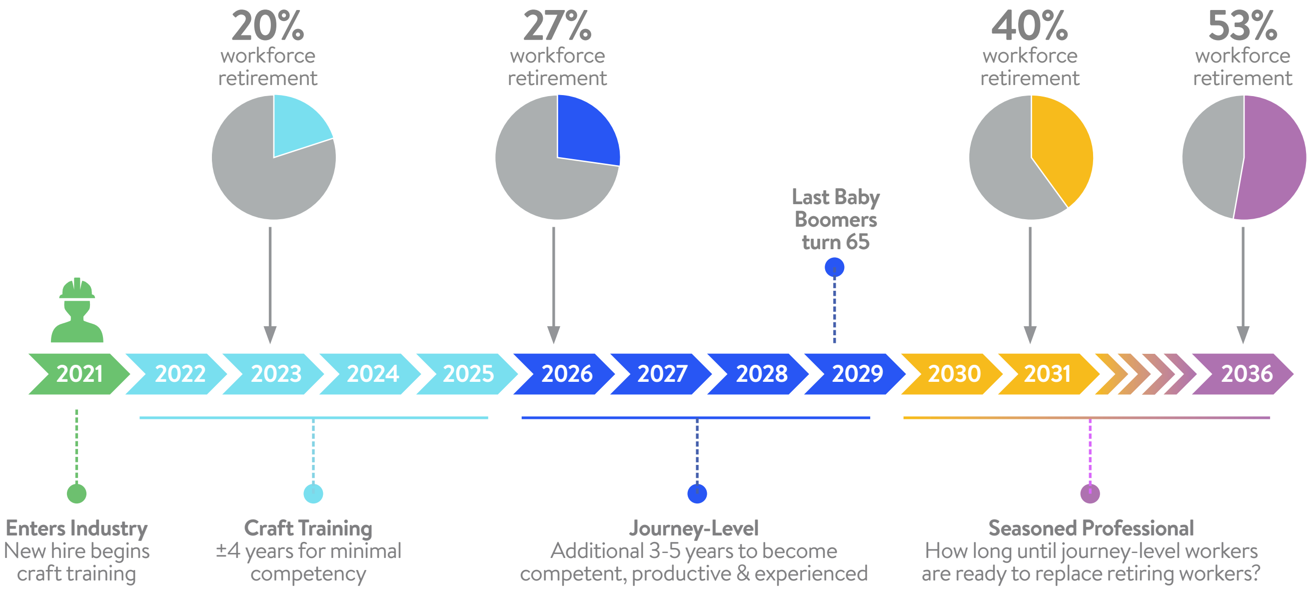

Figure 4-2. *Skilled labor retirement and pipeline trend for the most highly skilled disciplines: CLMA United States 20/20 Foresight Report (2021Q1)*

Changing Culture of the Skilled Trade Workforce

In addition to attrition, how are the dynamics of the skilled trade workforce expected to change leading up to 2030? To help answer this question, Construction Industry Institute Research Team-370 (CII RT-370)[26] examined changes in multiskilling trends. *Multiskilling* is a workforce strategy in which skilled trade workers are skilled in more than one construction trade. This strategy first emerged in the U.S. construction industry in the late 1990s, and CII RT-370 examined both how it is changing and what motivates these workers to become multiskilled.

To answer the question of why workers became multiskilled, CII RT-370 examined data from the Sloan Center for Construction Industry Studies 2000 Survey and its own workforce survey. The surveys asked multiskilled individuals (self-reported) why they became multiskilled, and this enabled a direct comparison of the two data sources.

As shown in Figure 4-3, in 2000, the top reason for a skilled trade worker to become multiskilled was financial. By 2020, earning money was still highly important, but consistent employment was the top priority. This is not surprising given the challenges of the Great Recession and COVID-19.

[26] Construction Industry Institute 2021. "Modeling the Composition of the 2030 Workforce" (Research Team-370) University of Texas, Austin. See https://www.construction-institute.org/resources/knowledgebase/knowledge-areas/general-cii-information/topics/rt-370.

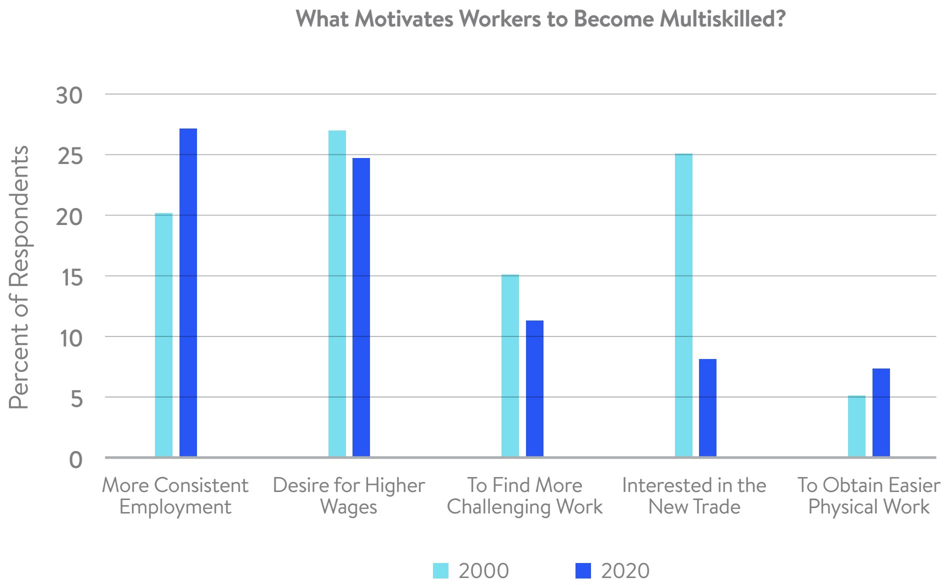

Figure 4-3. *Sloan Center for Construction Industry Studies 2000 Survey and 2020 RT-370 Craft Survey*

The construction industry has tended to treat the skilled workforce as somewhat expendable, rather than investing in the workforce during economic downturns. Releasing skilled workers during economic downturns has resulted in a diminished workforce and has motivated the skilled workforce to place a higher priority on employment consistency than on the more traditional priority of wages. As shown in Figure 4-3, other worker motivations such as more challenging work, learning a new trade, and doing easier work are distant concerns.

Based on survey data, skilled workers want and need more employment certainty, and this includes a specific desire for local employment opportunities. Skilled trade workers' desire to find employment in a local geographic region is highly impactful for projects in locations where there are fewer workers. This diminishes workforce mobility overall and may be detrimental to the power generation industry, which relies on travelers for many remotely located projects such as solar and wind generation.

The decrease in skilled labor mobility is partially driven by a fundamental change in construction households. There has been a significant growth in dual-income households, which is consistent with what is happening throughout the United States. In the 1970s, only about 30% of the spouses of skilled trade workers were employed. Four decades later, that number is over 80% and increasing.[27]

The mobility challenge is straightforward: skilled trade workers in a dual-income household are less able to move or travel outside of their geographic region for work. The data suggest that this explains why many skilled trade workers have become less mobile and by extension are becoming multiskilled. Multiskilling appears to be replacing mobility.

An interesting facet of the multiskilling trend is its organic nature. There is no obvious overall industry strategy, or even company tactics, to promote multiskilling. The desire for multiskilling reflects a practical response by individual workers to the reality of household circumstances at a given time, regardless of whether the industry desires it. It is the workforce's response to its own shift in mobility.

This multiskilling versus mobility evolution creates industry opportunity. For example, could more modularization and prefabrication offshoring return to the U.S. and be located in areas where there may be lower demand for skilled labor relative to the available workforce? This would create positive employment and economic benefits at micro and macro levels.

The construction industry must decide if this organic growth is the best way for multiskilling to evolve and whether to seize opportunity as a way to retain, strengthen, and grow the skilled workforce. Because it appears that the workforce wants this, and there is a consistent trend suggesting that less mobility and increasing multiskilling is here to stay, the construction industry must find a meaningful way to embrace this and extract value from it.

[27] University of Chicago, National Opinion Research Center, General Social Survey Database. See https://gss.norc.org/.

Models of Industry Change

There are effective models in which the construction industry has successfully examined industry-wide challenges, found solutions, and implemented change. One of these models is the strategy employed in addressing workplace safety, which could provide a model for addressing the existing and potential shortage of workers.

In the decades leading up to the 1990s, construction industry safety performance was desired but not an ingrained priority, even though industry knew how to be safe and Occupational Safety and Health Administration (OSHA) had standards to measure and benchmark safety performance. This is illustrated in Figure 4-4, which shows safety performance data provided by the Construction Industry Institute and Construction Users Roundtable through its joint safety benchmarking efforts, which shows a 7.19 Total Recordable Incident Rate (TRIR) in 1989. However, real change did not happen until project owners insisted on safety improvement and enforced it through the bid evaluation and contract award processes.

When owners declared safety to be a core value and business imperative, key contractor selection safety metrics were established, safety improvement innovation was unleashed, construction sites and projects become safer, and "zero safety incidents" became achievable. Even then, change took time, but persistent owner leadership and commitment to safety excellence ultimately transformed safety performance.

Many project owners understood the importance of safety for their own operations, and most already had strong employee safety programs in place. What was needed was a standardized, institutionalized process for the industry as a whole and labor providers in particular. The recommendation to prequalify contractors for safety performance originated with the Business Roundtable (BRT), was based on the 1982 Construction Industry Cost Effectiveness (CICE) study, and was predicated on demonstrated real cost savings in addition to avoiding accidents—that is, "Safety Pays." The efforts to institutionalize worker safety were broad and effective, resulting in the following:

- Avoided accidents reduced the direct cost of each accident, including costs of emergency management, staffing, administration, and investigations.
- Fewer accidents reduced the cost of crew work disruptions and productivity losses that occur when an accident happens.
- The decline in accidents reduced Workers Compensation insurance rates, dramatically reducing future hourly costs.

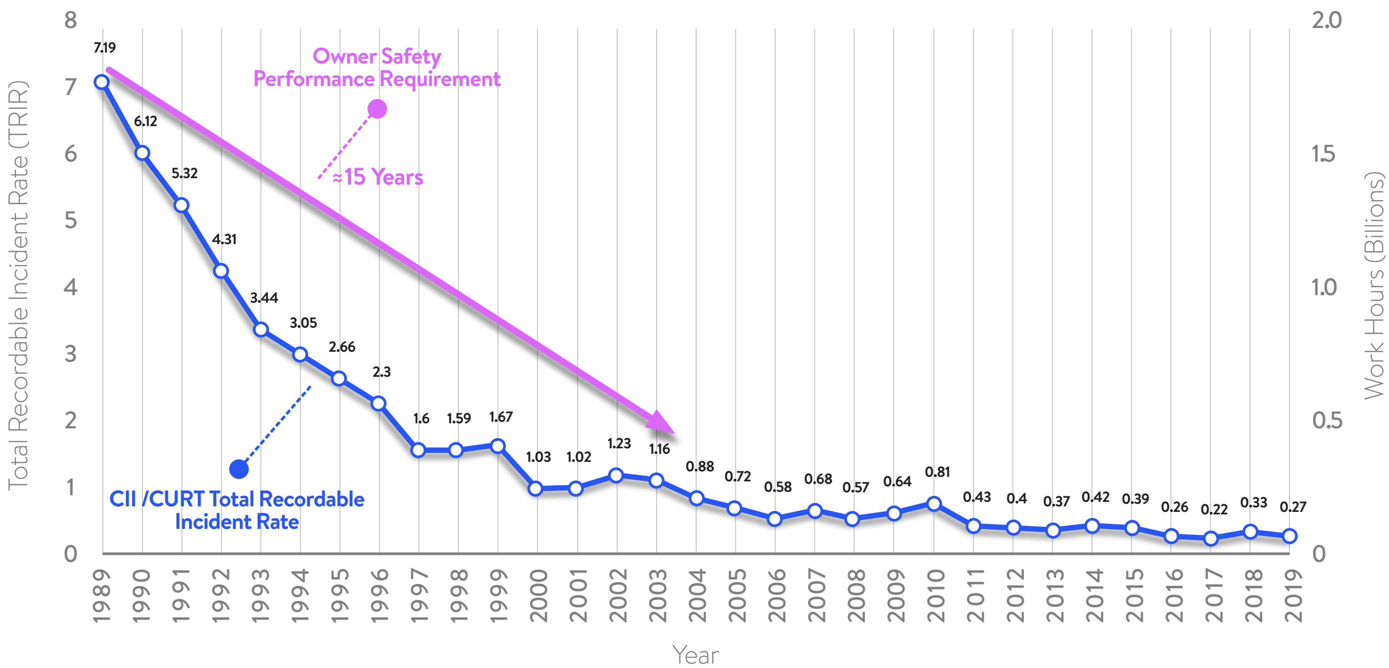

Figure 4-4. *CII/CURT total recordable incident rate (1989–2019)*

The safety model could be applied to the issue of workforce development and training. Project owners are in the unique position to lead, make workforce development a priority, incent the right behavior, and reduce project risk. For the past 30 years, owners have consistently agreed that contractor prequalification should include workforce development. In 1997, the BRT released a report in which it stated, "Owners should only do business with contractors who invest in training and maintain the skills of their workforce." This premise has been reaffirmed multiple times since by the Construction Users Roundtable and most recently in 2018 by the Construction Industry Institute (CII RT-335).[28]

Perhaps the most important lesson from the construction industry's successful efforts to improve workplace safety is that it requires a combination of industry commitment and quantitative measures to evaluate progress. The case for project owners' active involvement is very strong because they have much to lose financially when worker challenges are present. Contractors have the final responsibility to recruit, hire, train, and retain workers, but owners ultimately bear the costs of worker errors and inefficiency. The immediate opportunity is for owners to take the lead and focus on motivating contractors to proactively address pending shortages of skilled trade workers as well as workforce development and training. Owners have the most at stake and are in the position to lead.

Workforce Development Solution: Potential Transforming Policies

Workforce development is essentially a four-part process consisting of recruitment to the industry, training for those in the industry, retaining the human resource capital that the industry develops, and placing the craft professional in opportunities so that the person can excel throughout their career. The absence of any of these will likely result in a weakened skilled trade workforce.

In addition, the construction industry workforce development system involves many organizations across different sectors, outside construction, and in multiple locations. It is a complex system, and it requires advanced modeling techniques to fully understand the intricacies and factors influencing its performance. To understand it more fully, more recent research conducted by CII RT-335 posed and answered an essential question: What can be done to make the U.S. construction workforce development system effective?

For the purposes of the study, the workforce development system includes elements of the U.S. primary, secondary, and post-secondary education system, construction training, and placement and retention efforts for skilled trade workers. Elements excluded from the scope of the work include unemployment problems (for example, underemployment); specific primary, secondary, and post-secondary curriculum design; and comprehensive immigration reform.

Revitalizing the U.S. workforce development system could be a positive step on the path toward addressing not only the skilled shortage of construction skilled trade workers, but also the nation's shortage across numerous other industries. The power generation industry is an example of how implementation of transformative improvements now can help this sector more efficiently meet the targets of decarbonization and electric vehicle growth over the coming decade and beyond. Without meaningful change, the labor market data and current trends indicate that it could be challenging to meet either short- or long-term expectations.

To define a clear and meaningful path forward, a series of policies was developed through the CII RT-335 study that impact industry stakeholders and governmental agencies. Considering the relative benefits and costs associated with each policy, certain ones can begin to be implemented more quickly, in the short term (less than three years); others will require long-term, sustained efforts.

Short-term workforce development solutions include the following:

- Establishing and strengthening the awareness of career opportunities in the United States: Most graduating high school students expect to earn a bachelor's degree for employment opportunities and higher wages, yet most jobs in the U.S. require career and technical education (CTE) and the associated certification. Commitment to the equality of all workers comes from recognizing the dignity of their contribution to society.
- Revitalizing work-based learning programs: Despite the tremendous benefits associated with work-based learning, it remains a marginal education strategy in the United States. Improving participation in work-based learning programs can be achieved by removing barriers to company participation and promoting its exposure in secondary education.
- Measuring performance and involvement in workforce development when awarding construction contracts: As project owners recognized the importance of safety, they held their contractors to high standards of safety performance, which helped with long-term improvements in worker health and safety. Owners could assess construction firms' dedication and commitment to workforce development and investment in training much like the industry does with safety. This solution is discussed in greater detail in the following Contractor Workforce Development Assessment (CWDA) and training investment sections of this report and provides the most immediate opportunity to assist the power generation industry in preparing for the decade ahead.

[28] Construction Industry Institute. 2018. "Improving the U.S. Workforce Development System," (RT-335) University of Texas, Austin. See https://www.construction-institute.org/resources/knowledgebase/knowledge-areas/general-cii-information/topics/rt-335/pubs/fr-335.

Longer term workforce development solutions include the following:

- Redefining the measurement of the quality of our nation's secondary education system by career and college readiness: In terms of preparing graduates of the secondary education system, "career readiness" and "college readiness" are currently used interchangeably. Career readiness is a broader concept than just preparing individuals for university studies. The nation's secondary education system could be provided greater incentive to ensure the career readiness of all high school graduates to include pathways to craft labor careers.
- Increasing the participation of underrepresented groups in CTE: The groups that represent the greatest opportunity for new workers in the construction industry include women, minorities, and veterans. To increase the numbers of these groups within the construction industry, their presence within secondary and post-secondary CTE programs would need to be increased. In addition, the construction industry could improve recruiting and retention of these future professionals with improved worksite conditions and other incentives.
- Establishing and expanding collaboration between industry, education, and government: Industry and business leaders directly feel the challenge of recruiting people in nonmanagerial roles with required skills, training, and education. To promote CTE in both secondary and post-secondary education levels, the industry can play an active role in promoting industry involvement and investment into secondary and post-secondary CTE programs.
- Developing more balanced funding among post-secondary CTE and higher education: The overall governmental funding received by CTE programs across the United States has declined over the last decade. Increasing funding available to CTE programs most needed by industry through direct funding, incentive programs, and streamlined governmental funding programs can lead to more balanced funding to meet workforce needs.

Executing these workforce development solutions goes beyond any single implementation resource or any construction firm and will require new approaches in the communication of career opportunities, such as work-based learning and other initiatives, to youth in secondary and post-secondary education.

Workforce Development Solution: Assessing and Benchmarking Labor Risk

Implementation of these development solutions is necessary, but there must also be an effective process for evaluating effectiveness because a skilled, competent construction workforce is essential to safe, productive, and sustainable project execution. Historically, owners have advocated holding contractors accountable for investing in training and maintaining the skills of their workers. However, skilled and non-skilled worker shortages persist and correlate to the lack of contractor engagement in workforce development. To combat this issue, owners can take a leadership role by proactively requiring industry-wide recruiting, training, and retention efforts and metrics to measure these activities. Until recently, however, the industry has lacked a reliable metric to evaluate and represent a contractor's commitment to workforce development and training fairly, consistently, and objectively. Therefore, what has been missing in the selection process is a way to effectively measure and manage project labor risk in three specific ways:

1. **Leadership.** For decades, the construction industry has debated the workforce problem and its severity. It has implemented many programs to address the numerous workforce-related symptoms yet has not addressed the root cause of labor and workforce risk: leadership. Leadership is essential to bring about transformative change to the construction workforce culture. Effective, leadership-driven labor risk management can help address and transform systemic labor challenges and urgency for its deployment.
2. **Bid evaluation and contractor selection.** Effective evaluation of workforce development improves bid evaluation and contractor selection. Reacting later in the project, when labor challenges are more difficult to overcome, lessens an owner's influence and increases cost. With effective labor risk management comes a comprehensive solution for prequalifying, assessing, and monitoring workforce development.
3. **Return on investment for worker training.** Very little market research has been devoted to evaluating the return on investment for construction workforce development and training. Further, research indicates that very few construction firms internally measure the return on investment for their craft training efforts. A common reason for the lack of metrics is uncertainty about what should be measured, and many consider training to be essential regardless of any measurable ROI.

To address this, in 2007, under the guidance of the Construction Users Roundtable (CURT) Workforce Development Committee, the Contractors' Workforce Development Assessment (CWDA) was developed, vetted, piloted, and validated over a five-year period to make workforce development a key criterion in both the prequalification and the final selection of contractors— just as contractor safety, quality, and schedule are key selection criteria.

The purpose of the CWDA is to better inform project owners and hiring contractors during the selection process to reduce labor risk. This assessment tool and process enable stakeholders to evaluate contractor craft development and training programs, improve project labor certainty, and provide a set of objective measures to transform what has traditionally been a subjective analysis. It does this through objective metrics and effective peer benchmarking.

In 2020, the CWDA was enhanced and relaunched with numerous improvements, the goal of which was and is to evaluate and provide stakeholders with reliable metrics to represent a contractor's commitment fairly, consistently, and objectively to workforce development and training. Because the CWDA provides metrics and benchmarking data along with improvement recommendations in the form of a CWDA ScoreCard™, contractors participating in the process benefit as well.

Several key goals guided the development, vetting, and validation process to ensure that the CWDA clearly produced metrics that represented this commitment:

- Ask relevant questions to accurately measure workforce development and training programs.
- Weight questions by their importance and impact on workforce development.
- Consider and accommodate the impact of different contractor types (for example, construction manager, general contractor, and subcontractor).
- Ensure that the tool is labor posture neutral and absent of a labor posture preference.
- Engage qualified third parties to collect and audit information to maintain consistency.
- Minimize subjectivity in the validation process.

Because workforce development is a key criterion in both the prequalification and final section of contractors, the deployment of the CWDA provides the industry with a tool that serves both owners and contractors by:

- Equipping owners to lead in bringing about transformative change to the construction workforce by establishing the CWDA metrics and standards for use by contractors during the selection process and emphasizing the importance of a skilled workforce rather than relying on low bid as the key to improving the industry.
- Equipping contractors to improve their workforce development and training programs; deliver a competent, productive workforce on projects; and increase their competitiveness.

As noted previously, this strategy has proven successful when owners declared safety to be a core value and business imperative and established key contractor selection safety metrics. When owners made safety a non-negotiable expectation of doing business, the number of safety incidents categorized as highly preventable declined. When owners establish the same expectations related to workforce development and training as they did for safety decades ago, the CWDA metrics and benchmarking can lead to improved outcomes.

The benefits of the CWDA for both project stakeholders and the industry as a whole are clear:

- Enables hiring organizations (owners, EPCs, GCs, and so on) to evaluate and pre-qualify contractors to lessen project labor risk more effectively.
- Establishes industry-wide workforce development and training metrics.
- Helps contractors identify strengths and growth opportunities to increase profitability and improve operational excellence.
- Helps contractors protect their reputation and enhance their brand by delivering a competent, skilled workforce on every project.
- Promotes the safe and productive completion of projects on-time and on-budget.
- Effectively demonstrates workforce development commitment to project owner and contract partners.

A qualified workforce is critical to a safe, productive, on-time, and on-budget project delivery— which will be particularly important for the power generation industry as it expands capacity to meet societal expectations. It is also important to understand that the competence and quality of a contractor's workforce is the direct result of the contractor's commitment to workforce development and training. Project owners in the power sector could lead this change because it is the contractor's responsibility to recruit, hire, train, and retain workers, but ultimately owners bear the cost of workforce challenges. Owners are in position to lead by making workforce development a priority, incentivize the right behaviors, and reduce project risk. Active engagement in and advocacy for robust workforce development and training will improve the owner's bottom line and the state of industry.

Workforce Development Solution: The Impact of a 1% Investment

The benefits of workforce development and training along multiple dimensions was the focus of the Construction Industry Institute RT-231 study.[29] This research produced a recognition of the benefits of skilled labor training, which included improved productivity, reduced turnover, improved quality, reduced absenteeism, and improved safety.

For an industry that is typically slow to change and often skeptical, the CII RT-231 research was commissioned to help project owners, contractors, and other stakeholders understand the ROI on projects that is achievable through consistent investment in workforce development and training. The project owners of the power generation industry will similarly need to take transformative steps by leading this sector.

These worker development and investment concepts represent measurable metrics relative to early workforce investment on a project through contractor prequalification and contract compliance for comprehensive workforce development—forecasting, recruitment, training, and retention. The CII RT-231 study demonstrated a positive cost impact of craft training on labor productivity, turnover, absenteeism, injury, and rework by applying construction market survey data modeling two distinct project scenarios: a typical 24-month capital industrial project and a typical ongoing maintenance or capital contract.

Conclusions of the study on the benefits of craft training were presented in the context of the employer, the project, and the craft worker. As shown in Table 4-3, the study found that if 1% of the total project labor budget were invested in training, it would significantly benefit both workers and employers as well as improve overall project delivery.

The CII RT-231 study also analyzed heavy industrial construction firm case study data from the projects of two companies. One company monitored absenteeism and turnover rates on four projects over 15 months and found that craft training and certification had an immediate impact, as shown in Table 4-4.

Table 4-3. *Summary of expected training benefits identified through CII RT-231 survey*

Expected Training Benefit	Capital Project			Maintenance Project		
	Average	95% Confidence Rating		Average	95% Confidence Rating	
		Low	High		Low	High
Productivity Improvement	**11%**	6.8%	14%	**10%**	7.7%	12%
Turnover Decrease	**14%**	10%	18%	**14%**	8%	19%
Absenteeism Decrease	**15%**	10%	19%	**15%**	8.3%	21%
Injury Decrease	**26%**	18%	33%	**27%**	18%	37%
Rework Decrease	**23%**	17%	29%	**26%**	18%	35%

Table 4-4. *Turnover and absenteeism rate for workers (CII RT-231)*

Craft Labor Challenges	Workers with No Training	Workers Receiving Training	Company-Certified Workers
Voluntary Turnover Rate	6.5%	0.6%	3.4%
Absenteeism Rate	7.3%	2.5%	0.3%

[29] Construction Industry Institute. 2018. "Construction Industry Craft Training in the United States and Canada" (RS 231-1) University of Texas, Austin. https://www.construction-institute.org/resources/knowledgebase/knowledge-areas/general-cii-information/topics/rt-231/pubs/rs231-1.

Another company evaluated productivity on a construction maintenance project in which the owner actively promoted certification of all craft workers on the project and required the craft workers to be compliant with the National Center for Construction Education and Research (NCCER) Certified Plus (now "Certified") designation, an industry-recognized competency certification. In the study, the percentage of craft workers achieving this designation was measured over a 12-month period. The *productivity performance factor* was defined as the expected productivity divided by the actual productivity; therefore, a productivity performance factor of less than 1 indicates better than expected productivity performance. The data enabled the CII RT-231 study team to correlate productivity performance improvement to the number of craft workers achieving Certified Plus designation (Figure 4-5).

To establish the business case for craft training from a project as well as company perspective, the CII RT-231 team employed a benefit/cost ratio analysis, which indicated that a robust return is realized from an investment in training. The CII RT-231 team applied cost factors to the research data and evaluated them based on the craft workers' duration on the project. For example, increasing craft workers' time on the job decreases the total number of workers hired on the project. This translates into less turnover, fewer injuries, greater productivity, and less rework. In addition, increased exposure to training resulting in increased skill levels, producing a clear ROI that increases the longer craft workers are on the project. As shown in Table 4-5, this ROI is based on an investment of approximately $230,300 (1%) of a project's labor budget (≈$23 million) being invested in training efforts. The resulting benefit/cost ratio shows that for every dollar invested, a return of up to $3.00 can be achieved.

The data assembled through the CII RT-231 research effort—both survey and actual project data—demonstrate a compelling business case for workforce prequalification as it relates to workforce development and training. Although the CII RT-231 research focused primarily on training and indicates a high return for doing so, there are multiple attendant activities that should also occur in concert with training:

- **Validation.** Workforce development efforts should be effectively validated to ensure that they are effective and consistently employed.
- **Metrics.** Most companies do not measure the effectiveness of workforce development efforts, but it can and should be done.
- **Financing.** Owners are paying for training on union projects but rarely for non-union projects. Because owners will ultimately bear the cost of insufficient training, they should not simply push the responsibility over to contractors.
- **Data.** Robust collection of workforce-related data will help understand how improvement is being realized and how to continuously improve.
- **Patience.** Some efforts pay off immediately, but others take more time. As with safety improvement, tangible results will begin to be realized immediately, but full transformation takes time.

Through an effective labor risk management program, both the project owner and all participating contractors can have reliable analytics available for planning the project. In addition, the owner will be able to prequalify and select the best available contractors who are recruiting, retaining, developing, and training a competent skilled trade workforce that is required for the project.

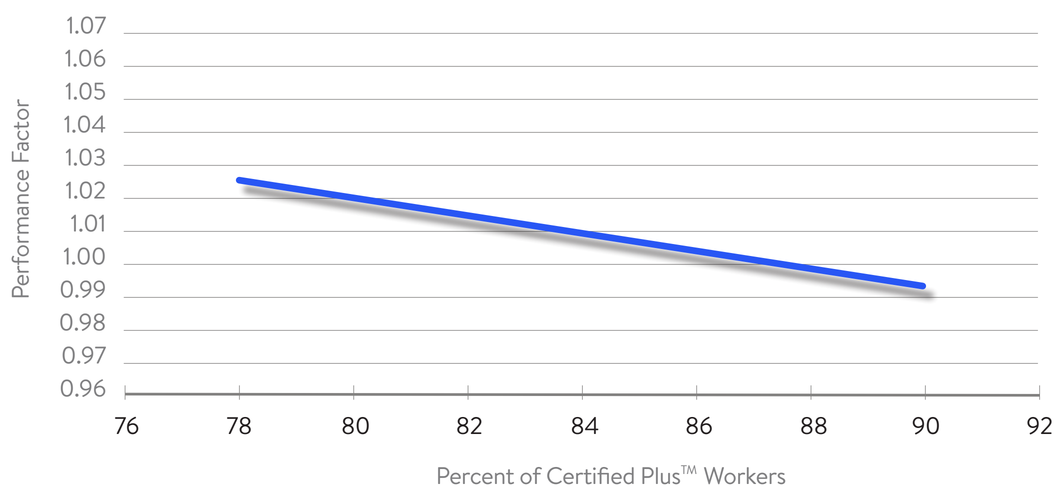

Figure 4-5. *Craft worker productivity factor vs. percentage of certification (CII RT-231)*

Table 4-5. *Benefit/cost ratios based on survey data for a single project (CII RT-231)*

	Single Project Training Models		
	Average Cost & Duration (18 wks)	**95% Confidence Rating**	
		Low	**High**
Estimated Productivity Improvement	**$322,257**	$207,564	$436,951
Estimated Turnover Cost Reduction	**$32,150**	$23,790	$40,509
Estimated Absenteeism Cost Reduction	**$74,871**	$51,592	$98,150
Estimated Injury Rate Reduction	**$66,940**	$47,452	$86,428
Estimated Rework Rate Reduction	**$25,774**	$18,876	$31,993
Estimated Total Cost Saving	**$521,992**	$349,252	$693,938
Estimated Training Cost	**$230,296**	$230,296	$230,296
Estimated Benefit/Cost Ratio (B/C)	**2.3**	1.5	3.0

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6. APPENDICES

A. Acronyms

BLS	Bureau of Labor Statistics
BRT	Business Roundtable
CII	Construction Industry institute (University of Texas, Austin)
CIR	Construction Industry Resources
CLMA	Construction Labor Market Analyzer
CWDA	Contractors' Workforce Development Assessment
CURT	Construction Users Roundtable
OES	Occupational Employment Survey/Statistics
NCCER	National Center for Construction Education and Research
NORC	National Opinion Research Center
REGEN	Regional Economy, Greenhouse Gas, and Energy
RTO	Regional Transmission Organization
SOC	Standard Occupational Code

B. Selected Standard Occupational Codes with Descriptions

Discipline Title	SOC	Discipline Description
Boilermaker	47-2011	Boilermaker Welders weld piping and other heavy-metal structures in support of boilermaker work operations. Referred to as Boilermakers in text.
Carpenter (Pile Driver Operator)	47-2072	Pile drivers install piling to hold back the earth during excavations, to set up the foundation of skyscrapers and bridges, and to build docks and wharfs. Due to the wide range of work in this trade, many pile drivers are certified welders and capable of working with a variety of sizes and shapes of steel.
Carpenter (Scaffold Builder)	47-2031	Carpenters construct, erect, install, maintain, and repair structures and components of structures made of wood, wood substitutes and other materials.
Concrete Finisher - Cement Mason	47-2051	Cement masons mix, place and consolidate concrete. Concrete finishers smooth and finish freshly poured concrete, apply curing or surface treatments, and install, maintain and restore various masonry structures such as floors, ceilings, sidewalks, roads and patios.
Craft Helper	47-3019	Construction trades helpers and laborers assist skilled tradespersons and perform general labor activities at construction sites.
Electrician	47-2111	Electricians install, maintain, test, troubleshoot and repair industrial electrical equipment and associated electrical and electronic controls in commercial and industrial facilities.
Elevator Installer and Repairer	47-4021	Elevator constructors and mechanics assemble, install, maintain, and repair freight and passenger elevators, escalators, moving walkways and other related equipment.
Instrumentation Technician	49-9069	Instrumentation Technicians install, inspect, test, adjust, and repair electric, electronic, mechanical, and pneumatic instruments and systems in industrial facilities.
Insulators	47-2131	Insulators apply insulation materials to plumbing, process, air-handling, heating, cooling and refrigeration systems, piping equipment and pressure vessels, and walls, floors and ceilings of buildings and other structures to prevent or reduce the passage of heat, cold, sound or fire.
Ironworker (Reinforcing)	47-2171	Rebar ironworkers fabricate, tie, and set reinforcing bar for concrete placements. May also be known as rod busters.
Ironworker-Welder	47-2221	Structural ironworkers place and install steel girders, columns, and other structural members to form completed structures or frameworks of buildings, bridges, and other structures.
Laborers	47-2061	Construction helpers and laborers perform general, physical labor activities at construction sites and oil/gas rigs and may assist skilled tradespersons.
Lineman	49-9051	Electric linemen install, relocate, or modify high-voltage electrical power lines that link utility grids to medium or low voltage distribution systems.
Millwright	49-9044	Construction millwrights and industrial mechanics install, maintain, troubleshoot, and repair stationary industrial machinery and mechanical equipment.
Operator (Heavy Crane)	53-7021	Crane operators operate cranes or draglines to lift, move, position or place machinery, equipment and other large objects at construction or industrial sites, ports, railway yards, surface mines and other similar locations.
Operator (Heavy Equipment)	47-2073	Heavy equipment operators operate heavy equipment used in the construction and maintenance of roads, bridges, airports, gas and oil pipelines, tunnels, buildings, and other structures.
Operator (Truck Driver)	53-3032	Truck drivers operate heavy trucks to transport goods and materials over urban and rural routes.
Painter	47-2141	Painters and decorators apply paint, wallpaper and other finishes to interior and exterior surfaces of buildings and other structures.
Pipefitter	47-2152	Pipe and combo welders fabricate components by welding, brazing, caulking, soldering, gluing or threading joints at industrial and commercial job sites. Referred to as Pipefitters in text.
Sheet Metal Worker	47-2211	Sheet metal workers fabricate, assemble, install, and repair sheet metal products including air handling ductwork.

For Standard Occupational Codes: *https://www.bls.gov/soc/2018/soc_2018_definitions.pdf*

C. Occupational Employment Statistics

Most statistics issued by the BLS measure industry employment. It is rarer to find data on occupational employment, which tallies the numbers of individuals in specific occupations, regardless of industry. The most useful data provide information on both industry and occupation. That information is provided at the U.S. level in the OES, but the small sample sizes of industry-occupation data at state and metropolitan geographies preclude its publication.

For example, BLS statistics count all employees in a natural gas transmission company when totaling employment by industry. In this case, that industry is Pipeline Transmission of Natural Gas (North American Industrial Classification 486210). The tallies include administrative aides, sales staff, accountants, and so on, and those totals are reported for the industry as industry employment. Very few of those employees, however, will be engaged in construction.

Instead, construction will be mostly confined to the construction industry. Pipeline construction companies are designated by NAICS Code 237120, Oil and Gas Pipeline and Related Structures Construction. Even within NAICS 237120, only a portion of employees will be classified within the construction trades, for example, as Plumbers, Pipefitters, and Steamfitters (Standard Industrial Classification Code 47-2152).

The BLS collects occupational information twice a year for a sample of firms in each industry and publishes it during spring of the following year as the National Occupational Employment and Wage Estimates (OES). The OES provides wage estimates for the 10%, 25%, 50%, 75%, and 90% percentiles of each occupational class by geographical region. The supply data for trades workers used in this report are derived from the OES and are assumed to provide a representative view of the industry.

Industrial construction workers—particularly the top 25% of these workers—represent the focus of this study. This group is identified as possessing the skills and experience required by general contractors and construction firms. These jobs often offer higher wages and long-duration employment opportunities.

The Occupational Employment and Wage Surveys are documented and discussed at the Bureau of Labor Statistics website. An overview of the of the sampling frame, frequency of surveys, and other methodology is available at https://www.bls.gov/oes/oes_emp.htm. The data files are available at https://www.bls.gov/oes/tables.htm. Additional documentation is provided at https://www.bls.gov/oes/oes_doc.htm.

D. Electric Power Construction Categories

Within the Construction Labor Market Analyzer, hundreds of algorithms are used in conjunction with project information about construction schedules and total construction cost. The models profile an individual project's skilled labor needs over time—both new construction and maintenance and repair for each of 10 power generation technologies. Aggregating all the individual project profiles for a metropolitan area, state, or region results in the number of workers needed from each skilled trade and when they are needed for that geographic area The 20 algorithms listed below are those used in this report.

	New Construction	Maintenance & Repair
Single & Combined Cycle Gas Plants	■	■
Coal & Petroleum Plants	■	■
Fossil (Environmental)	■	■
Fossil (New Generation)	■	■
Fossil (General & Other)	■	■
Hydroelectric Plants	■	■
Nuclear Power Plants	■	■
Solar Power Plants	■	■
Wind Power Plants	■	■
Transmission & Distribution	■	■

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