Wages, Benefits, and Change

A Supplemental Report to the Annual U.S. Energy and Employment Report

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NASEO
National Association of State Energy Officials

ENERGY FUTURES INITIATIVE

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The National Association of State Energy Officials (NASEO) is the only national non-profit association for the governor-designated energy officials from each of the 56 states and territories. Formed by the states in 1986, NASEO facilitates peer learning among state energy officials, serves as a resource for and about state energy offices, and advocates for the interests of the state energy offices to Congress and federal agencies. For more information about NASEO, please visit www.naseo.org.

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The Project Team would like to extend our sincere appreciation to our Peer Reviewers for their thoughtful, insightful, and expert contribution to the quality and content of this report.

87–106%
Increase in natural gas, renewable energy, and petroleum production from 2000 to 2019

37%
Decrease in domestic coal production between 2000 and 2019

EMPLOYMENT TRENDS

▲ **915,000**
New jobs created by the energy industry over 2015-19, almost 11 percent of the nation's job growth

14–22%
Growth in energy jobs in professional services, repair and maintenance, and mining and extraction over 2016-19—outpacing construction (+5%), manufacturing (+5%) and wholesale trade (-14%)

▲ **73,000**
New jobs created in petroleum and natural gas fuels over 2015–19, a 9% increase

▼ **17,000**
Jobs lost over 2015-19 in the **coal fuels sector,** an 18% decline

▲ **83,000**
New jobs created in solar and wind electric power generation over 2015-19, a 22% increase

» A detailed explanation of key findings begins on page 4

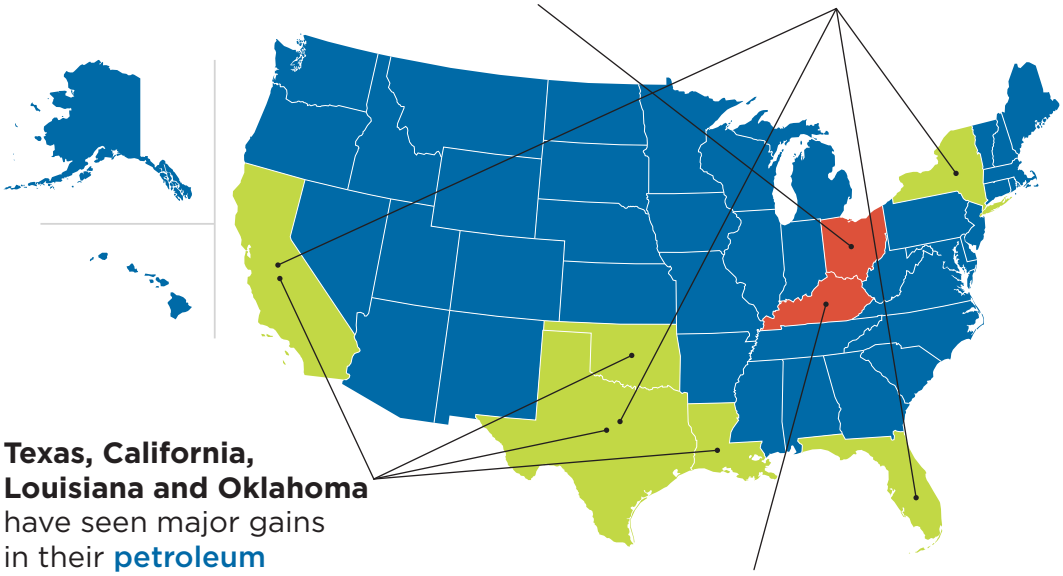
GEOGRAPHIC SHIFTS

Ohio had the highest number of **coal electric power generation workers** at the end of 2019 but shed 25 percent of its coal generation workforce—just over 4,000 jobs—between 2016 and 2019.

Total jobs, 2019	Jobs lost, 2016–19	Change, 2016–19
12,297	-4,078	▼24.9%

California, Texas, Florida and New York have added thousands of **natural gas electric power generation jobs.**

Jobs gained, 2016–19		
CA	3,565	▲21.0%
TX	2,966	▲60.4%
FL	2,697	▲22.0%
NY	1,305	▲32.1%



Texas, California, Louisiana and Oklahoma have seen major gains in their **petroleum fuels workforce.**

Jobs gained, 2016–19		
TX	39,257	▲22.4%
CA	8,737	▲18.0%
LA	6,679	▲14.8%
OK	6,547	▲19.3%

Kentucky's coal fuels sector, which includes mining, extraction, processing, and production, was hard hit between 2016 and 2019, shedding almost 4,400 jobs.

Total jobs, 2019	Jobs lost, 2016–19	Change, 2016–19
7,839	-4,396	▼35.9%

12%

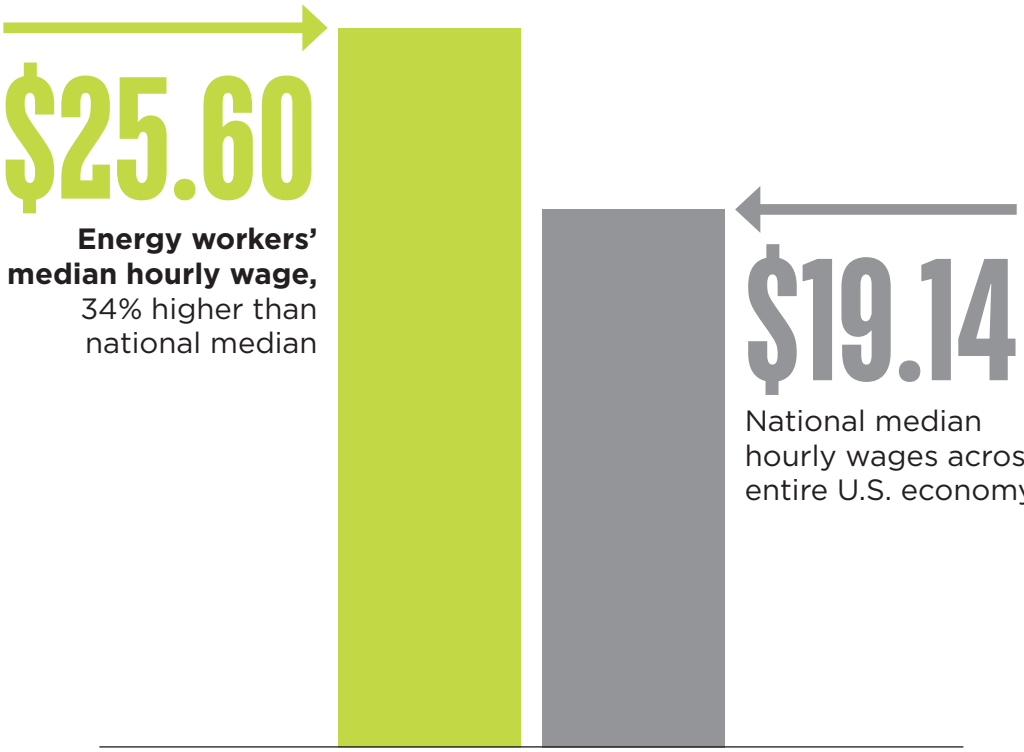
Decline in energy employment, compared to 20% decline nationwide, at the peak of job losses during April 2020

COVID-19 PANDEMIC

323,880

Energy jobs added back over June–December 2020, after losing 1.08 million over March–May

ENERGY WAGES



$25.60

Energy workers' median hourly wage, 34% higher than national median

$19.14

National median hourly wages across entire U.S. economy

95%–120%

Premium of energy job wages over the retail and accommodation and food service sectors, which have been hard-hit by the COVID-19 pandemic

$41.08

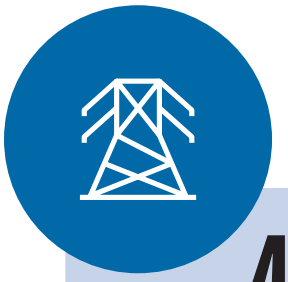
Median wage for energy utility employees, the highest of all industry segments and 115% above the national median. Mining and extraction jobs are next highest at $36.32. Utilities account for 7.2% of total energy employment.

UTILITY WORKERS

The utilities industry supports the highest hourly wage of all industries compared to the national median. Electric power generation and transmission, distribution, and storage are the only sectors with utilities jobs.

43%

Wage premium for an energy worker in the mining industry compared to the average mining employee. Energy workers earn such premiums in wholesale trade (29%) and repair and maintenance (21%) as well. Mining accounts for 6.4% of total energy employment.



42%

Electric power generation sector's wage premium over the national median. These jobs account for 10.7% of total energy employment.

63%

Transmission, distribution, and storage sector's wage premium over the national median. These jobs account for 16.5% of total employment.

HEALTHCARE BENEFITS

65%–100%

Workers in select energy occupations who receive either full or partial healthcare coverage from their employers.

Of the 41 energy occupations examined across all major energy technology sectors—including solar photovoltaic installers, carpenters, wellhead pumpers, electricians, sales representatives, and automotive service technicians—nearly all report above-average provision of healthcare benefits.

Energy wages are more likely to vary by industry segments, such as manufacturing, mining, or utilities, than by technology sectors.

INDUSTRIES

105%

Nuclear industry's wage premium over the national median. These jobs account for 0.8% of total energy employment.

66%

Electric power transmission and distribution industry's wage premium. These jobs account for 9.9% of total energy employment.

59%

Natural gas industry's wage premium. These jobs account for 7.6% of total energy employment.

50%

Coal industry's wage premium. These jobs account for 2.2% of total energy employment.

27%

Wage premium for energy storage jobs. These jobs account for 1.0% of total energy employment.

UNIONIZATION & ENERGY JOBS

Unionization is typically indicative of job quality for energy workers; this includes wages, benefits, skills training, and work readiness.

But current datasets from multiple federal government sources report **varying union membership rates across industry segments,** creating difficulties around extrapolating energy-specific unionization rates.

SECTORS

WHERE WORKERS EARN MORE THAN THE NATIONAL MEDIAN

Electric power generation: Nearly all sub-technologies

Fuels: All sub-technologies

Transmission & distribution, grid modernization, and energy storage: All sub-technologies

Energy efficiency: All sub-sectors

Motor vehicles: All sub-sectors

LOWER-PAYING ENERGY JOBS

Agricultural workers ■ Production helpers ■ Construction laborers ■ Insulation workers ■ Roustabouts ■ Assemblers and fabricators

The few energy jobs that pay below national medians do so because they fall within industry or occupational groups that already earn below national medians.

■ Read a detailed analysis on page 6

17%

Share of part-timers in the U.S. workforce who may not be included in Census unemployment data, which is typically based on full-time employees with unemployment insurance.

99.8%

U.S. counties with energy efficiency jobs, which grew in almost every state over 2016-19

- The data presented in this report offers a valuable opportunity for a deeper understanding of the role of energy jobs in the U.S. economy and the lives of workers. It is important to **understand that wages, job quality, and opportunity are based on a variety of factors, including qualifications, experience, and training, as well as technology and industry.**

- To support economic recovery and address energy transition impacts on communities, policymakers at all levels should **prioritize workforce funding and programming to support the continued development and expansion of pipelines to gainful energy careers,** particularly for disadvantaged communities and workers.

- The Department of Energy should consider leading an effort to **provide more granular detail on the skill competencies of energy occupations** to mirror the level of detail available from O*NET for standard occupations across the U.S. economy.

- The U.S. Department of Labor's Registered Apprenticeship program could be refined to **include more pre-apprenticeship and apprenticeship funding,** which would support longer development pipelines while offering workers the opportunity to learn and earn.

- Policymakers at the federal, state, and local level can use the trends and findings presented in this report as a springboard to **examine the impacts of and potential responses to energy and workforce transitions** at the local and state level.

- The Department of Energy should consider engaging states to **explore pathways to increase certification and licensure reciprocity for skilled energy labor.**

- State Energy Offices can **use energy employment, wages, and benefits data in order to understand the geographic, industrial, and occupational implications** of various energy policy mechanisms and investment strategies.

- Unionization is typically indicative of job quality for energy workers yet federal unionization data varies widely. To address this important issue, the National Economic Council should **consider convening relevant stakeholders, such as the Department of Energy Office of Jobs, the Bureau of Labor Statistics, the Census Bureau, the Energy Information Administration, and labor unions to establish protocols and methodologies** for gathering more granular, accurate, and reliable data on unionization rates in the energy sector.

- **Deeper investigation of the COVID-19 pandemic's impact and energy transition is required for a comprehensive understanding of the profiles of the jobs that will be created, lost, and changed,** including the accessibility of these energy jobs, wages and benefits, and opportunities for worker mobility and advancement.

» For details on each of these considerations, turn to page 13

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Executive Summary

Wages, Benefits, and Change: A Supplemental Report to the U.S. Energy and Employment Report (*Wage Report*) provides important insights for understanding the role of U.S. energy jobs in the 21st century.[1] The nation's energy industry is a significant employer of individuals across the United States. At the end of 2019, the five major energy technology sectors[2] employed more than 8.27 million workers, accounting for 5.4 percent of the approximately 150 million jobs in the United States. In just four years, these sectors created about 915,000 new jobs, almost 11 percent of all employment growth in the nation between 2015 and 2019. In fact, energy jobs in the U.S. grew at almost twice the rate of the overall economy during this time period.[i] The data and analyses provided in this report can help to focus the attention of policymakers, regulators, and the private sector on the underlying workforce challenges and opportunities posed by changes in the nation's energy system over the 21st century.

The research presented in this report extends well beyond a discussion on the quantity of jobs created and lost or the overall number of jobs in each energy technology sector. Instead, it explores the changing mix of energy jobs and the impacts on energy sector wages, employment benefits, accessibility, and the overall geographic distribution of energy jobs in the United States. The *Wage Report* discusses how hourly wages for energy jobs compare to national medians across both energy technologies, such as coal, oil, natural gas, energy efficiency, solar, and wind, as well as industry segments, such as mining, construction, manufacturing, utilities, wholesale trade, and professional services. The report also discusses current and emerging impacts of changes in the energy sector, including the geographic distribution of energy employment and the demographic composition of the workforce. *It is important to note that wage comparisons across technology sectors should be made with caution, as such comparisons would fail to consider other important aspects of energy employment, including accessibility, skill and education requirements, and geographic distribution.*

Over the last two decades, the U.S. energy sector has experienced significant changes in how energy is produced, transported, stored, and consumed. In general, national energy production has been shifting away from coal and towards natural gas, petroleum, and renewable sources.[3] This is due to a variety of factors, including advancements in energy technologies, the abundance and low price of natural gas, and state and federal policies promoting diverse energy sources and technologies. These transitions have had ripple effects on the U.S. economy and the energy labor force. By increasing awareness of these

[1] Energy jobs include all workers that dedicate any amount of their labor hours to the research, development, production, manufacture, distribution, sales, installation, and repair of energy and energy-related goods and services. For more information on energy job definitions, please refer to the Research Methodology Overview chapter.
[2] These include Electric Power Generation; Fuels; Transmission, Distribution, and Storage; Energy Efficiency; and Motor Vehicles.
[3] The changing mix of technologies and fuel sources is discussed in further detail in the Energy Trends in the 21st Century section of this report. Specifically, Figure 3 highlights energy production by source over the last 20 years.

trends and their impacts, this analysis can contribute to the development of policies and programs, particularly those designed for a robust post-COVID-19 pandemic economic recovery.

The *Wage Report* is equally important in its identification of the need for more data and analysis on U.S. energy jobs. The *U.S. Energy and Employment Report (USEER)* provides annual data on the energy workforce at the national, state, and county level—the only dataset of its kind in the United States, supplementing U.S. Bureau of Labor Statistics employment data. However, the *USEER* publications typically focus on national and state level data, which are valuable in identifying overarching trends, but are unable to describe the impacts of energy labor market changes on local communities. Additional wage and benefits data collected with more geographic granularity in future years may be paired with county-level energy employment data. These additions would be a valuable expansion for informing policymakers and stakeholders of how energy labor market changes are playing out in their local jurisdiction, informing future policy strategies and recommendations.

A particularly significant gap underscored by this report is data on unionization rates. At a high level, research suggests that unionization is correlated with higher wages, benefits, longevity, and opportunities for career mobility. Currently, data on unionization is collected by several federal agencies, using different metrics, and resulting in a range of unionization rates. Addressing these variations and developing robust and consistent federal data is an important area for improvement, and would assist policymakers, unions, employers, and workers in identifying the benefits, and potential tradeoffs, that unionization can bring in economic recovery, energy labor market changes, workforce development, and economic resilience.

Similarly, increased and improved federal data collection and differentiation as to whether major energy occupations offer full-time, part-time, or seasonal employment would address gaps in unemployment data. Census unemployment data is typically based on full-time employees with unemployment insurance and may fail to include the part-time workers, who represent more than one in six members—or 17 percent—of the U.S. workforce.[ii] A complete database on unemployed, part-time, and seasonally-employed workers would provide a more accurate understanding of the necessary policies and measures to effectively reduce unemployment and underemployment. This improved data would also inform the types of employment offered by major energy occupations, further improving understanding of energy job wages and benefits.[4]

While the focus of this report is mostly on wages and benefits, it is also important to recognize that understanding the implications of changes in the national energy landscape also requires a deeper understanding of educational and training requirements for growing sectors of the

[4] The exclusion of project-based, part-time, or seasonal energy workers may impact wages, though the research team is not currently able to determine what percentage of energy workers are excluded in this analysis. Future research and data collection efforts aim to gather more granular data on what percentage of the energy workforce are full-time, part-time, seasonal, and project-based workers.

energy labor market. Understanding the skills and education, apprenticeships, vocational training, and certifications needed for energy-related work sheds light on the accessibility of various energy jobs. For example, the preference for apprenticeships and vocational technical training—over for example, four-year college or post-graduate degrees—in many energy efficiency and renewable energy occupations suggests that these jobs may be more accessible to a wider population due to the lower costs of educational attainment.

For policymakers and other energy, economic, and workforce development stakeholders, a more precise understanding of wages and benefits can inform the development of more effective policies and programs. The need for targeted energy and workforce development efforts is particularly timely, as policymakers seek to promote an economic recovery in response to the COVID-19 pandemic. Based on pre-pandemic data, the fast-growing sectors of the energy economy provided higher hourly wages compared to jobs in industries that were hardest hit by the global pandemic, such as retail, hospitality, and food service. The median hourly wage for all energy workers in the U.S. is $25.60, 34 percent higher than the national median hourly wage of $19.14. The overall hourly wage for energy jobs is also 95 percent and 120 percent higher compared to the retail and accommodation and food service industries, respectively.[iii] In fact, wages for energy sectors with the lowest wage premiums, such as energy storage, energy efficiency, solar, and wind are still higher than national wages, providing at least a 27 percent premium above national median wages.

Though also impacted by the COVID-19 pandemic, the energy industry lost fewer jobs compared to other sectors of the economy. At the peak of job losses in April, the nation saw a roughly 20 percent decline in employment, while the energy industry saw a 12 percent decline. As public officials focus on recovery, the robust job creation record of the energy sector from 2015 through 2019 can underscore the value of energy infrastructure and project investments. These investments could reinvigorate the U.S. economy and create the quality jobs U.S. workers need, while maintaining sight of intersecting challenges such as climate change, resiliency, and public health. Strategic, data-informed, and effective policymaking will be crucial to realizing these benefits.

This report supplements the annual *United States Energy and Employment Report (USEER)*, which is jointly produced by the National Association of State Energy Officials (*NASEO*) and the Energy Futures Initiative (EFI). The analyses presented in this report synthesize data from the *2020 USEER*, a supplemental wage survey administered to energy sector employers in 2018 and 2019, *Five-Year Trends: The USEER 2016-2020*, monthly reports by BW Research on the impacts of COVID-19 on energy sector employment,[iv] and various publicly available datasets through the Bureau of Labor Statistics (*BLS*). This research examines the recent history and current context of the energy labor market but does not attempt to predict the future of energy employment in the United States.

Together with BW Research, *NASEO* and *EFI* seek to inform deeper understanding of U.S. energy jobs, including key drivers of change in the 21st century.

The following key findings are a synthesis of the important highlights from the *Wage Report* and the *Five-Year Report*, including overall energy trends in the U.S.—both production and employment—and an overview of wages across the different energy sectors.

Key Findings

Energy Production & Employment Trends

Energy employment in the U.S. was on the rise from 2015 through 2019. Over these five years, the energy industry[5] created almost 915,000 new jobs. Energy employment across the nation grew by 12 percent, double the rate of the overall U.S. labor market. New energy jobs from 2015 through 2019 accounted for almost 11 percent of total job growth in the nation.

From 2016 through 2019, energy employment in professional services, repair and maintenance, and mining and extraction experienced greater growth compared to other industries such as construction or manufacturing. Energy jobs in the former industry segments grew by roughly 14 to 22 percent, whereas construction and manufacturing experienced a job growth rate of five percent each, and wholesale trade[6] declined by 14 percent. Energy jobs within the agriculture industry also grew by about 12 percent from 2016 through 2019 while utility employment declined by less than one percent.

Over the last two decades, energy production in the United States has trended away from coal and towards natural gas, petroleum, and renewables. Between 2000 and 2019, domestic coal production declined by 37 percent, or 8.5 quadrillion BTUs.[7] Over the same time period, the production of natural gas grew by 87 percent (19.4 quadrillion BTUs), while renewable energy production grew by 89 percent (5.4 quadrillion BTUs) and petroleum grew by 106 percent (13.1 quadrillion BTUs).

These energy production trends are also mirrored in employment changes. Employment in petroleum and natural gas fuels grew by 73,000 jobs—almost nine percent between 2015 and 2019. Over the same time period, the coal fuels sector saw employment decline by 18 percent—or 17,000 jobs. Together, solar and wind electric power generation created almost 83,000 jobs during the same time frame, a growth rate of 22 percent.

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[5] Energy jobs include all workers that dedicate any amount of their labor hours to the research, development, production, manufacture, distribution, sales, installation, and repair of energy and energy-related goods and services. For more information on energy job definitions, please refer to the Research Methodology Overview chapter.
[6] Wholesale trade includes wholesale equipment and supplies merchant wholesalers of goods that are linked to the energy industry (including motor vehicles and motor vehicle parts and building materials). Also included in this category is all employment related to the pipeline transportation of fuels and the transport (via truck, rail, air, and water) of energy commodities such as coal, fuel oil, gas, motor vehicles, and petroleum.
[7] This is due to a combination of mechanization of the mining process as well as lower coal demand both domestically and internationally.

Shifts in dominant fuel sources and energy technologies are creating new geographic concentrations of energy jobs across the nation, particularly in the electric power generation and fuels technology sectors. Coal, oil, natural gas, solar, wind, and biofuel resources are specific to geographic regions in the United States, and this resource distribution determines the regional spread of energy jobs in these sectors. Some of these shifts are resulting in job losses in parts of the country that have historically been considered key regions for traditional energy jobs. For example, Ohio had the highest number of coal electric power generation workers at the end of 2019 but shed 25 percent of its coal generation workforce—just over 4,000 jobs—between 2016 and 2019 (Table 20). At the same time, California, Texas, Florida, and New York have added thousands of natural gas electric power generation jobs (see Table 21). Similarly, Kentucky's coal fuels sector, which includes mining, extraction, processing, and production, was hard-hit between 2016 and 2019, shedding almost 4,400 jobs (see Table 26), while other states like Texas, California, Louisiana, and Oklahoma have seen major gains in their petroleum fuels workforce (see Table 27).

Energy efficiency installation, maintenance, and repair jobs are unique in that they are ubiquitous across the United States. Energy efficiency jobs are found across 99.8 percent of all counties in the United States; this is due to the fact that energy efficiency technologies and services are applicable to commercial, industrial, and residential sectors across the economy. Unlike many other energy jobs which are more dependent on the concentration of either renewable or fossil fuel resources and infrastructures, installation, maintenance, and repair jobs in the energy efficiency sector are more universally distributed. In fact, out of the over 3,000 counties in the U.S., energy efficiency jobs are located in all but six.[8] In addition, energy efficiency jobs grew in almost every state between 2016 and 2019.

The global COVID-19 pandemic has resulted in significant job losses in the U.S. energy industry, but the energy sector lost a smaller proportion of jobs compared to other sectors of the economy. Between March through May 2020, the energy industry lost 1.1 million jobs, accounting for about 3.5 percent of the total 31.4 million jobs lost in the United States. In comparison, the following industry clusters experienced a higher percent of job losses: Tourism, Hospitality, and Recreation; Information and Communications; Other Services (including repair and maintenance); Defense, Aerospace, and Transportation Manufacturing; Retail; Professional and Business Services; and Building and Design. At the peak of job losses in April, the nation saw a roughly 20 percent decline in employment, while the energy industry saw a 12 percent decline in jobs. From June through December, the energy industry added back roughly 324,000 jobs to the economy, though it remains nine percent below peak employment at the end of 2019. COVID-19 energy job losses were concentrated across the energy efficiency and fuels technology sectors.

[8] Taliaferro County, GA; Quitman County, GA; Kalawao County, HI; Loup County, NE; McPherson County, NE; and King County, TX.

Energy Wages Overview

In general, energy sector employees earn higher hourly wages compared to the national median and other sectors of the economy; this is true across all energy technology sectors and nearly all energy industry segments. The median hourly wage for all energy workers in the U.S. sits at $25.60; this is 34 percent higher than the national median hourly wage of $19.14. Across all major energy technology sectors and nearly all industries, with the exception of agriculture, energy workers earn more per hour than national median wages (see Table 4 and Table 5). On average, energy jobs also earn a respective 95 and 120 percent more than specific sectors that have been hard-hit by the pandemic like retail or accommodation and food service, which have respective national median hourly wages of $13.16 and $11.64.[v]

There are a few energy jobs that pay below national medians; these jobs earn less because they fall within industry or occupational groups that already earn below national medians. Of all industries with energy-related employment, energy workers in the agriculture industry, which accounts for less than one percent of total energy employment, earn 45 percent below the national median wage of $19.14. This is because the median hourly wage for the agriculture industry overall sits at $13.18, which is already lower than the national median wage (see Table 5). Furthermore, of all the occupations examined within each major technology sector, energy-specific production helpers, construction laborers, insulation workers, roustabouts, and assemblers and fabricators earn below national medians. The lower wages associated with these energy jobs are largely because these occupational groups overall—including both energy and non-energy workers—earn below the overall national median or the associated industry-specific median. Additionally, utility workers within hydropower, who account for less than one percent of total energy employment, earn roughly 2.9 percent below the overall national utility industry wage (see Table 10), while coal mining and transportation workers earn a respective 2.7 and 29.4 below the national industry averages for mining and transportation employees (see Table 7). Out of all sub-technologies discussed in the report, the non-wind or solar renewable generation sub-sector[9] has a median hourly wage that is about nine percent below the national median; these jobs represent about 1.5 percent of total energy employment (see Table 17 and Table 18).

[9] This includes geothermal, low-impact and traditional hydropower, bioenergy, and combined heat and power electricity generation.

Energy Wages by Industry Segment[vi]

Industry	Median Hourly Wage (Energy Workers)	Median Hourly Wage (Overall Industry)	Premium/ Discount Compared to Overall Industry	Premium/ Discount Compared to National Median of $19.14	Total Employ-ment, 2019	Percent of Total Employ-ment, 2019
Agriculture[10]	$13.18	$13.18	**0%**	**-31%**	35,616	0.4%
Mining and Extraction	$36.32	$25.44	**43%**	**90%**	535,210	6.4%
Utilities	$41.08	$37.50	**10%**	**115%**	601,225	7.2%
Construction	$25.53	$23.57	**8%**	**33%**	2,142,087	25.6%
Manufacturing	$23.02	$20.46	**13%**	**20%**	1,778,343	21.3%
Wholesale Trade[11]	$19.94	$15.47	**29%**	**4%**	860,661	10.3%
Transportation (commodity flows)	$36.08	$34.31	**5%**	**89%**	285,375	3.4%
Professional Services	$28.17	$25.95	**9%**	**47%**	1,057,995	12.6%
Other Services (incl. Repair and Maintenance)	$19.68	$16.33	**21%**	**3%**	1,068,244	12.8%
National Median Wage	**$19.14**					

Utility and mining and extraction workers have the highest absolute hourly wages of all industry segments. Utility employees receive a median hourly wage of $41.08—115 percent above the national median wage of $19.14 and 10 percent higher than the overall median wage for all utility workers, which is $37.50. Energy workers in the mining industry earn $36.32 per hour, 90 percent above the overall national median of $19.14 (see Table 5). Utility jobs account for about 7.2 percent of total energy employment while mining jobs account for 6.4 percent of total energy employment.

However, energy workers in mining, wholesale trade, and repair and maintenance earn the highest wage premiums compared to each industry's overall median wage. This means that energy workers in these respective industries earn more than the average worker in each industry, which includes both energy and non-energy jobs. For example, an energy worker in the mining industry makes 43 percent more

[10] Energy-related jobs in agriculture are based entirely on publicly available data. The overall national agriculture industry wage is used here, as opposed to an energy-specific wage extrapolation. Because BLS does not provide agriculture wages to the six-digit NAICS level, $13.18 is the best proxy estimate for energy jobs in the agriculture industry. Though this is the only wage data point that does not use USEER-derived premiums or discounts, it is unlikely that an agriculture worker growing crops for fuels compared to other purposes will receive significantly different wages. Professional service occupations, such as scientific research, engineering, or sales are found in the "professional services" industry segment within the ethanol or biodiesel sub-technology sectors; premiums for these workers would be captured in these respective segments.

[11] The weighted median hourly wages for this industry segment include retail trade (NAICS 42-45). Though the *USEER* excludes retail employment, fuel dealers (NAICS 454310) are surveyed as part of the data collection effort.

compared to the average mining employee, both energy and non-energy.[12] Energy workers in wholesale trade earn a 29 percent wage premium compared to the overall wholesale trade industry while other services like repair and maintenance jobs support hourly wages that are 21 percent higher compared to the overall industry (see Table 5). Wholesale trade employment accounts for about 10 percent of total energy employment while other services like repair and maintenance represent almost 13 percent of all energy jobs.

Largely due to their high concentration of utility jobs, workers in the electric power generation and transmission, distribution, and storage sectors earn the highest wage premium over the national median. At $27.19 per hour, electric power generation workers earn a premium that is 42 percent higher than the national median wage of $19.14; this technology sector represents almost 11 percent of all energy jobs. Energy workers in the transmission, distribution, and storage sector account for 16.5 percent of all energy jobs and earn $31.25 per hour—63 percent above national median wages. The utilities industry supports the highest hourly wage of all industries compared to the national median (see Table 5), and utility workers account for a respective 21 and 30 percent of the electric power generation and transmission, distribution, and storage workforce. In contrast, the other three technology sectors—fuels, energy efficiency, and motor vehicles—have no utility jobs.

Energy Wages by Technology Sector[vii]

Technology Sector	Median Hourly Wage	Premium or Discount[13] Compared to National Median of $19.14	Total Employment, 2019	Employment Growth, 2017-2019	Percent of Total Energy Employment, 2019
Electric Power Generation	$27.19	42%	896,830	1.5%	10.7%
Fuels	$23.89	25%	1,148,893	6.9%	13.7%
Transmission, Distribution & Storage	$31.25	63%	1,383,646	3.8%	16.5%
Energy Efficiency	$24.44	28%	2,378,893	5.8%	28.4%
Motor Vehicles	$22.29	16%	2,556,492	3.8%	30.6%
Overall Energy Industry	**$25.60**	**34%**	**8,364,754**	**4.5%**	
National Median Wage	**$19.14**				

[12] Not all jobs in the mining industry are related to energy or fuel production. Some mining activity is dedicated to metal ore and mineral mining; these non-energy-related jobs are not included in energy employment and wage estimates, thus allowing for comparisons between energy-specific mining jobs and the overall mining industry average, which includes both energy and non-energy jobs. Energy-related mining workers earn a premium of 43 percent compared to the overall median hourly wage for all workers in the mining industry (energy- and non-energy-related).

[13] A "premium" is defined here as the percentage *above* the comparative wage. A "discount" would indicate that the wage is *below* the comparative wage; this would be portrayed as a negative percentage.

The key determinant in energy sector wages is industry mix. Though many factors such as geography, educational and skill requirements, and unionization rates contribute to median hourly wages, energy wages are more likely to vary by industry segments, such as manufacturing, mining, or utilities, than by technology sectors like electric power generation, fuels, energy efficiency, motor vehicles, or transmission, distribution, and storage.

Many energy workers in the examined occupations are more likely to receive healthcare and retirement benefits compared to national private sector averages. Across the U.S., 69 percent of private sector employees receive health insurance benefits and 67 percent receive retirement contributions from their employer. Of the 41 energy occupations examined in this report across all major energy technology sectors—including solar photovoltaic installers, carpenters, wellhead pumpers, electricians, sales representatives, and automotive service technicians—nearly all occupations except for one had above-average provision of healthcare benefits. Between 65 and 100 percent of individuals in these occupations receive either full or partial healthcare coverage from their employers. Across electric power generation, transmission, distribution, and storage, fuels, and motor vehicles, nearly all examined occupations except for one (solar photovoltaic installers) are also above the national average in terms of retirement contributions. Retirement provisions vary most in the energy efficiency sector, where the majority of examined occupations fall below the national average, with the exception of plumbers, construction trade supervisors, and construction managers (see Table 19 and Table 25 and Table 31 and Table 37 and Table 42).

Industry Crosscut Wages

The nuclear, electric power transmission and distribution, natural gas, and coal industries support the highest wage premiums compared to the national median. These four energy industries support hourly wages that are at least 50 percent higher than the national median hourly wage of $19.14. The nuclear industry in particular supports a high hourly wage; at $39.19, these jobs earn 105 percent more than the national median but account for less than one percent of total energy jobs. Electric power transmission and distribution jobs comprise about one in ten energy jobs and support hourly wages of $31.80—66 percent above the national median—while natural gas and coal workers earn a respective 59 and 50 percent above the national median (see Table 6). Natural gas jobs represent 7.6 percent of total energy employment while coal jobs account for 2.2 percent of all energy jobs.

Hourly wages for the energy industries with the lowest premiums—energy storage, energy efficiency, solar, and wind—are still significantly higher than national median hourly wages. Workers in the energy storage, energy efficiency, solar, and wind industries earn at least 27 percent above national median hourly wages, with wind workers earning as much as 36 percent above the national median.

Overall Industry Crosscut Wages, 2019[14]

Industry Crosscut	Median Hourly Wage	Premium or Discount Compared to National Median	Total Employment, 2019	Percent of Total Energy Employment, 2019
Nuclear	$39.19	104.8%	70,323	0.8%
Electric Power Transmission & Distribution	$31.80	66.1%	830,291	9.9%
Natural Gas	$30.33	58.5%	636,043	7.6%
Coal	$28.69	49.9%	185,689	2.2%
Hydropower	$26.97	40.9%	67,772	0.8%
Oil	$26.59	38.9%	839,831	10.0%
Wind	$25.95	35.6%	114,774	1.4%
Solar	$24.48	27.9%	345,393	4.1%
Energy Efficiency	$24.44	27.7%	2,378,893	28.4%
Storage (excl. fossil fuels)	$24.36	27.3%	80,550	1.0%
National Median Wage	**$19.14**			

Electric Power Generation Sector

Natural gas has overtaken coal as the main fuel source in the nation's electricity generation mix. In 2000, coal accounted for 52 percent of the national electricity generation mix while natural gas represented 16 percent. By 2019, natural gas produced 39 percent of the nation's electricity, followed by coal at 24 percent.[viii] Emissions standards, low natural gas prices, and the efficiency of new natural gas turbine technology is resulting in coal to natural gas conversions across the country. In 2019, 29 GW of coal-fired capacity was either converted to also burn natural gas or completely replaced with natural gas combined cycle plants.[ix] Accordingly, in 2019 alone, the natural gas generation sub-sector added 7,500 utility sector jobs.

Workers in nearly all sub-technologies of the electric power generation sector earn more per hour than national median wages. Nuclear and coal generation have the highest median hourly wages; these sectors support wages that are a respective 115 and 80 percent above the geographically weighted wages. Natural gas electric power generation jobs also support significantly higher wages, with a 77 percent wage premium. Solar, oil, and wind electric power generation employees earn wage premiums that are approximately 20 to 35 percent above national wages, while other renewable electric power generation[15] sub-

[14] Total employment in this table will not sum to total energy jobs in the U.S. for 2019 as these industry crosscuts represent the sum of various sub-sectors across the energy industry but do not include all energy-related jobs.
[15] Other renewable generation includes geothermal, low-impact and traditional hydropower, bioenergy, and combined heat and power.

technologies have a wage discount of about nine percent below the geographically weighted median (see Table 17).

All occupations examined within the electric power generation sector pay hourly wages that are above the national median. Nuclear occupations within electric power generation support some of the highest wage premiums. Nuclear engineers, nuclear power reactor operators, and nuclear technicians all earn more than double the national median wage. Gas plant and power plant operators within electric power generation also earn more than double the national median (see Table 18). Plumbers and carpenters earn a respective 51 and 33 percent above national wages, while supervisors of construction trades within the electric power generation sector earn a wage premium of 71 percent. Solar photovoltaic installers who are licensed electricians earn a greater wage premium (34 percent wage premium) than non-licensed solar PV installers (13 percent wage premium).

Fuels Sector

The U.S. is becoming a major global producer of natural gas and petroleum fuels. In 2011, the United States surpassed Russia as the world's largest producer of natural gas, and in 2018, the U.S. surpassed Saudi Arabia as the largest producer of petroleum. The increased production in these two sub-sectors has contributed to energy employment growth of almost nine percent in four years, creating 72,100 jobs. In fact, petroleum and natural gas account for the largest source of jobs within the fuels technology sector, and within these two sub-sectors, mining and extraction had the greatest growth in jobs in 2019.

Jobs in all fuels sub-technologies pay a premium over national wages. Coal fuels workers earn the highest wage premium, at 37 percent above the geographically weighted median hourly wage, followed by nuclear, natural gas, and petroleum fuels (29 to 32 percent wage premium). Renewable fuels jobs have a wage premium that is two percent above the geographically weighted median (see Table 23).

While some occupations in the fuels sector pay above national wages, some pay less than the national median. Petroleum pump operators earn $35.66 per hour, which is 86 percent above the geographically weighted median. Continuous mining machine operators, wellhead pumpers, and rotary drill operators earn almost 40 percent above national wages. Of the occupations examined, production worker helpers and oil and gas roustabouts earn hourly wages that are below the geographically weighted median (see Table 24).

Transmission, Distribution, and Storage Sector

Traditional transmission and distribution, grid modernization, and energy storage workers earn more than national wages. These sub-sectors support wages that are at least 24 percent above the geographically weighted median. Traditional transmission and distribution workers earn $32.24 per hour—a 68 percent premium—

followed by grid modernization with a 34 percent premium and energy storage workers with a 24 percent premium (see Table 29).

All transmission, distribution, and storage occupations examined earn more than national wages. Power distributors and dispatchers, electrical and electronics repairers, and electrical power-line installers and repairers earn more than double the geographically weighted median. Construction laborers in the transmission, distribution, and storage sector earn one percent above national wages (see Table 30).

Energy Efficiency Sector

Energy efficiency sub-sectors earn a wage premium roughly 23 to 25 percent above national wages. Workers across ENERGY STAR® appliances, renewable heating and cooling, traditional and high efficiency HVAC, and efficient lighting sub-technologies all earn more than the geographically weighted median (see Table 35).

Nearly all occupations examined in the energy efficiency sector earn more than the overall construction industry's median hourly wage. Supervisory and managerial positions earn the highest wage premiums, at a respective 35 and 98 percent above the geographically weighted median for the construction industry (see Table 36). In contrast, insulation workers and construction laborers earn less than the overall construction industry's median hourly wage. Electricians, plumbers, and HVAC mechanics earn roughly 23 to 28 percent more than national wages for the construction industry, while carpenters in the energy efficiency sector earn 10 percent more than the average construction worker in the United States.

Motor Vehicles Sector

Workers across the motor vehicles sub-sectors earn more than national median wages. The other alternative transportation sub-sector, which includes natural gas, hydrogen, and fuel cell vehicles, pays 21 percent above the geographically weighted median wage, followed by gasoline and diesel motor vehicles (18 percent wage premium), and electric, hybrid, and plug-in hybrid vehicle technologies (16 percent wage premium) (see Table 40).

Sales and production supervisors receive the highest wage premiums in the motor vehicles sector. Wholesale and manufacturing sales representatives earn 103 percent more per hour than the geographically weighted median, while supervisors of production and operating workers earn a 51 percent wage premium. Automotive repair and maintenance mechanics earn between six to nine percent above national wages, while welders in the motor vehicles sector receive a 15 percent wage premium. Motor vehicle assemblers and fabricators earn 16 percent below the geographically weighted median (see Table 41).

Considerations for Policymakers

The considerations offered below are based on the data and findings presented in this report and, more generally, the current context of the U.S. energy transition and the aftermath of the COVID-19 pandemic. At the national level, a variety of federal agencies could potentially implement energy sector workforce development and economic recovery strategies. These agencies include the U.S. Department of Energy, the U.S. Department of Labor, and the Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization, among others. State and local agencies, including through State Energy Offices, workforce development and commerce agencies, and entities promoting education, career development, and technology commercialization, will also play crucial roles in advancing high-quality jobs and opportunities in the energy sector. For these reasons, multi-agency, federal-state-local, and public-private coordination, including with union and labor partners, is a necessary framework to prioritize and execute economic and job recovery strategies. For the State Energy Offices, U.S. State Energy Programs funds administered by the U.S. Department of Energy provides flexible resources directly to states to advance governors' energy policy priorities, including workforce development, just transition, energy technology-based economic development, and other important imperatives outlined in this report.

The data presented in this report offers a valuable opportunity for a deeper understanding of the role of energy jobs in the U.S. economy and the lives of workers. It is important to understand that wages, job quality, and opportunity are based on a variety of factors, including qualifications, experience, and training, as well as technology and industry. A rudimentary comparison of median wages based solely on technology, such as wind, solar, energy efficiency, nuclear, electric power, or natural gas, can be misleading. Such comparisons obscure factors that affect median wages for energy occupations, such as geography, union representation, education and other qualification requirements, and industry and occupational focus, as well as the accessibility of jobs based on geography, educational and training requirements, and technology adoption and growth in a given community or state. Such nuances underscore the need to contextualize discussions of wages and benefits with local realities, such as job growth and decline, investments in education and training, the number of and competitiveness for specific jobs, and long-term job prospects.[16] Energy jobs, their role in the U.S. economy, and the opportunities they present for Americans is complex. The *Wage Report*, together with the annual *USEER*, seeks to increase understanding of this important sector.

[16] To illustrate, clean energy careers are lucrative and rewarding for many individuals and communities, and typically do not entail the same investment of time and resources that other energy occupations, such as chemical engineers for oil and gas operations, may require. Energy efficiency jobs exist in nearly every county in every state across the country and distributed renewable energy jobs are also very ubiquitous. Wages offered in these jobs exceed national median wages, and based on pre-pandemic data, work in these fields has the potential for significant and continued growth, while other energy sectors have experienced job losses.

Managing Workforce Transitions and Economic Recovery

To support economic recovery and address energy transition impacts on communities, policymakers at all levels should prioritize workforce funding and programming to support the continued development and expansion of pipelines to gainful energy careers, particularly for disadvantaged communities and workers. The economic fallout resulting from COVID-19 has disproportionately impacted workers in hospitality, tourism, and retail occupations. It has also disproportionately impacted women and ethnic and racial minorities as well as younger (Millennial and Gen Z) age groups—demographics already underrepresented in the energy sector. Many of the hardest-hit occupations in the COVID-19 pandemic may not offer directly transferable skillsets to energy careers, but with the appropriate policy and financial supports, an energy employment rebound could help provide new and improved job prospects for an expanded and more diverse set of workers.[17] Targeted support could come from state and local workforce programs as well as federal programs, such as augmented Workforce Innovation and Opportunity Act (WIOA) funding formulas or Employment and Training Administration (ETA)-administered grant funding, similar to Workforce Innovation Fund (WIF) grants.

The Department of Energy should consider leading an effort to provide more granular detail on the skill competencies of energy occupations to mirror the level of detail available from O*NET[18] for standard occupations across the U.S. economy. Such data would help federal and state policymakers improve their understanding of incumbent worker displacement due to energy market and policy changes, as well as opportunities for transition. Workforce transitions and the COVID-19 pandemic are impacting existing energy sector workers, especially in communities with labor markets centered around single industries such as coal mining. Supporting the transition of incumbent energy sector workers into new jobs will require a multi-pronged analysis, including examinations of other energy resources available in the community, the transferability of skillsets, the comparability of wages and benefits, and the psychology of job transition and loss at the individual and community levels.

Energy Career Skills, Experience, and Exposure

The U.S. Department of Labor's Registered Apprenticeship program could be refined to include more pre-apprenticeship and apprenticeship funding, which would support longer development pipelines while offering workers the opportunity to learn and earn. Registered

[17] Increased funding and financial support are necessary in efforts to diversify the energy workforce; however, they are insufficient without changes in workplace culture and hiring and investment practices. A forthcoming report from NASEO in collaboration with the Historically Black Colleges and Universities (HBCU) Community Development Action Coalition (CDAC) will examine diversity in the U.S. energy workforce, including perceptions, awareness, career access, advancement, and navigation, wages, and benefits. Its findings highlight the importance of improving representation and inclusion across all segments of the energy economy, from research and development to commercialization and deployment.
[18] O*NET, sponsored by the U.S. Department of Labor, is a comprehensive dataset of occupation-specific data, including knowledge, skills, and abilities as well as common work tasks and activities. These data are segmented by Standard Occupational Classification (SOC) code and can be cross-analyzed to produce skill transferability profiles for various occupations.

Apprenticeship is a proven vehicle for developing construction talent, which is critical to the deployment of new and updated energy infrastructure. Refinements to Registered Apprenticeship are especially timely given the potentially substantial increase in the demand for construction, manufacturing, and other deployment-focused activities as the economy recovers and the energy sector continues to decarbonize.

Additional Research and Collaboration

Policymakers at the federal, state, and local level can use the trends and findings presented in this report as a springboard to examine the impacts of and potential responses to energy and workforce transitions at the local and state level. By leveraging *USEER,* BLS, and other datasets, granular analyses unlock opportunities for better-informed policymaking, targeted training and workforce development investments, strategic partnerships across the public and private sectors, and a heightened understanding of the workforce implications of energy policies, regulations, and investments under consideration. Workforce assessments and skill gap research have been conducted by several states, including Connecticut, Vermont, Massachusetts, Rhode Island, Pennsylvania, and New York, among others. These studies focus on the regional realities of each state—understanding energy sector strengths and employer needs as well as local markets and policy climates—and directly inform policy and program design.

The Department of Energy should consider engaging states to explore pathways to increase certification and licensure reciprocity for skilled energy labor. Energy-specific licensure requirements and job availability vary across different states and regions. To address variations in licensing requirements for common energy occupations, such as electricians or HVAC workers, state and local agencies may consider licensing reciprocity across states, particularly where workers meet more stringent safety requirements or other standards of another state. Streamlining licensing requirements across jurisdictional boundaries can ease employment navigation for jobseekers as well as hiring and project application for employers. State Energy Offices would play a pivotal role in such conversations in order to expand access to new markets and opportunities for their residents.

State Energy Offices can use energy employment, wages, and benefits data in order to understand the geographic, industrial, and occupational implications of various energy policy mechanisms and investment strategies. While certain incentives and targets like those designed to improve energy efficiency may have wide-ranging impacts, other policies focused on specific energy sectors, such as offshore wind, may have more localized effects, or may even require workforce reinforcements from other states. Economic impact modeling and scenario planning can be used to better understand the potential for future growth across specific energy sectors and regions in the nation and the types of energy-related training and workforce development supports that may be needed in a region over the coming years. Collaboration among State Energy Offices, the U.S. Department of Energy, and the Bureau of Economic Analysis could support new

research that identifies how federal and state-level stimulus investments will impact jobs across various sectors of the energy economy.

Unionization is typically indicative of job quality for energy workers yet federal unionization data varies widely. To address this important issue, the National Economic Council should consider convening relevant stakeholders, such as the Department of Energy Office of Jobs, the Bureau of Labor Statistics, the Census Bureau, and the Energy Information Administration to establish protocols and methodologies for gathering more granular, accurate, and reliable data on unionization rates in the energy sector. Accurate unionization data would contribute substantially to U.S. energy jobs data. Current datasets across the Department of Energy, Bureau of Labor Statistics and Census Bureau produce varying union membership rates across industry segments, creating difficulties around extrapolating energy-specific unionization rates. There are several opportunities to explore cross-agency collaboration on unionization rates. These could include funding more granular data collection on unionization rates by industry and state within the Bureau of Labor Statistics, as well as integrating existing data that is already collected by the Energy Information Administration (EIA) on unions, such as mine safety data. In concert with these expanded federal labor data collection efforts, the current *U.S. Energy and Employment Report* data collection funding could be augmented to include more granular information on union representation by offering more segmentation by job type, region, and industrial sector. This is especially important for shifting business models that outsource direct employment to other related industries.

Research and analysis in the *USEERs, 5-Year USEER*, and *Wage Report* indicate that U.S. energy jobs can play a major role in economic recovery from the COVID-19 pandemic and the energy transition, yet additional study is needed in order realize these opportunities. Deeper investigation is required for a comprehensive understanding of the profiles of the jobs that will be created, lost, and changed, including the accessibility of these energy jobs, wages and benefits, and opportunities for worker mobility and advancement. The study should identify job growth, advancement, and accessibility (both geographic and qualifications) to enable the development of education and training programs, job crosswalk opportunities, impacts on workers and communities, as well as local, state, and federal policies. This research and analysis of the pandemic's impact and energy transition can further ensure the contribution of energy jobs toward a just and equitable future for all U.S. workers.

Chapter 1
Research Methodology Overview

Chapter 1 provides a description of each metric presented in the report, highlighting the data source, why this measure was selected, and how it supports the overall understanding of energy employment transitions.

Employment

The report includes brief overviews of historical energy employment trends. These trends are discussed in conjunction with overall national shifts in how energy is produced in the United States. The inclusion of employment trend data highlights how the growth and distribution of energy jobs is correlated with the dominant modes of energy production and the changing mix of new technologies and fuel sources.

Energy employment data for this report is taken from the *U.S. Energy and Employment Report* (*USEER*) series[19], which has been released annually since 2015.[x] These reports track energy jobs at the county, state, and national level across five major technology sectors and their

[19] Details on the *USEER* data collection effort and methodology may be found here: https://www.usenergyjobs.org/.

component sub-technologies as well as by industry sector. These data have been key to understanding the job growth and decline of various energy sectors in the United States.

Energy Jobs Defined

For the purposes of this report, an energy job is defined as employment that dedicates any proportion of labor hours to the research, development, production, manufacture, distribution, sales, installation, and repair of energy and energy-related goods and services.[20]

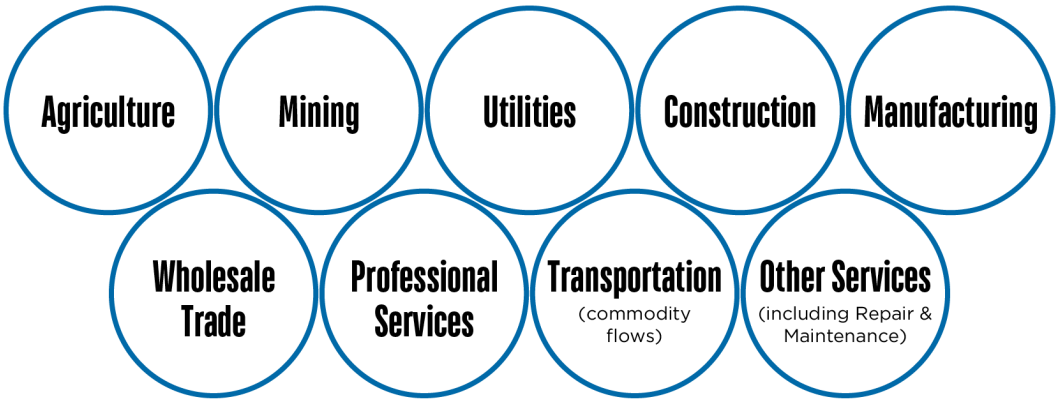
Employment data is described in terms of technology sectors and industry segments. Energy jobs are delineated into five major technology sectors, featured in Figure 1, and their component sub-technologies. Examples of sub-technologies for electric power generation would include coal, nuclear, natural gas, solar, and wind; examples of energy efficiency sub-technologies include ENERGY STAR® appliances; LED[21], CFL[22], and other efficient lighting; as well as high efficiency HVAC technologies.[23]

Within these major technology sectors, energy jobs are distributed across economic activities or value chain segments; these are commonly referred to as industries. In total, there are nine industry segments, featured in Figure 2, that contain energy and energy-related jobs in the U.S. labor market.

[20] The *USEER* provides data for direct employment only and does not attempt to estimate indirect or induced employment related to the analyzed sectors. Workers involved in the manufacture of technologies and equipment, such as solar panels, are included in employment estimates. However, this does not include indirect jobs associated with the production and manufacture of component parts and raw materials, such as polysilicon production (the raw material used in solar panels).
[21] A light-emitting diode is a semiconductor light source that emits light when current flows through it.
[22] A compact fluorescent lamp is a fluorescent lamp designed to replace an incandescent light bulb.
[23] For a more detailed look at energy sub-technologies, please refer to the Energy Sectors chapter of this report.

Figure 1.
Five Major Technology Sectors in the Energy Industry

Figure 2.
Nine Industry Segments Containing Energy and Energy-Related Jobs



Wages & Benefits

This report focuses on energy sector wages and benefits which are presented to inform discussion and understanding on the impacts of energy labor market changes on the prevailing wages and employment benefits available for jobseekers and new entrants into the energy labor force. Data for this section is taken from a supplemental survey associated with the *USEER* outreach effort that focuses specifically on occupational wages, healthcare benefits, and retirement provisions for 77 Standard Occupational Classification (SOC) codes, ranging from engineers, accountants, and gas plant operators to insulation workers, HVAC mechanics, and electricians. It is important to note that all wages reported are based on full-time employment, at 2,080 hours of work per year and excludes any seasonal or part-time energy jobs that may only be needed on a project-by-project basis.[24]

[24] The exclusion of project-based, part-time, or seasonal energy workers may impact wages, though the research team is not currently able to determine what percentage of energy workers are excluded in this analysis. Future research and data collection efforts aim to gather more granular data on what percentage of the energy workforce are full-time, part-time, seasonal, and project-based workers.

In addition to occupation-specific wages provided in the Energy Technology Sectors chapter[25] of this report, the document also includes high-level aggregations of wage data by energy technology, sub-technology, and industry segment. These data are estimates based on a combination of the proprietary survey data mentioned above and the Bureau of Labor Statistics, Occupational Employment Statistics, May 2019 National Industry-Specific Occupational Employment and Wage Estimates dataset.[xi]

Throughout the report, energy wages are compared to the national median wage of $19.14 in order to identify wage premiums and discounts. For the purposes of this report, a "premium" is defined as the percentage *above* the comparative wage, while a "discount" would indicate that wages are *below* the comparative wage; this would be portrayed as a negative percentage.

The report compares energy wages to the national median wage in order to produce a standardized comparative metric across the entire document. It is important to recognize, however, that using the national median wage eliminates some nuance inherent in wage data. Jobs that pay significantly higher than the national median wage are likely to require more experience, education, training, and certifications. Wage comparisons to the overall national median wages do not consider these variables that play a role in determining wages for various energy sectors and occupations.

Where appropriate, energy wages are also compared to overall industry-specific median hourly wages. For example, hourly wages for energy workers in the construction industry are compared to the construction industry's overall median wage, which includes both energy and non-energy workers. In addition to comparing to the overall national median wage of $19.14, industry comparisons highlight if energy-specific mining, manufacturing, construction, repair and maintenance, wholesale trade, or professional service jobs earn more than the average worker in each of those industries (see Table 5).

In the Energy Technology Sectors chapter, sub-technology wages are compared to a geographically weighted median. Since some sub-sectors are more highly concentrated in specific states, such as solar jobs in California, the national median wage is weighted by the state-specific sub-technology job concentration to account for the uneven employment distribution across the nation.

Wages vs. Earnings

All data used in this report is based on hourly wages and not hourly earnings. Wages represent straight-time, gross pay before taxes and payroll deductions. Earnings are a measure of gross payrolls divided by total hours paid during the pay period; earnings are the average return in a given industry. The averages of hourly earnings differ from both median and average wage rates.

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[25] Please see the following sections in the Energy Technology Sectors chapter: Electric Power Generation; Fuels; Transmission, Distribution, and Storage; Energy Efficiency; and Motor Vehicles.

For these reasons, caution is advised when comparing hourly earnings from Bureau of Labor Statistics (BLS) data sources such as the Current Employment Statistics (CES) to hourly wages from the BLS Occupational Employment Survey (OES). The **occupational** wage data presented in the Energy Technology Sectors chapter are occupation-specific median hourly wages and not industry-specific average hourly earnings. As an example, the hourly earnings for the construction industry in CES are slightly higher compared to hourly wages for construction and extraction occupations in the OES dataset.

Geography

Within each Energy Sector chapter, there is a brief discussion on how shifts in dominant fuel sources and energy technologies are creating new geographic pockets of energy jobs across the nation. These shifts are resulting in job losses in parts of the country that have historically been considered key regions for traditional energy jobs. While installation, maintenance, and repair jobs in the energy efficiency sector are more universally distributed and exist in nearly every county across the nation, in large part, the prevalence of energy jobs is dependent on the concentration of either renewable or fossil fuel resources and infrastructures; this is especially true for the electric power generation and fuels technology sectors. Coal, oil, natural gas, solar, wind, and biofuel resources are specific to geographic regions in the United States, and this resource distribution determines the regional spread of energy jobs in these sectors.[xii]

This geographic context is important to understanding energy employment transitions, particularly when high job loss areas are not congruent with job gains experienced elsewhere in the nation. It is clear that these gains and losses are not evenly spread across the country; states like Kentucky and Ohio are seeing employment declines in their coal generation and fuels sectors while other states like California and Texas have experienced the positive labor market impacts of booms in natural gas electric power generation, petroleum fuels, energy efficiency, and motor vehicles. At the same time, as the U.S. transportation fleet continues to be electrified, it is possible that the ethanol workforce in the Midwest and central states will suffer too. Understanding these regional realities will be key to any state-level strategic planning, economic revitalization, and workforce development initiatives.

The state-level energy employment data for this report is also taken from the *USEER* series.

Demographics

As with geographic concentration, the Energy Sector chapters also include a brief section on energy workforce demographics. Race and ethnicity for the demographic sections mirror the same terminology used in the Bureau of Labor Statistics Current Population Survey. These data are also culled from the 2020 *USEER* and are used to serve as a short introduction to the potential social justice challenges and opportunities raised by the U.S. energy transition. It is possible that the

shifting mix of energy jobs will result in social equity implications, depending on where job loss and growth is concentrated.

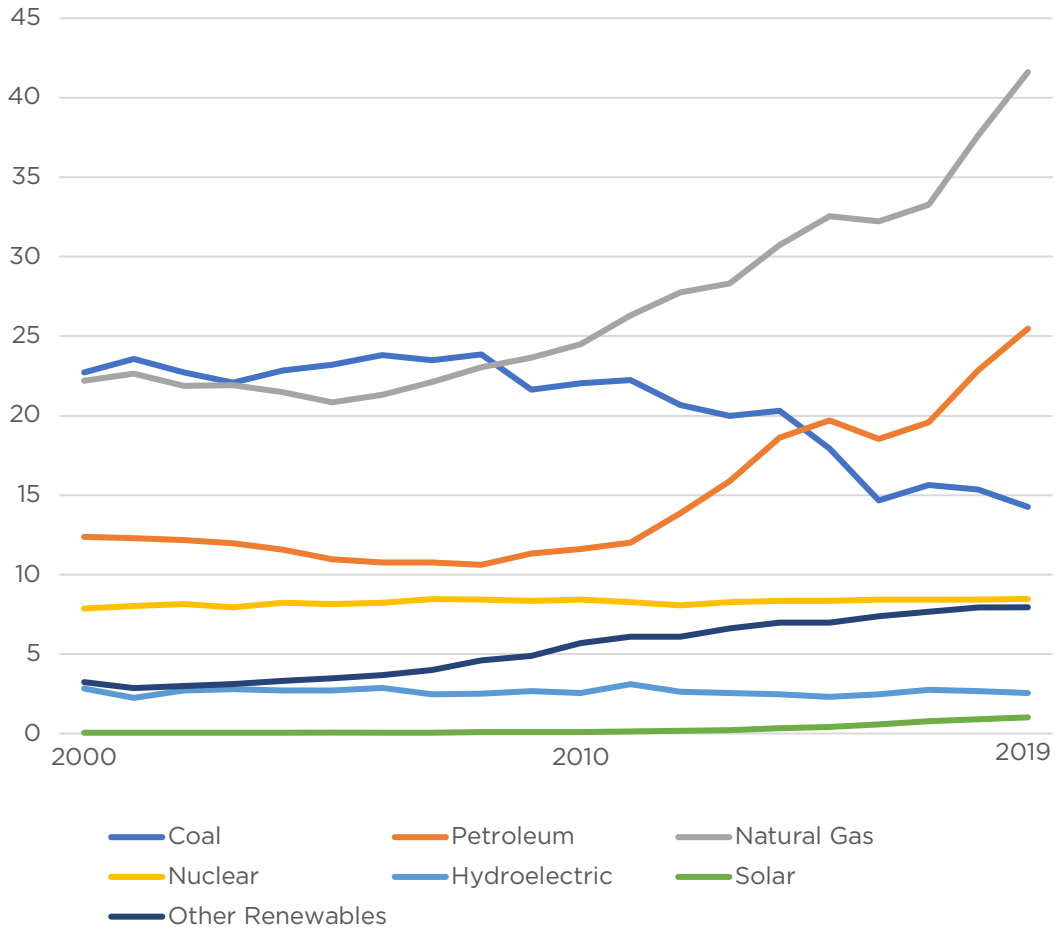
Though a smaller component of this publication, future research efforts may focus more specifically on the extent to which impacts of these employment transitions are born by specific demographic populations. Additional research may also be used to ensure that new energy jobs have equitable access for racial and ethnic minorities and provide sustainable wage opportunities and high job quality for traditionally underserved populations.

Chapter 2
Energy Trends in the 21st Century

Energy Production & Employment Trends

In the first two decades of the 21st century, domestic coal production declined by more than 37 percent while natural gas and renewable energy production respectively increased by 87 and 89 percent. Over the same time period, petroleum production grew by 106 percent (Figure 3).[xiii] These shifts in energy production over the last 20 years are due to a variety of factors, including new technologies and the lower price of natural gas and renewables compared to coal as well as state and federal policies designed to decarbonize the U.S. energy system. Figure 3 shows these significant changes in energy production over the last two decades and especially in the last three to four years.

Figure 3.
Primary Energy Production by Source, 2000-2019
Quadrillion British Thermal Units



Energy employment trends reflect these changes in energy production. Coinciding with the growing production of petroleum and natural gas fuels, these sectors of the energy labor market have grown by a combined 8.9 percent, creating 73,000 new jobs between 2015 and 2019. At the same time, the coal fuels sector shed 17,000 jobs—a decline of 18 percent. Solar electric power generation employment has grown by 45,200 jobs since 2015, for a growth rate of 15 percent over four years, while wind jobs have increased by 37,700 workers—a 49 percent increase.[xiv]

The impacts of these energy shifts on the U.S. energy labor market are clear. Changing resource use and technology developments are resulting in marked growth and decline across multiple sectors, and within these sectors, these changes will further be reflected as shifts in industry focus and occupational demand. For example, the buildout of new energy systems and infrastructures increases the need for construction workers while improved efficiency and lower staffing requirements may stagnate growth in the utilities sector,[26] unless this

[26] These changes are discussed in more detail in Chapter 5: Energy Technology Sectors.

growth is offset by increased electrification. It is these changes that are impacting energy sector wages and employment benefits, as average hourly wages vary most significantly by industry segments, like mining, construction, professional services, and utilities.[27]

Trends over the last three years indicate that energy jobs in wholesale trade have declined the most, shedding 14 percent of the workforce from 2016 through 2019. At the same time, professional services have seen the greatest growth in employment (22 percent increase), followed by other services like repair and maintenance (15 percent increase), mining and extraction (14 percent increase), and agriculture (12 percent increase). Energy-related construction and manufacturing have grown between 2016 and 2019, at a rate of five percent each, while employment in the utilities sector has declined by less than a percent.

Shifts in dominant fuel sources and energy technologies are also creating new geographic centers of energy jobs across the nation. These shifts are resulting in job losses in parts of the country that have historically been considered key regions for traditional energy jobs. While installation, maintenance, and repair jobs in the energy efficiency sector are more universally distributed and exist in nearly every county across the nation, in large part, the prevalence of energy jobs is dependent on the concentration of either renewable or fossil fuel resources and infrastructures; this is especially true for the electric power generation and fuels technology sectors. Coal, oil, natural gas, solar, wind, and biofuel resources are specific to geographic regions in the United States, and this resource distribution determines the regional spread of energy jobs in these sectors.[xv]

Over half of the states in the nation have climate change and clean energy policies in place. By providing incentives, establishing mandates, and setting goals and standards, state energy and climate policies are a major driver for technology deployment and diffusion. As such, they have direct impacts on the local workforce and market demand for certain skillsets, areas of knowledge, and experiences and backgrounds.

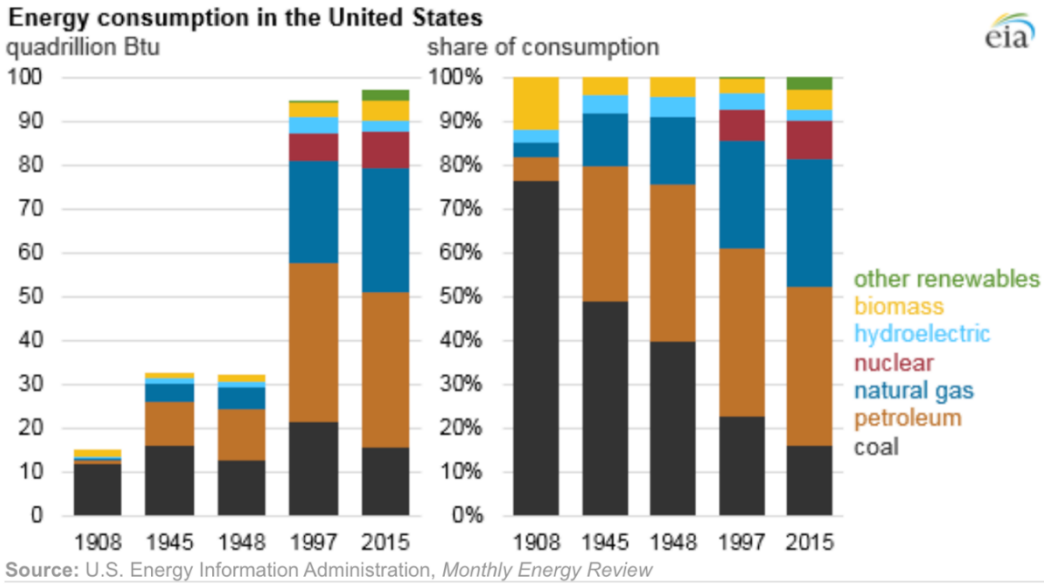
Investments in certain energy technology and industry segments can create both positive and negative ripple effects. Discussions about energy jobs transitions are often associated with coal-dependent communities, but as the U.S. energy economy continues to evolve, it appears equally applicable to local economies dependent on a wide variety of fuels, technologies, and systems. State policies to reduce greenhouse gas emissions in the transportation sector, for instance, by investing in electric vehicle charging infrastructure, may create greater demand for alternative fuel vehicle workers in California but negatively impact automotive manufacturing in Michigan or corn-ethanol plants throughout the Midwest. A deeper understanding of these potential impacts can help target workforce training, retraining and unemployment support to those who are deeply impacted by the adoption of new energy technologies, systemic changes, and policies.

[27] Please see Chapter 3: Energy Job Wages Explained for more information on what factors influence energy sector wages.

Energy Jobs and Transition: Challenges and Opportunities

The energy sector has changed significantly not just over the past two decades, but also over the last hundred years. These changes, largely due to technology and economic trends, have profound impacts on energy jobs and the communities that depend upon them. These impacts compound as a result of indirect jobs (both energy and non-energy) and tax revenues associated with energy.[28] This section of the *Wage Report* looks at five examples to help inform policies that can address how these shifts impact energy jobs and communities. Unlike the rest of the *Wage Report*, this section explores challenges and opportunities associated with changes in energy jobs due to energy transitions and trends that cannot be provided solely by energy jobs data.

Figure 4.
Changes in U.S. Energy Consumption, 1908-2015[xvi]



https://www.eia.gov/todayinenergy/detail.php?id=28592
U.S. Energy Production, consumption has changed significantly since 1908, November 1, 2016

[28] With respect to community impacts, jobs and tax revenue impacts are part of a broader phenomenon when a major industry locates in a community or closes its facilities in the community. For example, in the case of power plant closures, the plant is the top taxpayer, providing about 80 percent of property taxes. Impacts from the closure include the loss of these property taxes plus the loss of income and sales taxes from lost jobs. School districts in particular are also impacted. A 2019 study published by Brookings also showed that coal-related revenue in three specific counties may fund a third or more of local government budgets. *See generally:* https://www.pjstar.com/news/20190826/power-plant-closures-could-hit-local-tax-revenue-hard and https://www.the74million.org/article/it-just-becomes-like-a-ghost-town-as-nuclear-plants-close-in-record-numbers-across-u-s-small-town-school-districts-brace-for-catastrophic-tax-loss/ and https://www.brookings.edu/wp-content/uploads/2019/05/Morris_Kaufman_Doshi_RiskofFiscalCollapseinCoalReliantCommunities-CGEP_Report_FINAL.pdf.

SPOTLIGHT

Coal Mine and Power Plant Closures

Dille and Widen, West Virginia and Gillette, Wyoming

The share of coal has been declining since 1908, and mine and powerplant closures have lasting impacts on communities. This spotlight on Dille and Widen, West Virginia, mining towns until 1963, and Gillette, Wyoming, a state that has recently experienced a 40 percent reduction in coal production, underscores the importance and need for policies to address these community impacts.

Dille and Widen, West Virginia are former mining towns with a population of approximately 3,000 until December 1963 when the Rich Run Mine was shut down. Today, the population of Widen and Dille is closer to 300 people. The nearest jobs are a gas station and fast-food restaurant in Birch River, a 15-minute drive away. A food pantry run by the Dille Church of the Nazarene serves fifty percent of families living in Dille, Widen, Birch River, and Harrison.[xvii] "I've seen more people in need," Mitzi Frame, a volunteer at the pantry, said. She continued, "it stems from when the mines shut down in Widen years and years ago. It just didn't get any better." Patricia Fischer, Pastor of the Dille Church of the Nazarene stated, "I've even prayed about an industry for this community. Poverty leads to a lot of different issues other than hunger."[xviii]

Gillette, Wyoming is the center of the Powder River Basin which currently produces about 40 percent of U.S. coal.[xix] In 2016, the economy crashed primarily due to low natural gas and renewable energy prices which resulted in less demand for coal, a common trend in this decade. "That was when the economy just collapsed. The energy

> "I've seen more people in need. It stems from when the mines shut down in Widen years and years ago. It just didn't get any better."
>
> *—Mitzi Frame, on Dille and Widen*

industries always have been boom-and-bust, but this was a big one," said Gillette Mayor Louise Carter-King. Wyoming coal production peaked in 2008 at 468 million short tons; by 2019, that number was 277.[xx] According to a local resident, Steve Gray, who was laid off three times since 2015, the impact has been devastating. "My bank accounts were drained—lost my house, all the repossessions. It was tough."[xxi]

Jake Higdon, a senior climate policy analyst at the Environmental Defense Fund, has focused on ensuring fairness for workers and communities negatively impacted by the fossil fuel shift. Referring to a successful transition from an industry town, he notes, "there is no perfect example so far, because we haven't put forward the policies and investment needed to meet the scale of the energy transition challenge. Workers and communities reliant on fossil fuels will need a range of tools and policies that support economic development, workforce training, public benefits, environmental remediation and more. We've seen how these policies, when planned hand-in-hand with local communities, can help lay the foundation for future prosperity. For example, Athens County, Ohio has leveraged federal grants to build collaboration among businesses, entrepreneurs, and other stakeholders around local economic development, and the promising new Colorado Office of Just Transition is working with labor and utility stakeholders to provide advance notice and training for workers in power plants that will be closed."

There does appear to be increased interest in addressing the impacts of reduced coal use on energy jobs and communities. Provisions such as those found in the American Coal Miners Act[29], the Marshall Plan for Coal Country Act[30], and Assistance to Coal Communities Program[31] from the last Congress could provide aid to coal workers and their families during transitionary periods. More recently, President Biden issued *an Executive Order establishing a Working Group on Coal and Power Plant Communities*, recognizing the negative impacts of the current energy transition and the importance of providing resources to energy jobs and impacted communities.[xxii]

[29] S.27 — 116th Congress (2019-2020)
[30] S.4306 — 116th Congress (2019-2020)
[31] https://www.eda.gov/coal/

SPOTLIGHT

Nuclear Power Plant Retirements

Zion, Illinois and Ottawa County, Ohio

Between 2013 and 2020, ten nuclear plants have retired, and six are scheduled to retire by 2025, largely due to low-cost natural gas from fracking.[xxiii] *Nuclear plant operations on average deliver around $400 million annually to the economic livelihood of local communities.*[xxiv] *When the plant closes, impacts are not limited to energy job losses; tax revenue from property taxes, sales taxes, and income taxes decline significantly. A major impact is on education funding by up to 80 percent, reducing gateways to a longer-term recovery. Furthermore, after the plant closes, in addition to the lost direct jobs, indirect jobs and tax revenues, the community now is host to a nuclear waste site.*

Photo: M. Readey

Zion, Illinois, a suburban community about 50 miles north of Chicago, was the site of the Zion Nuclear Power station which employed 1,200 individuals until the plant closed in 1998.[xxv] When the Zion Nuclear Power Station closed, the town lost $19 million in annual property tax revenues, approximately 50 percent of the Zion's tax base. To help address the deficit, the town doubled property taxes, resulting in an exodus of both businesses and residents, making it difficult to attract homebuyers and continuing the negative tax cycle.

"We've got a $1.6 million deficit that we're looking at next year. And over the past four or five years, we've had deficits and we've had to cut, cut, cut," said City Administrator David Knabel.[xxvi] Zion "had to eliminate 14 police officers, eight public works employees, and five jobs in the building department," according to then Mayor Al Hill in 2018.[xxvii] This has led to diminished response times for emergencies and underserved populations. The plant site now hosts tons of highly radioactive nuclear waste. "Even after decommissioning is finished—perhaps in about 2020—no one will want to invest in building a resort or condos there with the waste still on site," said Hill.[xxviii]

Ottawa County, Ohio is the site of the Davis Besse Nuclear Plant which was scheduled to close in 2020. State legislation has temporarily delayed the closure and the future of the plant remains uncertain. Ohio school Superintendent Guy Parmigian of Benton Salem District explains just how reliant the District on the Davis Besse plant for tax revenue. Since 2018, 25 percent of the district's budget has been cut, and the school system has eliminated several positions, and that is while the plant is still operating. "It's kind of now like, I don't want to say the party's over, but the party's not what it used to be, and that plant isn't generating that same revenue that it used to for us," Parmigian said. The city proposed for a third time a twice rejected a proposal meant to bring in $1.5 million in tax revenue. "The worst-case scenario, shuttering the plant, would be disastrous for the district," Parmigian said.[xxix]

A report by the Nuclear Decommissioning Collaborative outlines the real fears of nuclear plant site communities.[xxx] A loss of tax revenue from the plant leads to a spiral where local community taxes are increased making it even more difficult for residents to pay when they are also losing their jobs with no new energy jobs on the horizon.[xxxi] People do not want to move into the community because of high tax rates and the lack of industry. The once economically healthy community continues in this downward spiral.

Federal initiatives to help these communities include the proposed "Sensible, Timely Relief for America's Nuclear Districts' Economic Development Act of 2020," and the U.S. Economic Development Administration's Research and National Technical Assistance program which has funded initiatives such as the Nuclear Closure Communities Technical Assistance program.[xxxii]

> "I don't want to say the party's over, but the party's not what it used to be, and that plant isn't generating that same revenue that it used to for us. The worst-case scenario, shuttering the plant, would be disastrous for the district."
>
> *—Guy Parmigian, on Ottawa County*

SPOTLIGHT

Creating Jobs & Improving Local Economies through Reclamation Programs

Abandoned Mines & Gas Wells in Pennsylvania

As illustrated by Dille and Widen, West Virginia and Gillette, Wyoming, abandoned mines and gas wells often are associated with lost energy jobs and the resulting impact on nearby communities. But reclamation programs are one example that can offer opportunities for new jobs associated with state programs as well as other benefits such as increased property values and, potentially, tourism.

Photo: Nicholas A. Tonelli

In Pennsylvania, the Department of Environmental Protection (DEP) and the Bureau of Abandoned Mine Reclamation administer the federal Abandoned Mine Lands (AML) program to address problems resulting from coal mining prior to 1977. Pennsylvania continues to account for one-third of the country's AML problem with 43 of the state's 67 counties having identified abandoned mine problem areas. Pennsylvania has nearly 300,000 acres of abandoned mine land in need of reclamation, with an estimated cleanup cost of $5 billion.[xxxiii]

"Mine reclamation equals jobs. From excavation, to truck hauling, heavy equipment operation, engineering, to natural stream channel design, to tree planting," says R. John Dawes, Executive Director of the Foundation for Pennsylvania Watersheds. He adds: "Ancillary jobs in support of these direct jobs include food service, hotel/motel use, and all the indirect services needed to keep this important community-based effort going. These jobs impact the local economy as the money stays locally." A study on the abandoned mine discharges in the West

> "Mine reclamation equals jobs. From excavation, to truck hauling, heavy equipment operation, engineering, to natural stream channel design, to tree planting."
>
> —*R. John Dawes*

Branch Susquehanna River Watershed found that every $1 spent by the state on AML remediation spurs roughly $1.50 in local economic activity.[xxxiv]

The project construction contractors—often former mine operators themselves—typically employ former miners and other local workers in coalfield communities because they possess the necessary skills for the task.[xxxv] "When these mines closed, these communities lost jobs and were left with land that was difficult to repurpose," Governor Tom Wolf said in a 2016 press release.[xxxvi] "This [AML] program will help strengthen coal communities and put people back to work, while also improving the environment in these areas."

Pennsylvania also now sees a similar job transition opportunity with the abandonment of gas and oil wells. The state, having engaged in commercial oil drilling since 1859, reports the largest estimate of undocumented orphaned wells—100,000 to 560,000—in the country. The DEP's Well Plugging Program was established in 1984 to plug oil and gas wells with no identifiable responsible party. Many abandoned wells emit methane, a greenhouse gas 34 times more potent than carbon dioxide over a 100-year time frame. In Pennsylvania, closing the wells would prevent freshwater contamination and result in annual emissions savings.[xxxvii]

"Abandoned wells must be cleaned out before they can be plugged," notes Arthur Stewart, Secretary of the Pennsylvania Grade Crude Oil coalition. "The clean out requires special equipment and knowledge, and the people with that equipment and knowledge are the conventional oil and gas workforce."

On average, in the United States, plugging ten wells requires about 2.4 person-years of work; plugging Pennsylvania's remaining abandoned and orphaned wells would create roughly 816,000 job-years for oil and gas workers in Pennsylvania.[xxxviii] Stewart explains, "these family-sustaining jobs, paying average per capita income or more, include rig and heavy equipment operators, CDL drivers, and mechanics."

Ultimately, "a program to plug abandoned wells is a win for the environment and a win for the economy," says Stewart. Particularly given the economic and labor market context following the global COVID-19 pandemic, "a program to plug abandoned wells would bring much needed help to rural economies hit hard by COVID-19's impact on small businesses," Stewart explains.

SPOTLIGHT

Working with Unions & Workforce Development

Offshore Wind in Massachusetts

The emerging U.S. offshore wind industry presents a key growth opportunity along the Atlantic coast. Massachusetts, for example, has already procured 1,600 megawatts (MW) of wind farm development, which is expected to employ 6,800 to 9,800 local full-time equivalent jobs over the projects' lifespans[xxxix]—with another 1,600 MW in the future pipeline. The growth in offshore wind is due in large part to the state's policy and legislative leaders as well as efforts by the Massachusetts Department of Energy Resources (DOER) to study wind opportunities and engage electric distribution companies in soliciting and entering into long-term offshore wind contracts. To ensure that the jobs pay prevailing wages and meet safety and quality standards, as well as an adequate supply of local, well-trained labor, Massachusetts is working with industry and labor to create Project Labor Agreements for the offshore wind sector.

Vineyard Wind project rendering

"From energy efficiency, distributed energy, and advanced heating and cooling technology, Massachusetts' experience shows that investing in clean energy provides significant dividends for our economy and workforce development," notes Commissioner Patrick Woodcock of the Massachusetts Department of Energy Resources. "Building on this economic success, DOER has identified offshore wind as a significant opportunity to revitalize our ports, create jobs, and bring cost-effective clean energy near significant electrical demand."

Vineyard Wind, the developer of the first 800 MW build-out, has included or is in negotiations to include Project Labor Agreements (PLAs) in their contracts that ensure in-state union labor is used where possible.

"We are in the process of identifying which unions will be best suited for each task and supporting the development of necessary training programs," says Vineyard Wind's Manager of Workforce and Supply Chain Development Jennifer Cullen. "By engaging unions in this process, our firm can rely on existing networks to recruit, train, and supply the sufficient qualified workforce for the job."

The Massachusetts Clean Energy Center (MassCEC) has recognized the benefits of preparing a local workforce to develop offshore wind farms in-state and beyond, investing $2 million—alongside Vineyard Wind and Mayflower Wind, the Commonwealth's second project—to support offshore wind technical training and career development programs for Massachusetts residents. The funding includes specific contributions to the International Brotherhood of Electrical Workers (IBEW) Local Union #223 and the Piledrivers and Divers Local Union #56. Local 56—the predominant provider of marine construction labor in the Northeast—has used the funds to sponsor member participation in the Global Wind Organization's Basic Safety Training program, a necessity for offshore wind labor. IBEW Local 223 is partnering with offshore wind cable supplier, JDR Cables, to establish an electrician training program for offshore work at their training facility in Taunton, Massachusetts.

"MassCEC is pleased to be working with our local unions to ensure they are fully prepared to supply highly-skilled construction and installation talent for the emerging offshore wind industry," explains MassCEC CEO Stephen Pike.

A unique benefit to union labor is their access to a larger pool of qualified talent. Local 56 is affiliated with the United Brotherhood of Carpenters (UBC), one of the largest union networks in North America.

"Local 56 has particular relationships with sister organizations in New York, New Jersey, and Pittsburgh," says Local 56 Business Manager Dave Borrus. "We contact them to fill employment gaps when necessary to ensure all projects have a sufficient workforce in a timely manner."

IBEW Local Union #223 Business Manager Doug Nelson adds, "Our collaboration with JDR and MassCEC will ensure offshore wind developers have a local workforce that is qualified, prepared, and has the ability to work safely under these new working conditions… The quality of workmanship is there, the safety of workers is there, and the opportunity to earn a living wage is there."

> "By engaging unions in this process, our firm can rely on existing networks to recruit, train, and supply the sufficient qualified workforce for the job."
>
> *—Jennifer Cullen*

SPOTLIGHT

Preparing for the Future by Adopting and Adapting New Energy Technologies

Texas's Oncor Electric Utility's Advanced Microgrid

New energy technologies have been a major driver for changes in energy jobs. Successful adoption of commercialized technologies often depends on innovative energy companies and strategic partnerships. Utilities in particular are impacted not just by new technologies for their sector but also from other sectors. For example, projected increases of the number of electric vehicles are expected to convert historic flat demand to increase in electricity consumption by 20 percent and 38 percent by 2050.

Photo: Jphill19

Oncor is an electricity transmission and distribution company whose service area encompasses more than 400 communities in Texas, including Dallas, Fort Worth, Round Rock, Midland, and Odessa. The utility employs about 4,000 people and serves more than 10 million Texans. The company delivers electricity and does not own, operate, or control power generation plants, facilities, or assets. Oncor is actively preparing for the future of energy production and transmission. In partnership with S&C Electric and Schneider Electric, Oncor built one of the most advanced microgrids in North America in Lancaster, Texas in 2015 to better understand the challenges and opportunities that microgrids and distributed energy present.

> "New energy sources are showing us that there are cleaner and better ways of doing things, but this process is also more complicated, requiring workers with skillsets and abilities who are able to handle these complex challenges."
>
> *— David Treichler*

The microgrid actually consists of four interconnected microgrids making use of nine different distributed generation sources. Today, the microgrid allows the utility to better manage and optimize the transmission and distribution of electricity in the 21st century.

David Treichler, the Director of the Strategy and Emerging Issues team at Oncor, highlighted how the future of energy is changing the workforce at the utility. “New energy sources are showing us that there are cleaner and better ways of doing things, but this process is also more complicated, requiring workers with skillsets and abilities who are able to handle these complex challenges” he said.

Specifically, the utility is increasingly looking for workers with broad engineering capabilities, who can understand complex systems and integrate software and hardware systems. Analytical and digital skillsets are also growing in importance. This increased need for highly technical workers will bring higher and higher wages, as firms compete for top talent. Just like the big technology firms, “we’re looking for the best and brightest as well” Mr. Treichler says.

The Impacts of COVID-19 on U.S. Energy Jobs in 2020

The COVID-19 pandemic has fueled historic job losses in the United States. Impacts on the overall U.S. workforce from March through May totaled almost 31.4 million job losses. The insured unemployment rate rose more than 11 percentage points from March through May, reaching 15.6 percent—the highest recorded rate since the Bureau of Labor Statistics (BLS) began tracking this data in 1948. Initial unemployment claims for April totaled 23.1 million.[32] While workers in industries like food service and hospitality were hit first and hardest, negative impacts are now being felt throughout the economy.[xl]

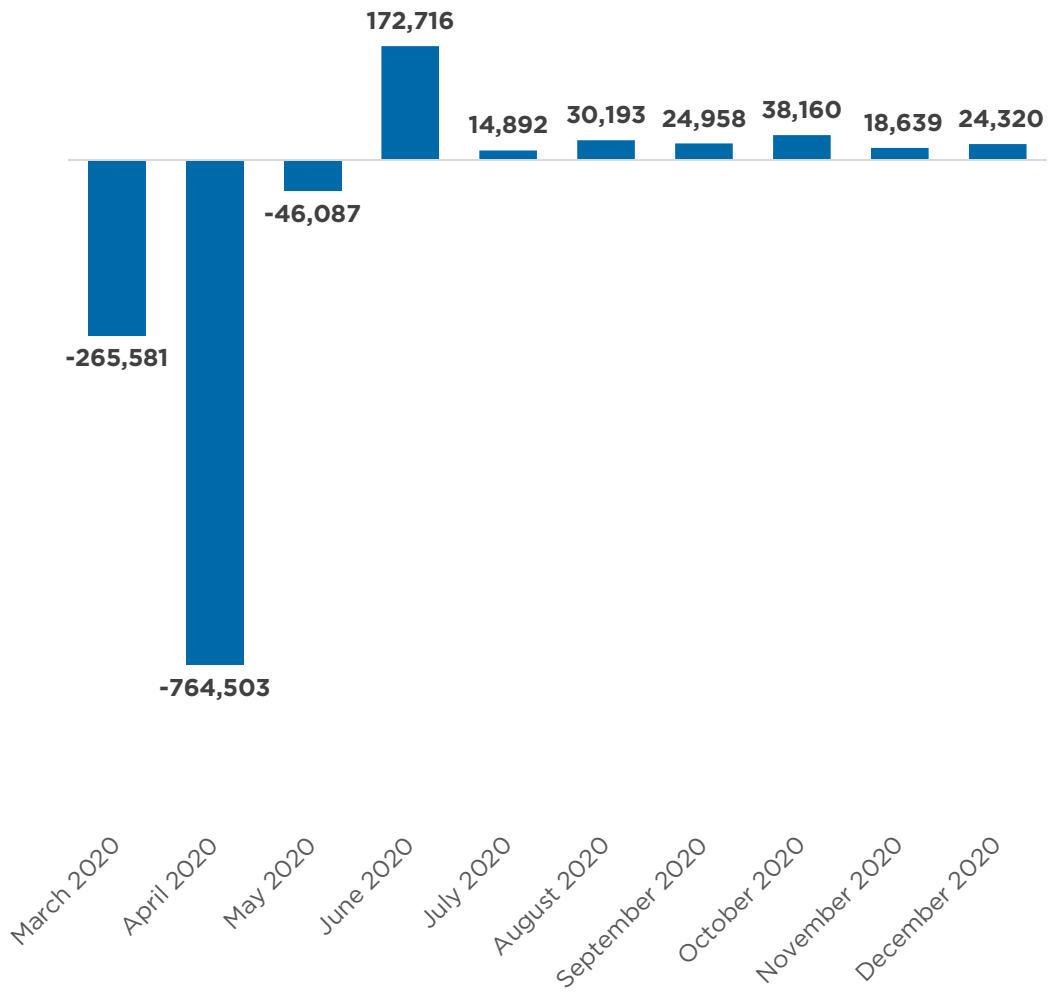
Energy workers—those working in electric power generation; fuels; transmission, distribution, and storage; energy efficiency; and motor vehicles—were also significantly impacted, as the energy industry overall shed an estimated 1.03 million jobs at the peak of the pandemic in April and an additional 46,000 jobs in May (Figure 5). This total surpasses nearly all industry-wide growth measured since the first *USEER* five years ago.

As of December 2020, the energy industry remains 12 percent below pre-COVID-19 employment levels, or roughly 752,300 workers shy of peak employment at the end of 2019. Job losses were experienced largely from March through May, totaling nearly 1.1 million displaced energy workers over these three months, or about 3.5 percent of the total 31.4 million jobs lost across the nation during this time. At the peak of job losses in April, the nation saw a roughly 20 percent decline in employment compared to a 12 percent decline in the energy sector. As shown in Figure 5, the energy sector has seen monthly job gains since June, though these gains have been modest.[xli] Despite significant energy job losses, employment declines in the energy sector were lower compared to other industry clusters such as Tourism, Hospitality, and Recreation; Information and Communications; Other Services (including repair and maintenance); Defense, Aerospace, and Transportation Manufacturing; Retail; Professional and Business Services; and Building and Design.

The 2021 *USEER* will provide more details on the impacts of COVID-19 on U.S. energy jobs.

[32] It is also important to note that the impacts of the COVID-19 pandemic are not felt evenly across all communities. The Bureau of Labor Statistics (BLS) Employment Situation Summary indicates that Black or African American and Hispanic or Latinx workers continue to suffer from disproportionately high levels of unemployment.

Figure 5.
U.S. Energy Jobs Change, March 2020 – December 2020



Energy sectors that were especially hard hit by the COVID-19 pandemic include energy efficiency and fuels. As of December 2020, the energy efficiency sector lost a cumulative roughly 240,000 jobs compared to the end of 2019, a decline of 10 percent. Over the same time, the fuels sector saw jobs decline by about 11 percent—a loss of more than 125,000 jobs. The motor vehicles sector shed just over 238,000 workers for a decline of more than nine percent, while the electric power generation sector declined by just over seven percent, or almost 64,000 job. Transmission, distribution, and storage jobs declined by six percent—over 85,000 jobs.

Table 1 illustrates the geographic impact of energy job losses from March through December. Georgia, Kentucky, Louisiana, Hawaii, and Alaska had the greatest relative job losses, all declining by 15 to 21 percent. In terms of absolute job losses, California, Texas, Michigan, Georgia, and Pennsylvania shed roughly 35,000 to almost 90,000 jobs.

Table 1.
Cumulative Energy Job Losses by State, March – December 2020

State	Jobs Lost	Percent Decline	State	Jobs Lost	Percent Decline
Alabama	15,495	10.4%	Montana	2,833	9.3%
Alaska	4,308	15.0%	Nebraska	4,363	7.6%
Arizona	8,335	6.7%	Nevada	4,742	7.8%
Arkansas	4,096	6.4%	New Hampshire	1,644	5.3%
California	89,507	9.4%	New Jersey	14,725	10.1%
Colorado	8,692	5.4%	New Mexico	7,861	13.5%
Connecticut	5,775	7.6%	New York	16,751	4.9%
Delaware	1,864	8.1%	North Carolina	22,673	10.4%
District of Columbia	2,086	10.1%	North Dakota	5,730	11.5%
Florida	31,643	9.3%	Ohio	29,243	8.3%
Georgia	42,226	20.5%	Oklahoma	17,765	12.8%
Hawaii	3,907	15.2%	Oregon	6,978	7.2%
Idaho	2,141	6.5%	Pennsylvania	34,865	12.9%
Illinois	13,814	4.5%	Rhode Island	3,116	13.1%
Indiana	23,473	8.2%	South Carolina	12,971	9.2%
Iowa	6,316	7.3%	South Dakota	745	2.8%
Kansas	5,817	6.8%	Tennessee	11,561	5.4%
Kentucky	29,419	19.3%	Texas	63,398	6.6%
Louisiana	27,030	15.9%	Utah	3,475	4.0%
Maine	2,057	8.1%	Vermont	1,814	8.0%
Maryland	9,348	7.1%	Virginia	13,107	7.0%
Massachusetts	14,708	7.8%	Washington	21,366	13.8%
Michigan	48,106	11.5%	West Virginia	6,197	9.4%
Minnesota	11,738	9.1%	Wisconsin	10,469	6.8%
Mississippi	6,411	9.2%	Wyoming	3,237	7.3%
Missouri	12,353	7.6%	**US TOTAL**	**752,292**	**9.0%**

Chapter 3
Energy Job Wages Explained

What makes this report different?

This report supplements the *USEER* series, providing a baseline for understanding energy sector wages. Though it includes brief discussions of additional metrics, this report is uniquely focused on wages.

Wage data is nuanced; it can be sliced in a variety of ways and examined through multiple lenses. As discussed above in the Employment section of the Research Methodology Overview, energy jobs can be grouped into technology sectors and sub-sectors as well as industry segments, or any combination of these. Median hourly wages can be described using any one of these groupings.

The highest level of employment and wage aggregation is an industry crosscut, which combines jobs across the technology sectors highlighted in Table 2 based on fuel type. The *USEER* provides data on industry crosscuts for nuclear, coal, oil, and natural gas because jobs in these industries span electric power generation, fuels, and transmission and distribution. In order to get an accurate understanding of average

wages in the overall coal industry, for example, all related jobs must be factored in; this includes power plant operators or electricians at coal-fired power plants, coal miners and extraction workers, truck drivers transporting coal, and construction workers engaged in the building or decommissioning of coal-fired power plants. Table 2 provides an example of the coal industry crosscut, what technology sectors are encompassed in the coal industry, as well as the related industries within each technology sector. For wages for the coal industry crosscut, please refer to Table 7.

Table 2.
Industry Crosscut Example

Industry Crosscut	Technology Sectors	Related Industries
Coal Industry	Electric Power Generation	Utility generation from coal-fired power plants; construction or decommissioning of coal-fired electric power plants; manufacture of technologies or component parts related to coal electric power generation; wholesale trade and distribution of coal electric power generation technologies; professional service support (legal, financing, consulting, etc.)
	Fuels	Mining, extraction, and production of coal fuels; manufacture and wholesale trade of technologies and component parts related to coal fuel production; professional service support
	Transmission & Distribution	Distribution and transport of coal fuel products

The next levels of aggregation are the five technology sectors mentioned in Figure 1 (Five Major Technology Sectors in the Energy Industry). These employment and wage estimates encompass all the sub-technologies specific to each sector and regardless of fuel source. The employment total for the electric power generation sector, for example, includes all workers that in some way support electricity generation across all fuel types—coal, oil, nuclear, natural gas, renewables. This includes the construction of new electricity generation facilities, installation of solar photovoltaic or wind turbine projects, utility employees, the manufacture or wholesale trade of components for electric power generating technologies, and professional service support (Table 3). Electric power generation employment and wage estimates would exclude any fossil fuel mining and extraction workers as these individuals would be in the fuels sector.

Table 3.
Five Energy Technology Sectors & Component Sub-Technologies

Technology Sector	Related Sub-Technologies	Industries
Electric Power Generation	Solar, wind, nuclear, coal, hydroelectric, geothermal, and biomass electric power generation	Construction, Utilities, Professional and Business Services, Manufacturing, Wholesale Trade, and Other Services[33]
Fuels	Coal, petroleum, natural gas, nuclear, corn ethanol, and woody biomass fuels	Mining and Extraction, Manufacturing, Professional and Business Services, Wholesale Trade, Agriculture and Forestry, Construction, and Other Services
Transmission, Distribution, and Storage	Traditional transmission and distribution, battery storage, smart grid, microgrid	Construction, Utilities, Wholesale Trade, Professional and Business Services, Manufacturing, and Other Services
Energy Efficiency	Efficient lighting, traditional HVAC, ENERGY STAR appliances, renewable heating and cooling, advanced and recycled building materials	Construction, Professional and Business Services, Manufacturing, Wholesale Trade, Other Services
Motor Vehicles	Gasoline and diesel transportation, electric vehicles, plug-in hybrid vehicles, hydrogen, and fuel cell vehicles	Manufacturing, Repair and Maintenance, Wholesale Trade, Professional and Business Services

From here, the data can be further disaggregated into each of the sub-technologies described in column two of Table 3 above. This level of granularity provides hourly wages for workers in specific sub-components of the technology sectors, such as solar electric power generation, natural gas electric power generation, coal fuels, petroleum fuels, nuclear fuels, efficient lighting, ENERGY STAR appliances, plug-in hybrid vehicles, battery storage, or smart grid.

This report is organized following these levels of aggregation, beginning with the highest level of aggregation—industry crosscuts—and moving down through major technology, sub-technology, industry segment, and occupational wage data.

[33] Other Services largely consists of NAICS 81, which includes repair and maintenance and non-profit organizations.

What do energy jobs pay?

The energy sector pays well above the median hourly wage in America. This is true across all technology sectors and nearly all industry segments. Overall, the energy sector's median hourly wage is $25.60—34 percent higher than the national median hourly wage of $19.14 across all industries and occupations (Table 4).[xlii]

All technology sectors support a wage premium over the national median. Transmission, distribution, and storage workers earn roughly $31 per hour, or 63 percent above the national median wage, and electric power generation workers earn about $27 per hour—42 percent above national wages.

Table 4.
Energy Wages by Technology Sector[xliii]

Technology Sector	Median Hourly Wage	Premium or Discount[34] Compared to National Median of $19.14	Total Employment, 2019	Employment Growth, 2017-2019	Percent of Total Energy Employment, 2019
Electric Power Generation	$27.19	42%	896,830	1.5%	10.7%
Fuels	$23.89	25%	1,148,893	6.9%	13.7%
Transmission, Distribution & Storage	$31.25	63%	1,383,646	3.8%	16.5%
Energy Efficiency	$24.44	28%	2,378,893	5.8%	28.4%
Motor Vehicles	$22.29	16%	2,556,492	3.8%	30.6%
Overall Energy Industry	**$25.60**	**34%**	**8,364,754**	**4.5%**	
National Median Wage	**$19.14**				

Across industry segments, utility employees and mining and extraction workers earn the highest premiums compared to the national median hourly wage, at $41 and $36 per hour, respectively (see column five in Table 5). However, when comparing energy worker wages to overall industry-specific wages, energy workers in mining, wholesale trade, and repair and maintenance had the highest wage premiums (see column four in Table 5). For example, energy workers in wholesale trade earn a 29 percent premium compared to the overall wholesale trade industry, which includes both energy and non-energy workers.

[34] A "premium" is defined here as the percentage *above* the comparative wage. A "discount" would indicate that the wage is *below* the comparative wage; this would be portrayed as a negative percentage.

Table 5.
Energy Wages by Industry Segment[xliv]

Industry	Median Hourly Wage (Energy Workers)	Median Hourly Wage (Overall Industry)	Premium/ Discount Compared to Overall Industry	Premium/ Discount Compared to National Median of $19.14	Total Employ-ment, 2019	Percent of Total Employ-ment, 2019
Agriculture[35]	$13.18	$13.18	**0%**	**-31%**	35,616	0.4%
Mining and Extraction	$36.32	$25.44	**43%**	**90%**	535,210	6.4%
Utilities	$41.08	$37.50	**10%**	**115%**	601,225	7.2%
Construction	$25.53	$23.57	**8%**	**33%**	2,142,087	25.6%
Manufacturing	$23.02	$20.46	**13%**	**20%**	1,778,343	21.3%
Wholesale Trade[36]	$19.94	$15.47	**29%**	**4%**	860,661	10.3%
Transportation (commodity flows)	$36.08	$34.31	**5%**	**89%**	285,375	3.4%
Professional Services	$28.17	$25.95	**9%**	**47%**	1,057,995	12.6%
Other Services (incl. Repair and Maintenance)	$19.68	$16.33	**21%**	**3%**	1,068,244	12.8%
National Median Wage	**$19.14**					

[35] Energy-related jobs in agriculture are based entirely on publicly-available data using several specific NAICS codes. As such, the overall national agriculture industry wage is used here, as opposed to an energy-specific wage extrapolation. Because BLS does not provide agriculture wages to the six-digit NAICS level, $13.18 is the best proxy estimate for energy jobs in the agriculture industry.
[36] The weighted median hourly wages for this industry segment include retail trade (NAICS 42-45). Though the *USEER* excludes retail employment, fuel dealers (NAICS 454310) are surveyed as part of the data collection effort.

What determines energy sector wages?

There are many factors that contribute to the hourly wages of energy workers. Wages in the energy sector are dependent on education, skills, and experience level, as well as other attributes specific to an occupational role, such as worker safety, geographic location, labor market competition, or union representation. Though it may be difficult to pinpoint a single key determinant, the industry mix of a technology sector appears to be highly correlated to energy worker wages.

Generally speaking, energy-related jobs in construction and manufacturing pay less than those in utilities, mining and extraction, and professional services (see Table 5). Workers in the utilities sector earn $41.08 per hour while energy-specific construction jobs support an average hourly wage of about $25.53 per hour; utility employees earn a 61 percent premium over energy workers in the construction industry.

As a result, the industry mix of each technology sector is critically important to understanding energy wages. Technology sectors with a high proportion of utility jobs, such as electric power generation or transmission, distribution, and storage, are more likely to support higher overall wages; the high concentration of utilities jobs skews the overall sector-wide median wage. The higher wages for these two sectors are in fact evident in Table 4 above.

It is important to note that industry as a driver of energy wages can also be seen as a function of unionization. Though not the main focus of this report, unions are important to the discussion on energy jobs and wages. However, a consensus on unionization data is challenging due to variations among federal datasets. For example, current datasets across the Energy Information Administration (EIA) and the Department of Labor's Bureau of Labor Statistics and Mine Safety and Health Administration (MSHA) produce varying results across industry segments. In particular, coal mining unionization cited by the Current Population Survey indicates that union coverage for coal miners was at roughly 10 percent in 2019[xlv] while the EIA publication of MSHA data in 2019 cited a roughly 20 percent unionization rate for the coal mining industry.[xlvi] Such varying methodologies and definitions contribute to difficulties in extrapolating energy-specific unionization rates.

Chapter 4
Industry Crosscuts

The following section includes aggregated industry crosscuts across technology sector based on fuel type. For example, natural gas jobs span electric power generation, fuels, and transmission and distribution.[37] Across all industry crosscuts, workers in the nuclear, electric power transmission and distribution, natural gas, and coal industries earn hourly wages that are at least 50 percent higher than national median wages. Nuclear workers earn the highest wage premium, at nearly 105 percent above the national median wage of $19.14.

Other industries like wind, solar, energy efficiency, and storage all support wage premiums that are at least 35 percent above the national median. These energy industries have lower median hourly wages compared to other energy industry crosscuts (Table 6). In general, however, all energy industry crosscuts support wages that are higher than the national median hourly wage.

[37] For more information on the difference between industry crosscuts and energy technology sectors and sub-technologies, please refer to Chapter 3: Energy Job Wages Explained. Caution is advised when comparing employment totals to the USEER, as energy jobs may be summed in a variety of ways.

Table 6.
Overall Industry Crosscut Wages, 2019[38]

Industry Crosscut	Median Hourly Wage	Premium or Discount Compared to National Median	Total Employment, 2019	Percent of Total Energy Employment, 2019
Nuclear	$39.19	104.8%	70,323	0.8%
Electric Power Transmission & Distribution	$31.80	66.1%	830,291	9.9%
Natural Gas	$30.33	58.5%	636,043	7.6%
Coal	$28.69	49.9%	185,689	2.2%
Hydropower	$26.97	40.9%	67,772	0.8%
Oil	$26.59	38.9%	839,831	10.0%
Wind	$25.95	35.6%	114,774	1.4%
Solar	$24.48	27.9%	345,393	4.1%
Energy Efficiency	$24.44	27.7%	2,378,893	28.4%
Storage (excl. fossil fuels)	$24.36	27.3%	80,550	1.0%
National Median Wage	**$19.14**			

[38] Total employment in this table will not sum to total energy jobs in the U.S. for 2019 as these industry crosscuts represent the sum of various sub-sectors across the energy industry but do not include all energy-related jobs.

Coal

The coal industry crosscut includes utility workers as well as mechanics, technicians, and other construction workers that support coal electric power generation and coal-fired power plants; coal fuel mining, extraction, and production workers; individuals involved in the transportation and distribution of coal fuel products; and those engaged in financial, legal, or other business support for coal companies. Between 2016 and 2019, the coal industry shed jobs at a rate of six percent, from roughly 197,600 to 185,700 workers.

Coal jobs are largely concentrated in the mining and utilities sector, which combined account for 51 percent of all coal jobs (Figure 6). The overall median hourly wage for coal workers is $28.69 per hour, with energy workers in specific industries like utilities and professional services earning more than the average coal worker. In contrast, mining and transportation jobs earn less than the overall median hourly wage (Table 7). Despite the high wages, many jobs in coal generation and fuels do not require degrees. Powerplant operators, electrical power-line installers, and industrial machinery mechanics all require no more than a high school diploma while continuous mining machine operators have no formal educational requirement. However, many of these jobs require long-term on-the-job training, and the length of work experience may contribute to higher wages.

Figure 6.
Coal Jobs by Industry Segment, 2019

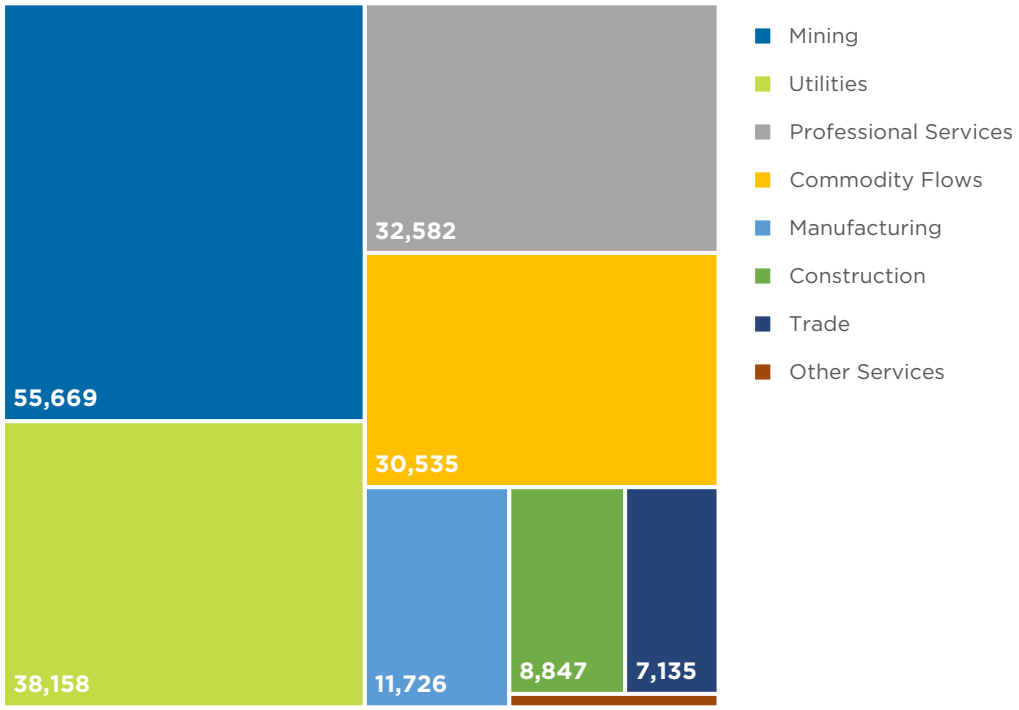


Table 7.
Coal Wages by Industry Segment, 2019

Industry	Median Hourly Wage (Coal Workers)	Median Hourly Wage (Nationally)	Premium or Discount
Mining	$24.75	$25.44	-2.7%
Utilities	$41.30	$37.50	10.1%
Construction	$26.65	$23.57	13.1%
Manufacturing	$22.64	$20.46	10.7%
Wholesale Trade	$17.43	$15.47	12.7%
Transportation (commodity flows)	$24.24	$34.31	-29.4%
Professional Services	$29.17	$25.95	12.4%
Other Services (incl. Repair and Maintenance)	$18.46	$16.33	13.0%
Overall	**$28.69**	**$19.14**	**49.9%**

Electric Power Transmission & Distribution

The electric power transmission and distribution industry includes all jobs associated with electricity transmission, including utility workers; construction workers that support the installation and maintenance of power lines or the building of new smart grid and microgrid systems; manufacturers developing products and component parts relevant to electricity transmission; sales representatives involved in selling technologies related to electricity transmission; and those engaged in financial, legal, or other business support for these companies. Between 2016 and 2019, electric power transmission and distribution grew by three percent, or roughly 24,000 workers.

Most electric power transmission and distribution[39] jobs are either in utilities or construction. The utilities industry represents 36 percent of all jobs and construction workers account for 35 percent of jobs (Figure 7). Electric power transmission and distribution workers earn a median hourly wage of $31.80—66 percent above national wages (Table 8). With the exception of engineers and general and operations managers, many jobs in electric power transmission and distribution do not require a four-year degree. Electrical power-line installers, customer service representatives, control and valve installers, and meter readers typically require a high school diploma at entry.

[39] It should be noted that the "electric power transmission and distribution" industry crosscut is not the same as the major technology sector "transmission, distribution, and storage". The electric power transmission and distribution industry crosscut excludes any petroleum and natural gas transmission, distribution, or storage, as these jobs would be counted under the separate petroleum and natural gas industry crosscut sections. For more information on the difference between industry crosscuts and energy technology sectors and sub-technologies, please refer to Chapter 3: Energy Job Wages Explained. Caution is advised when comparing employment totals to the USEER, as energy jobs may be summed in a variety of ways.

Figure 7.
Electric Power Transmission & Distribution Jobs by Industry Segment, 2019

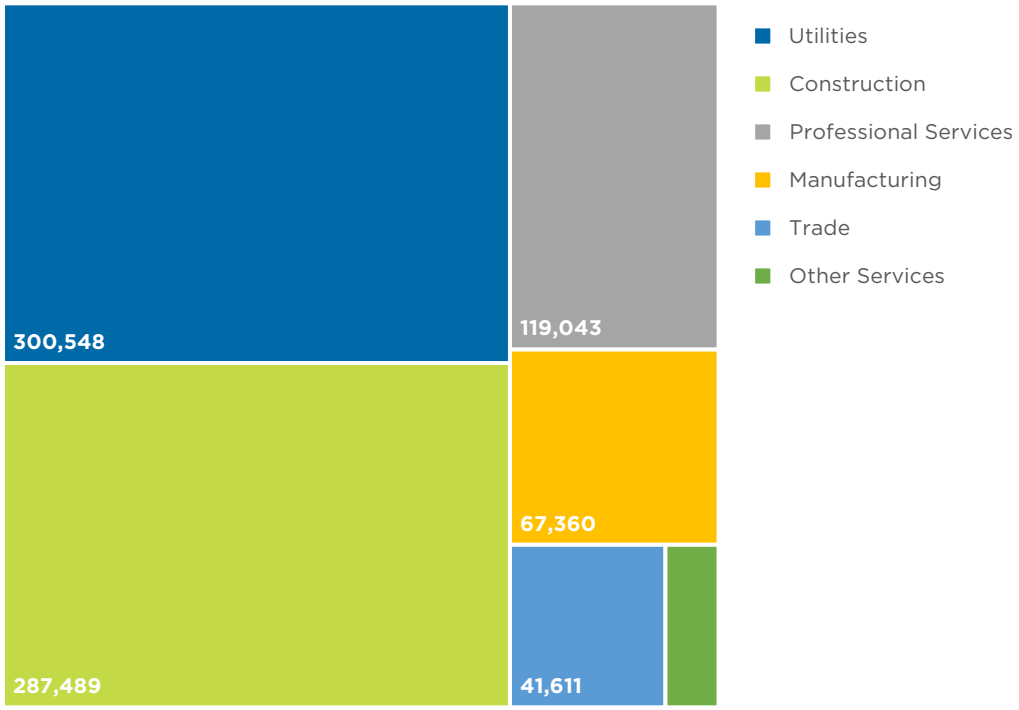


Table 8.
Electric Power Transmission & Distribution Wages by Industry Segment, 2019[40]

Industry	Median Hourly Wage (Electric Power Transmission & Distribution Workers)	Median Hourly Wage (Nationally)	Premium or Discount
Utilities	$40.64	$37.50	8.4%
Construction	$25.61	$23.57	8.7%
Manufacturing	$22.23	$20.46	8.7%
Wholesale Trade	$16.81	$15.47	8.7%
Professional Services	$28.20	$25.95	8.7%
Other Services (incl. Repair and Maintenance)	$17.74	$16.33	8.6%
Overall	**$31.80**	**$19.14**	**66.1%**

[40] Industry segments with the same premium are a result of low sample size. In order to produce an estimate for these wages, the research team relied on technology-specific premiums applied across each industry segment.

Energy Efficiency

The energy efficiency industry includes all construction and installation workers engaged in building efficiency improvements, such as weatherization, HVAC and lighting upgrades and installations, or the maintenance of heating and cooling systems; manufacturers of energy efficient products and component parts including ENERGY STAR appliances and LED, CFL, and other efficient lighting technologies; wholesale sales representatives that sell energy efficient products; and those engaged in financial, legal, or other business support for these companies. Between 2016 and 2019, the energy efficiency workforce grew by nine percent, adding about 197,400 jobs to the energy workforce.

Energy efficiency jobs are concentrated in construction and professional services, though at 56 percent of total employment, construction workers account for the majority of energy efficiency employment; professional services represent 21 percent of total jobs (Figure 8). Overall, energy efficiency workers earn $24.44 per hour, which is 28 percent above the national median wage (Table 9). Because so many occupations in energy efficiency are concentrated in construction, much of the workforce consists of carpenters, electricians, plumbers, HVAC mechanics, construction supervisors or managers, and construction laborers. Of these occupations, only construction managers typically possess a degree and HVAC mechanics require a postsecondary nondegree award; however, the remaining occupations typically require only a high school diploma.

Figure 8.
Energy Efficiency Jobs by Industry Segment, 2019

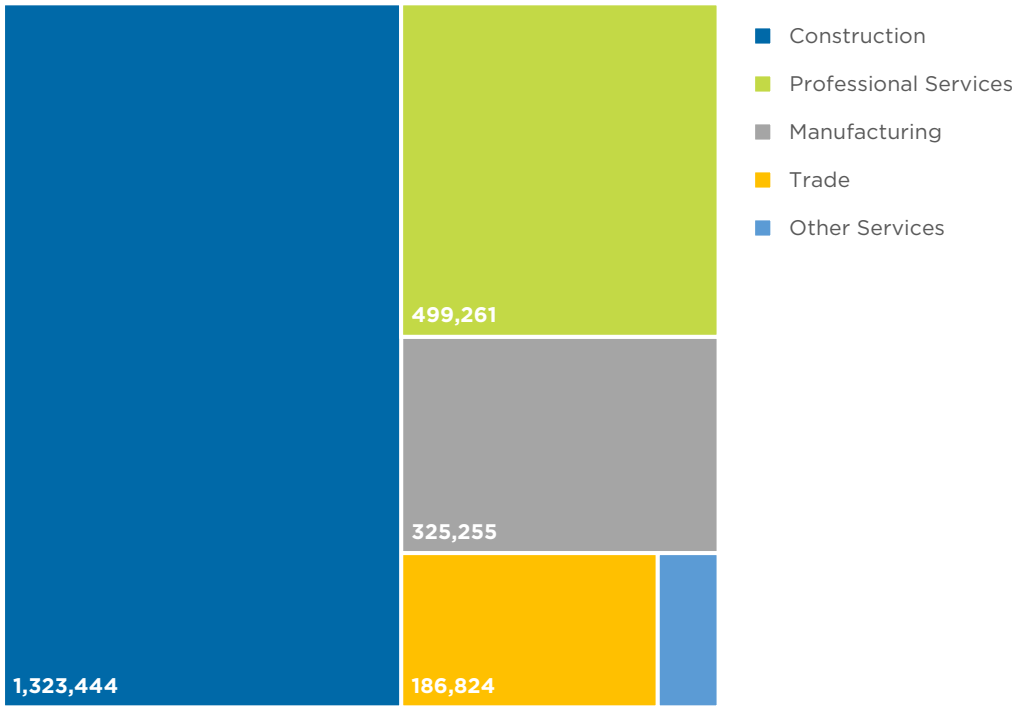


Table 9.
Energy Efficiency Wages by Industry Segment, 2019[41]

Industry	Median Hourly Wage (Energy Efficiency Workers)	Median Hourly Wage (Nationally)	Premium or Discount
Construction	$25.10	$23.57	6.5%
Manufacturing	$21.78	$20.46	6.5%
Wholesale Trade	$16.47	$15.47	6.5%
Professional Services	$27.62	$25.95	6.4%
Other Services (incl. Repair and Maintenance)	$17.39	$16.33	6.5%
Overall	**$24.44**	**$19.14**	**27.7%**

[41] Industry segments with the same premium are a result of low sample size. In order to produce an estimate for these wages, the research team relied on technology-specific premiums applied across each industry segment.

Hydropower

The hydropower industry includes all jobs that directly and indirectly support electricity production through low-impact and traditional hydropower. This includes manufacturing jobs and wholesale sales representatives that develop and sell technologies and components for hydroelectric dams; utility workers; construction and maintenance workers that support hydropower; and those engaged in financial, legal, or other business support for these companies. Between 2015 and 2019, hydropower firms created roughly 2,200 new jobs, for a growth rate of over three percent in four years.

Unlike the other crosscuts, hydropower has a fairly even spread of jobs across manufacturing, utilities, professional services, and construction. Manufacturing and utilities each account for 26 percent of total hydropower employment, followed by professional services at 19 percent and construction at 16 percent (Figure 9). The median hourly wage for the hydropower industry is $26.97—41 percent above national wages. Of all utility jobs across each industry crosscut, hydropower utility workers have the lowest median wage of $36.40 which is three percent below the national median hourly wage (Table 10). Many of the jobs found in the utilities sector of the hydropower industry require only a high school diploma or equivalent upon entry; these include power plant operators, electrical power-line installers, industrial machinery mechanics, or supervisors. Engineers, managers, and computer systems analysts all require degrees.

Figure 9.
Hydropower Jobs by Industry Segment, 2019

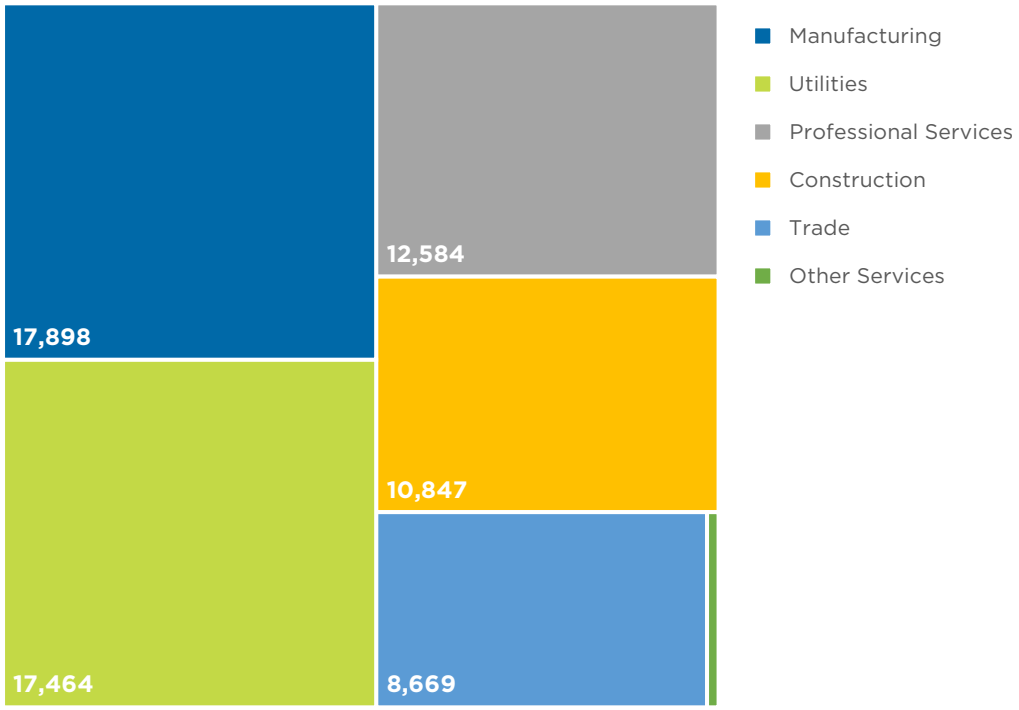


Table 10.
Hydropower Wages by Industry Segment, 2019[42]

Industry	Median Hourly Wage (Hydropower Workers)	Median Hourly Wage (Nationally)	Premium or Discount
Utilities	$36.40	$37.50	-2.9%
Construction	$25.84	$23.57	9.6%
Manufacturing	$22.43	$20.46	9.6%
Wholesale Trade	$16.96	$15.47	9.6%
Professional Services	$28.45	$25.95	9.6%
Other Services (incl. Repair and Maintenance)	$17.90	$16.33	9.6%
Overall	**$26.97**	**$19.14**	**40.9%**

[42] Industry segments with the same premium are a result of low sample size. In order to produce an estimate for these wages, the research team relied on technology-specific premiums applied across each industry segment.

Natural Gas

The natural gas industry includes all jobs supporting the natural gas and advanced natural gas production and electricity generation in the U.S., including utility employees at natural gas power plants; construction workers building new natural gas power plants; workers engaged in the extraction and production of natural gas fuels; individuals engaged in the wholesale trade and distribution of natural gas fuels as well as natural gas fuels storage; and those engaged in financial, legal, or other business support for these companies. Between 2016 and 2019, the natural gas industry grew by almost five percent, creating just over 28,300 new jobs in four years.

Similar to coal, natural gas employment is heavily concentrated in utilities and mining; together these two industry segments account for 55 percent of natural gas employment. The natural gas industry also has significant employment in the construction industry, which represents 17 percent of total natural gas jobs (Figure 10). Natural gas workers earn $30.33 per hour—58 percent above the national median. Natural gas workers in the mining industry earn a 48 percent premium over the average worker in mining and extraction trades. Overall, utility employees receive the highest median hourly wages, at $41.03 per hour (Table 11). The occupational staffing pattern for the natural gas industry is similar to coal, with many construction- and mining-related positions that do not require more than a high school diploma.

Figure 10.
Natural Gas Jobs by Industry Segment, 2019

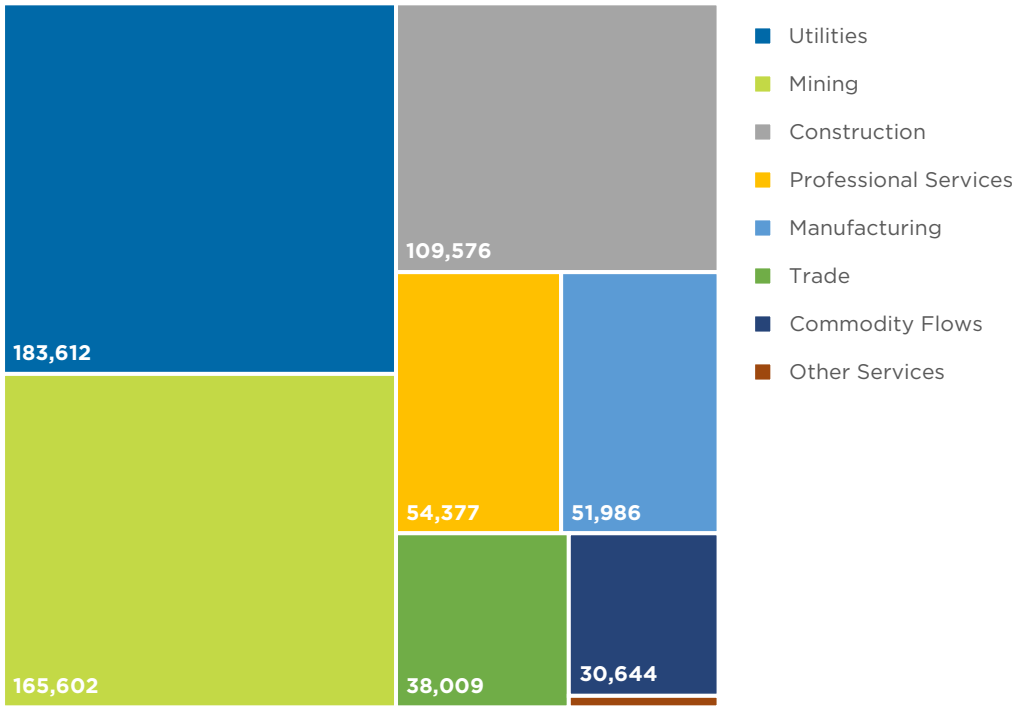


Table 11.
Natural Gas Wages by Industry Segment, 2019

Industry	Median Hourly Wage (Natural Gas Workers)	Median Hourly Wage (Nationally)	Premium or Discount
Mining	$37.67	$25.44	48.1%
Utilities	$41.03	$37.50	9.4%
Construction	$27.56	$23.57	16.9%
Manufacturing	$22.54	$20.46	10.2%
Wholesale Trade	$17.07	$15.47	10.3%
Transportation (commodity flows)	$35.89	$34.31	4.6%
Professional Services	$28.17	$25.95	8.6%
Other Services (incl. Repair and Maintenance)	$18.28	$16.33	11.9%
Overall	**$30.33**	**$19.14**	**58.4%**

Nuclear

The nuclear industry includes all jobs associated with nuclear electric power generation and the production and distribution of nuclear fuels. This includes utility employees; construction and maintenance workers; mining, manufacturing, and production; and those engaged in financial, legal, or other business support for these companies. Between 2016 and 2019, the nuclear industry saw jobs decline by just over eight percent, or roughly 6,500 jobs.

Nuclear jobs are largely concentrated in the utilities industry; 63 percent of all nuclear jobs are found in utilities, with professional services accounting for 21 percent of nuclear employment (Figure 11). The nuclear industry has median hourly wages of $39.19, which is almost 105 percent higher the national median of $19.14. Again, individuals working in utilities receive the highest median hourly wage at $47 per hour, or 25 percent above the average utility worker in the United States (Table 12). Within the nuclear utilities industry, nuclear and electrical engineers require a Bachelor's degree. However, many of the other jobs including power reactor operators, technicians, supervisors, and mechanics require no more than a high school diploma.

Figure 11.
Nuclear Jobs by Industry Segment, 2019

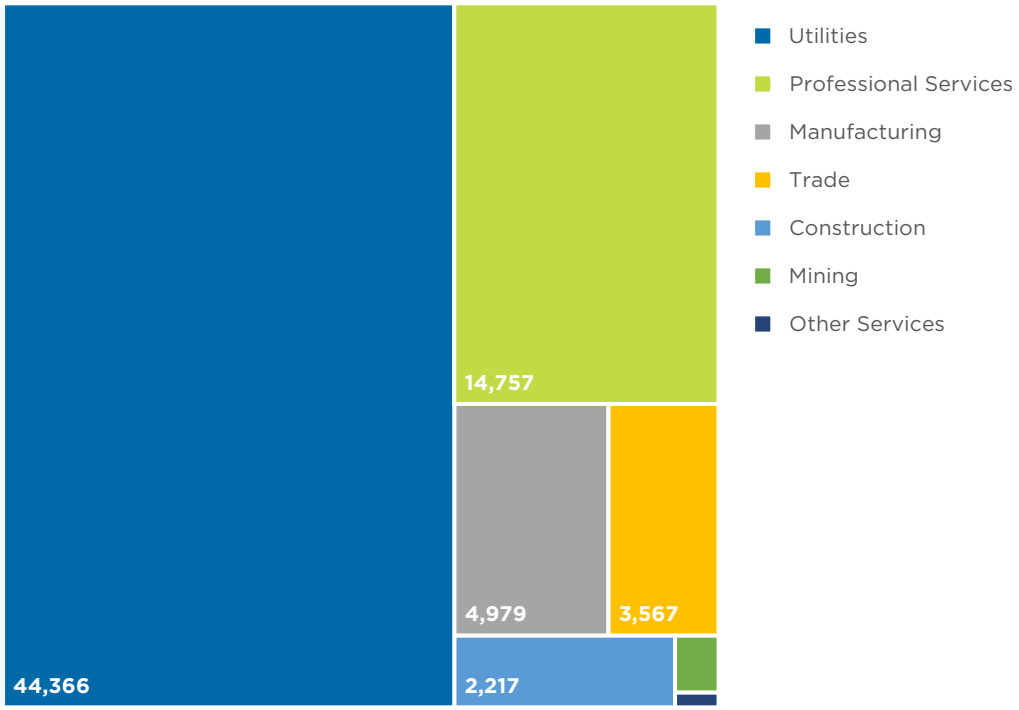


Table 12.
Nuclear Wages by Industry Segment, 2019

Industry	Median Hourly Wage (Nuclear Workers)	Median Hourly Wage (Nationally)	Premium or Discount
Mining	$30.86	$25.44	21.3%
Utilities	$47.00	$37.50	25.3%
Construction	$26.41	$23.57	12.0%
Manufacturing	$22.62	$20.46	10.6%
Wholesale Trade	$17.24	$15.47	11.4%
Professional Services	$28.86	$25.95	11.2%
Other Services (incl. Repair and Maintenance)	$18.30	$16.33	12.1%
Overall	**$39.19**	**$19.14**	**104.8%**

Petroleum

The petroleum industry includes all individuals that support the extraction, production, distribution, and electricity generation from petroleum fuels. This includes all workers in the oil mining, extraction, and production industries; workers involved in the transportation of petroleum fuels; construction workers that support the building or maintenance of power plants; and those engaged in financial, legal, or other business support for these companies. Between 2016 and 2019, the petroleum industry grew by 23 percent, resulting in an additional nearly 156,800 new jobs in the energy workforce over those four years.

The petroleum industry[43] consists mostly of mining and manufacturing jobs. Mining and extraction workers account for 37 percent of petroleum industry employment, followed by manufacturing at 19 percent (Figure 12). The overall median wage for petroleum industry jobs sits at $26.59, or 39 percent above national wages. Petroleum mining and extraction workers earn 48 percent above the average mining and extraction employee in the U.S., but utility employees are the highest paid in the industry (Table 13). Similar to coal and natural gas, many of the mining and production jobs in the petroleum industry have typical entry level education requirements that range from no formal credential to a postsecondary nondegree award.

[43] The petroleum industry crosscut in this report includes "other fossil fuels". As such, not all industry segment employment totals in Figure 12 below will not match those described in Table 37 of the 2020 USEER due to the slight difference in sub-technology definition.

Figure 12.
Petroleum Jobs by Industry Segment, 2019

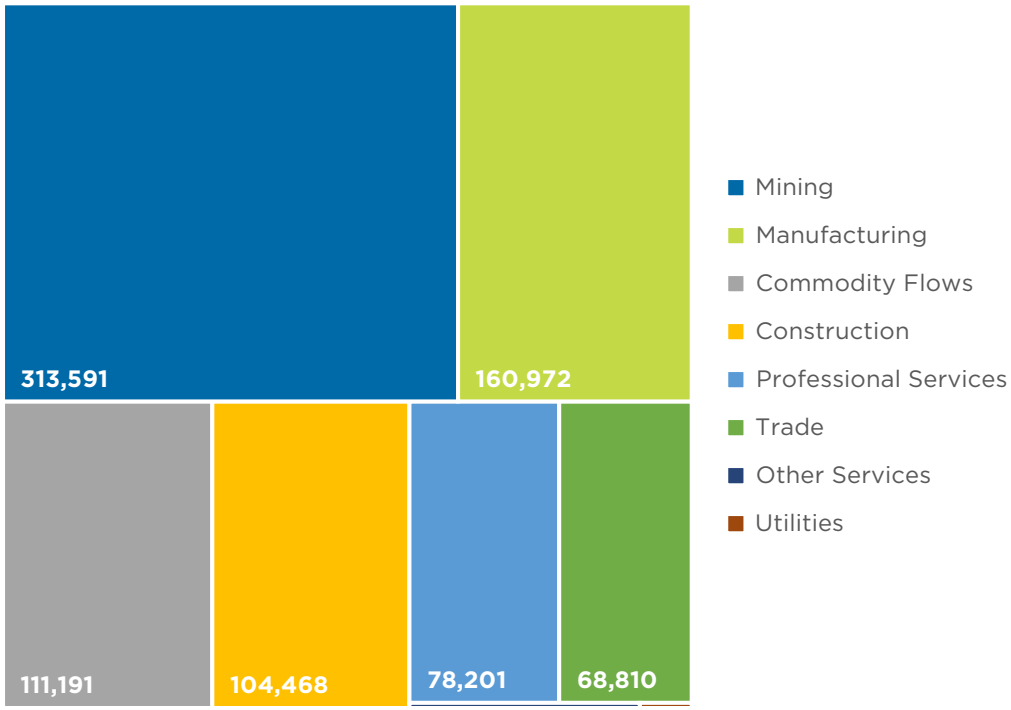


Table 13.
Petroleum Wages by Industry Segment, 2019[44]

Industry	Median Hourly Wage (Oil Workers)	Median Hourly Wage (Nationally)	Premium or Discount
Mining	$37.67	$25.44	48.1%
Utilities	$41.30	$37.50	10.1%
Construction	$27.44	$23.57	16.4%
Manufacturing	$22.47	$20.46	9.8%
Wholesale Trade	$16.99	$15.47	9.8%
Transportation (commodity flows)	$39.34	$34.31	14.7%
Professional Services	$28.50	$25.95	9.8%
Other Services (incl. Repair and Maintenance)	$17.94	$16.33	9.9%
Overall	**$26.59**	**$19.14**	**38.9%**

[44] Industry segments with the same premium are a result of low sample size. In order to produce an estimate for these wages, the research team relied on technology-specific premiums applied across each industry segment.

Solar

The solar industry consists mostly of construction workers like electricians and solar photovoltaic installers that are engaged in the building of residential, commercial, and utility-scale solar photovoltaic or concentrated solar power projects; manufacturers of solar panels and component parts; wholesale trade representatives involved in the sales and distribution of solar products; and those engaged in financial, legal, or other business support for these companies. Between 2016 and 2019, the solar industry shed jobs at a rate of almost eight percent—a loss of just over 28,400 workers. However, since then the solar industry has rebounded between 2018 and 2019.

The majority of solar jobs are found in construction. Just over half—53 percent—of solar workers are in the construction industry, followed by professional services at 14 percent and manufacturing at 13 percent (Figure 13). The median hourly wage for solar workers is $24.48, or 28 percent above the national median (Table 14). Because many jobs are found in the construction industry, educational requirements for the solar industry are likely similar to those found in energy efficiency described above. Construction and installation occupations like solar photovoltaic installers, electricians, and construction laborers typically require a high school diploma at entry.

Figure 13.
Solar Jobs by Industry Segment, 2019

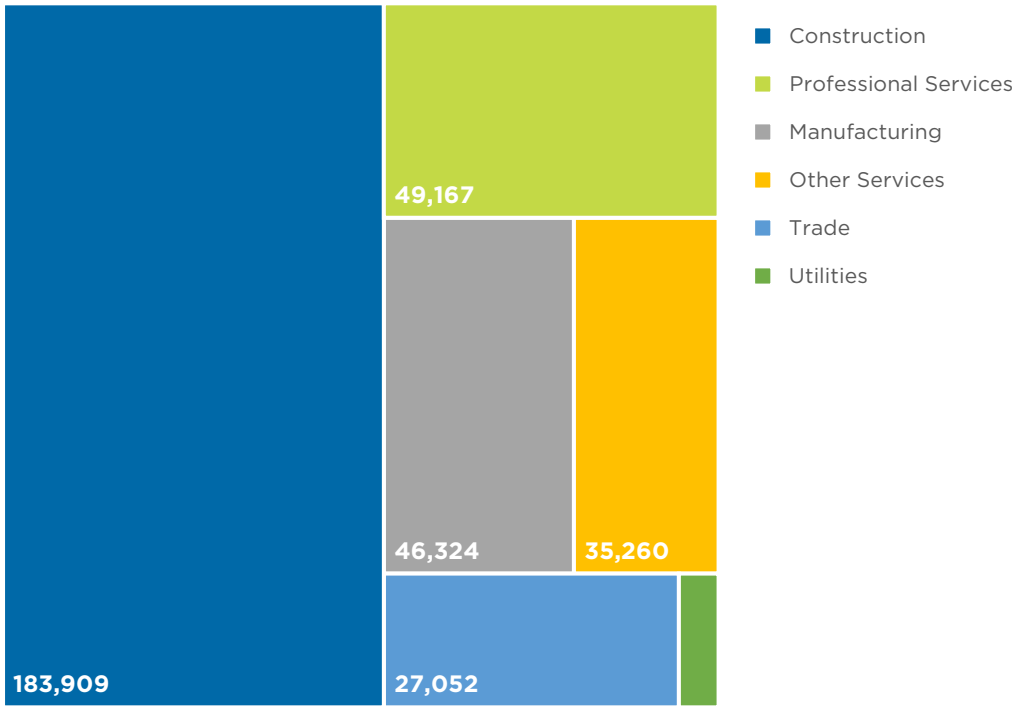


Table 14.
Solar Wages by Industry Segment, 2019[45]

Industry	Median Hourly Wage (Solar Workers)	Median Hourly Wage (Nationally)	Premium or Discount
Utilities	$43.17	$37.50	15.1%
Construction	$25.89	$23.57	9.8%
Manufacturing	$22.47	$20.46	9.8%
Wholesale Trade	$16.99	$15.47	9.8%
Professional Services	$28.50	$25.95	9.8%
Other Services (incl. Repair and Maintenance)	$17.94	$16.33	9.9%
Overall	**$24.48**	**$19.14**	**27.9%**

[45] Industry segments with the same premium are a result of low sample size. In order to produce an estimate for these wages, the research team relied on technology-specific premiums applied across each industry segment.

Storage (excluding fossil fuels)

The storage industry includes battery[46], mechanical, and thermal storage, but does not include storage of natural gas, petroleum, coal, nuclear, or biofuels, as these are included in their respective industry crosscuts. These jobs include construction and installation positions involved in the building or connecting energy storage units to electricity generating units and the grid; manufacturers and wholesale trade representatives of storage technologies and components; and those engaged in financial, legal, or other business support for these companies. From 2016 through 2019, the storage industry saw jobs decline by almost 11 percent—roughly 9,600 jobs.

The majority of energy storage jobs are found in construction and manufacturing. Construction employees account for 47 percent of total energy storage employment, while manufacturing workers represent 22 percent of total jobs (Figure 14). Median hourly wages are at $24.36 for the overall industry, which is 27 percent above national wages (Table 15). As with the energy efficiency and solar industries' prevalence of construction jobs, typical educational requirements for many occupations in this industry range from a high school diploma to a postsecondary nondegree credential.

[46] This includes lithium batteries, lead-based batteries, other solid-electrode batteries, vanadium redox flow batteries, and other flow batteries.

Figure 14.
Storage Jobs by Industry Segment, 2019

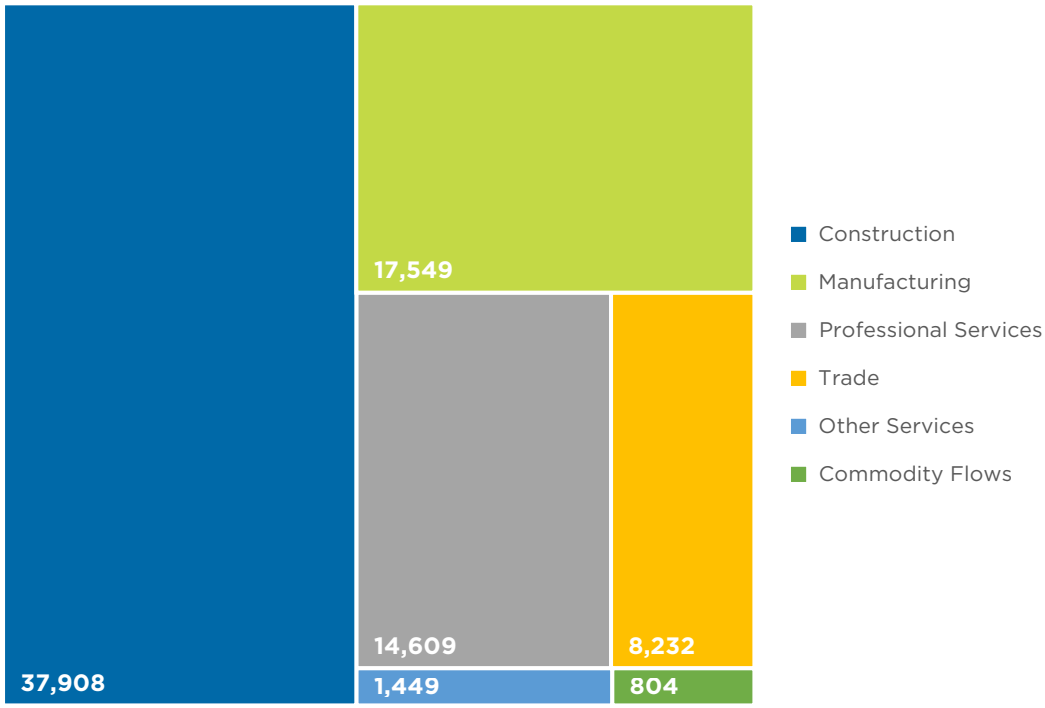


Table 15.
Storage Wages by Industry Segment, 2019[47]

Industry	Median Hourly Wage (Storage Workers)	Median Hourly Wage (Nationally)	Premium or Discount
Construction	$25.53	$23.57	8.3%
Manufacturing	$22.16	$20.46	8.3%
Wholesale Trade	$16.76	$15.47	8.3%
Transportation (commodity flows)	$41.22	$34.31	20.1%
Professional Services	$28.10	$25.95	8.3%
Other Services (incl. Repair and Maintenance)	$17.69	$16.33	8.3%
Overall	**$24.36**	**$19.14**	**27.3%**

[47] Industry segments with the same premium are a result of low sample size. In order to produce an estimate for these wages, the research team relied on technology-specific premiums applied across each industry segment.

Wind

The wind industry includes mostly construction and installation jobs such as wind turbine service technicians involved in the development of new wind turbine projects; manufacturers and wholesale trade representatives of wind turbines and component parts; and those engaged in financial, legal, or other business support for these companies. From 2016 through 2019, the wind industry saw jobs grow by almost 13 percent—an additional 13,000 workers in the energy labor market.

Wind industry jobs are mainly found across construction, professional services, and manufacturing. Construction workers account for about a third of total jobs, while professional service workers in the wind industry represent a quarter of total employment (Figure 15). Median hourly wages for the wind industry sit at $25.95—about 36 percent higher than the national median (Table 16). Wind turbine service technicians typically require a postsecondary nondegree award, and many of the other construction-related positions in this industry require a high school diploma or equivalent. Engineers, management analysts, and general and operations managers in the wind industry do typically require a Bachelor's degree.

Figure 15.
Wind Jobs by Industry Segment, 2019

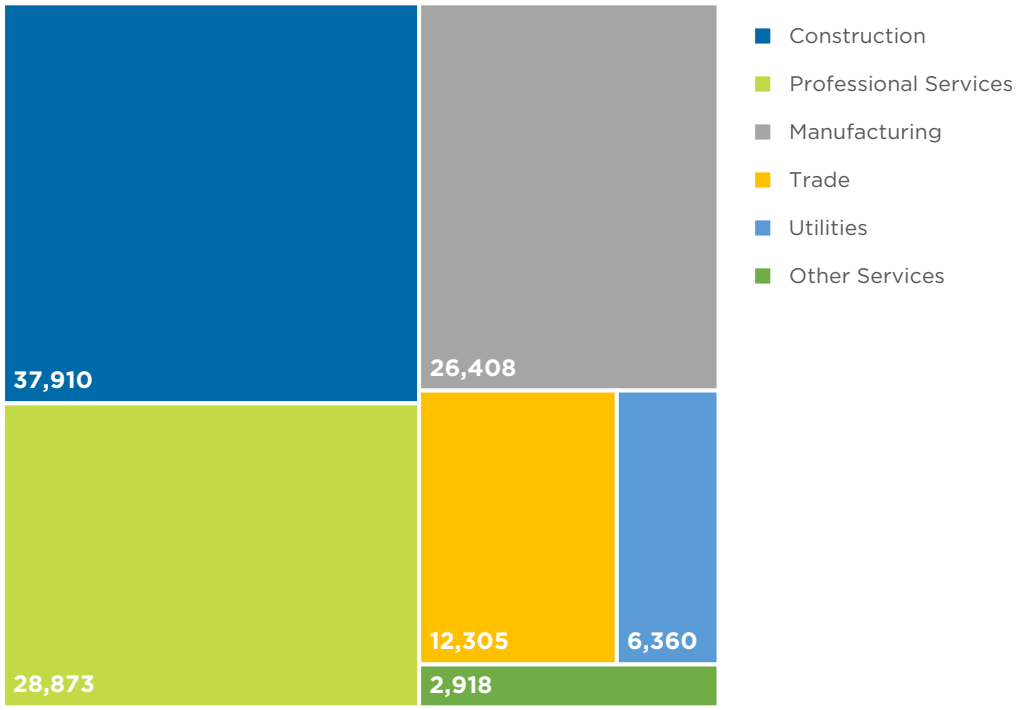


Table 16.
Wind Wages by Industry Segment, 2019[48]

Industry	Median Hourly Wage (Wind Workers)	Median Hourly Wage (Nationally)	Premium or Discount
Utilities	$39.23	$37.50	4.6%
Construction	$26.56	$23.57	12.7%
Manufacturing	$23.06	$20.46	12.7%
Wholesale Trade	$17.44	$15.47	12.7%
Professional Services	$29.24	$25.95	12.7%
Other Services (incl. Repair and Maintenance)	$18.40	$16.33	12.7%
Overall	**$25.95**	**$19.14**	**35.6%**

[48] Industry segments with the same premium are a result of low sample size. In order to produce an estimate for these wages, the research team relied on technology-specific premiums applied across each industry segment.

Chapter 5
Energy Technology Sectors

Electric Power Generation

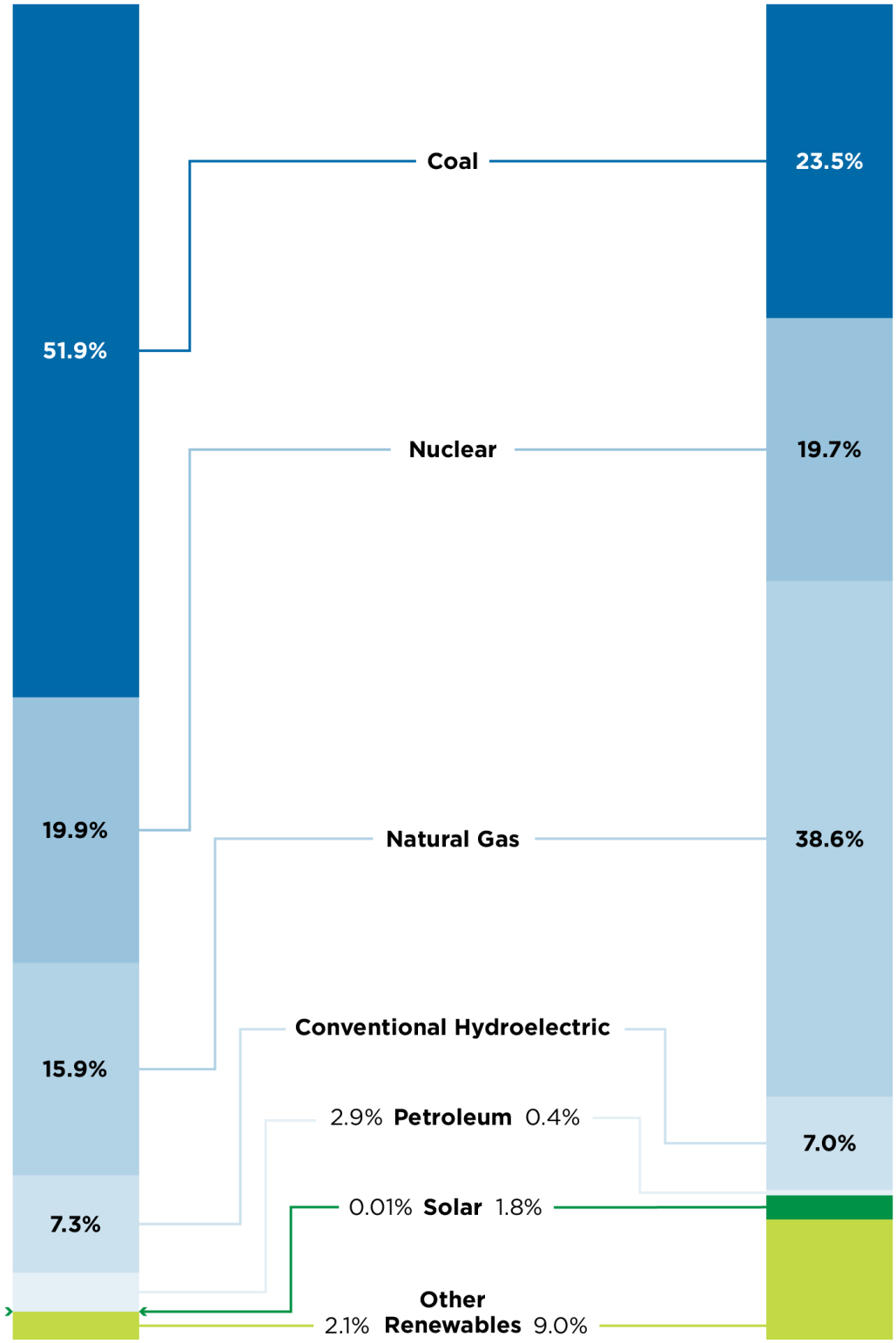
Trends Impacting the Electric Power Generation Sector

In the first two decades of the 21st century, the U.S. electric power generation (EPG) sector shifted dramatically from relying on coal as the primary fuel for electricity to a more diverse portfolio. Figure 16 highlights how coal accounted for 52 percent of the national electricity generation mix in 2000, followed by nuclear at 20 percent and natural gas at 16 percent; renewables and solar accounted for less than three percent. By 2019, natural gas generation produced 39 percent of the nation's electricity, followed by coal at 24 percent and nuclear at just under 20 percent (Figure 17).

Since 2000, renewable generation, including hydropower, solar, wind, biomass, and geothermal energy rose from just over nine percent to almost 18 percent in 2019. Wind is now the largest source of renewable electricity.[xlvii]

Figure 16. Electricity Generation Mix, 2000

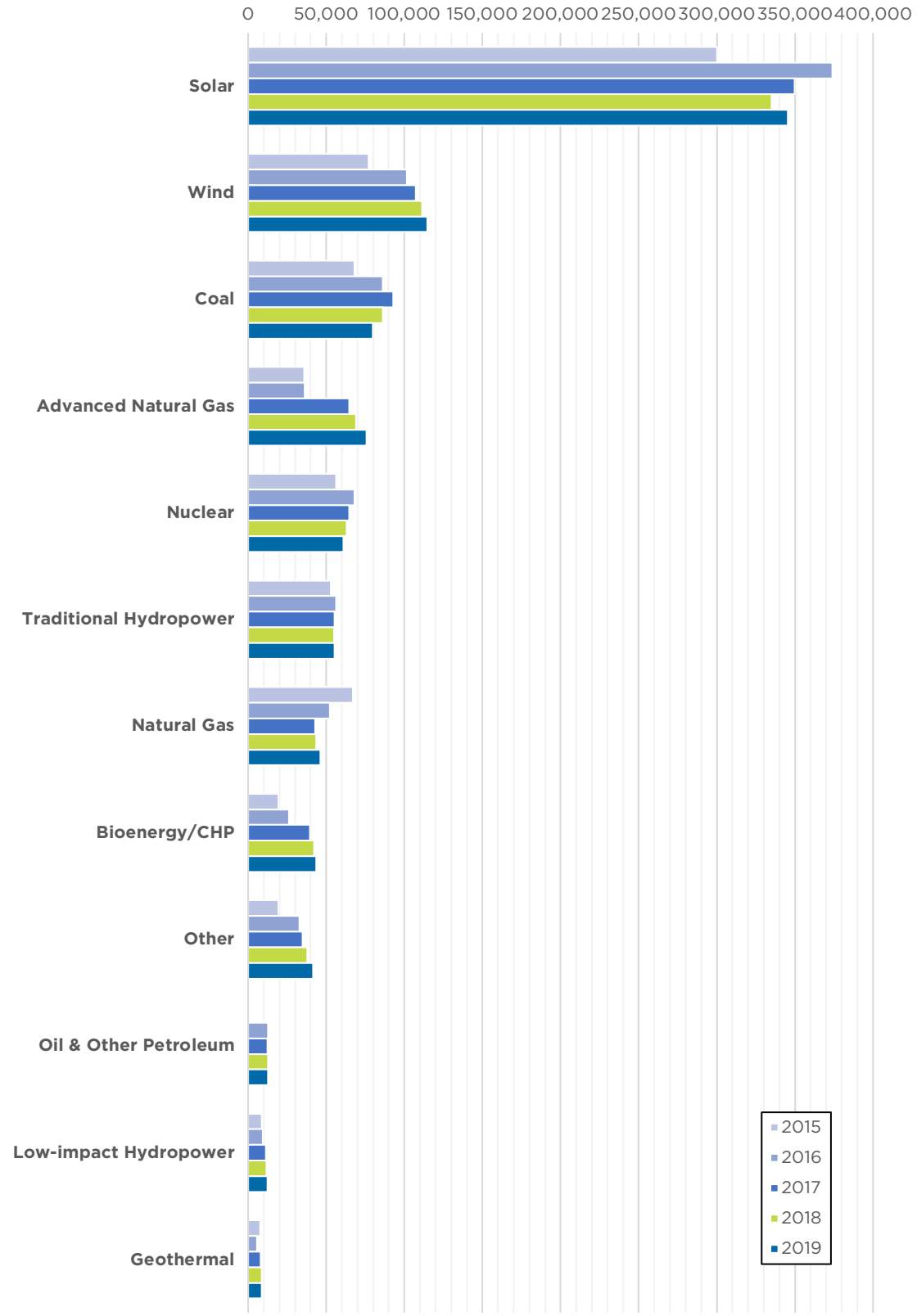
Figure 17. Electricity Generation Mix, 2019



At the end of 2019, the EPG sector employed 896,830 workers, a net increase of almost 26 percent—or about 183,400 new jobs—since 2015. This growth largely reflects the build out of generation capacity in natural gas and renewables. Most recently, sharp declines in employment have taken place in both coal and nuclear generation. From 2016 through 2019, coal generation lost over 6,300 jobs, while nuclear generation lost almost 7,300 jobs—an almost 11 percent decline.

Solar employment, which expanded rapidly at the beginning of the decade, added over 73,600 jobs between 2015 and 2016 before seeing declines from 2016 through 2018. The solar workforce rebounded by roughly 10,400 jobs from 2018 through 2019. Figure 18 shows the fluctuations in employment by generation sub-technology between 2015 and 2019. Despite year-over-year variations in many technologies, the overall trends remain clear.

Figure 18.
EPG Employment by Sub-technology, 2015-2019



Coal & Nuclear Generation

The job losses in coal and nuclear generation are not surprising, as both sub-sectors have seen the decommissioning or retirement of power plants over the last decade. Between 2010 and the beginning of 2019, more than 546 coal-fired power units—roughly 102 gigawatts (GW)—were retired, and plant owners project to retire another 17 GW by the end of 2025.[xlviii] Similarly, since 2013, six commercial nuclear reactors have closed down with another eight planned closures by 2025.[xlix]

As would be expected given these closures, the primary occupations employed within utilities—which is the largest industry sector for both nuclear (73 percent) and coal generation (48 percent)—are also seeing job losses. The number of nuclear engineers, nuclear power reactor operators, and nuclear technicians employed within the nuclear electric power generation sector[49] in the U.S. has declined by a rate of roughly 17 to 26 percent between 2016 and 2019. In total, employment of these occupations in nuclear electric power generation declined by almost 3,600 workers.[l]

Natural Gas Generation

With the low cost of natural gas extraction, its relatively low capital costs for new generation, and the capacity to balance variable renewable power, natural gas usage has expanded rapidly, becoming the number one generation source in 2016.[li] In 2019 alone, natural gas generation added almost 7,500 employees in its utility sector for a total of 66,500 jobs. Over the same time, natural gas generation created about 500 new construction jobs resulting in 20,200 total workers.

However, natural gas facilities do not require the same number of operations jobs as coal-fired power plants. For example, an 1,100 megawatt (MW) natural gas power plant built by DTE Energy in Michigan will replace three coal-fired units that currently employ 500 people. The new plant will employ only 35 people when it opens in 2022.[lii]

Due to emissions standards, low natural gas prices, and the efficiency of new natural gas turbine technology, these coal to natural gas conversions are occurring across the country. In 2010, there was almost 317 GW of coal-fired capacity. By the end of 2019, roughly 49 GW were retired, 14 GW had been converted to also burn natural gas, and 15 GW were completely replaced with natural gas combined cycle plants.[liii]

Solar Generation

For solar electric power generation, the employment trends are slightly more nuanced. Despite declining overall employment, total solar photovoltaic installer occupations grew by roughly 20 percent between 2016 and 2019,[liv] indicating that the overall declines in employment are less related to deployment and appear to be the result of shifting

[49] NAICS 221113 (Nuclear Electric Power Generation)

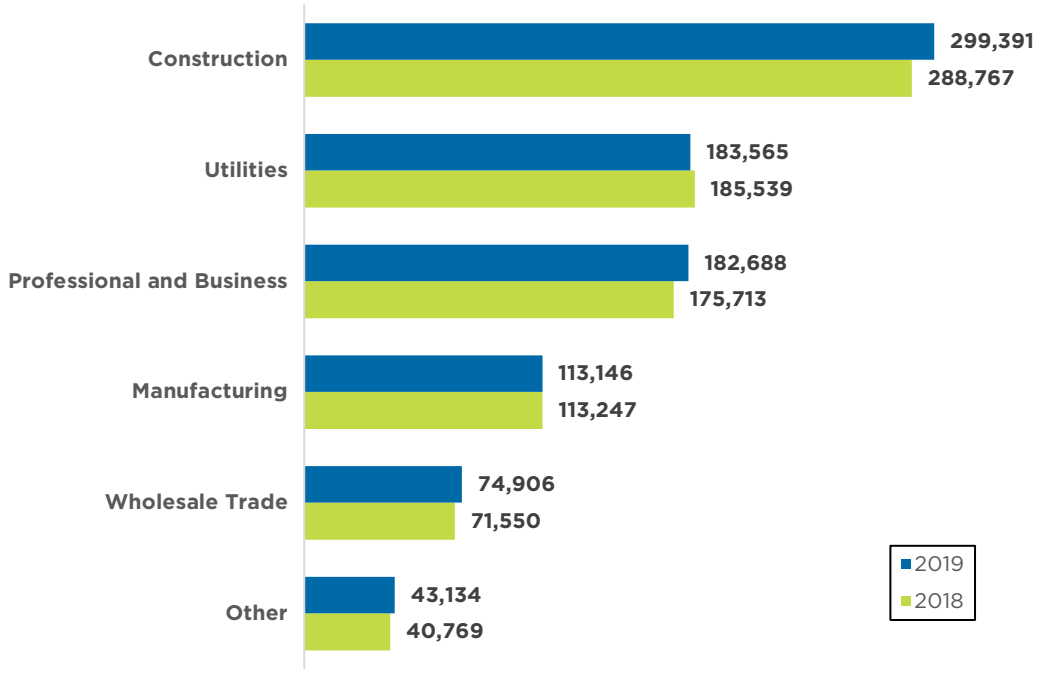
business models and the loss of door-to-door sales jobs in this sub-technology.

One of the most important trends in the solar industry is the shift to utility-scale projects. In 2019, two-thirds of installed solar capacity was for utility-scale projects and another 14 percent was for non-residential buildings such as commercial real estate. In fact, only 20 percent of installations were for the residential sector. However, just over 50 percent of employment was found in residential installations, a decline of almost five percent over the last four years. The share of utility-scale solar employment has risen by about nine percentage points to almost 30 percent between 2017 and 2019.[lv]

EPG Sector Employment & Wages

Jobs in the EPG sector are spread across six primary industrial sectors as shown in Figure 19 below, which compares changes in these sectors from 2018 through 2019. Overall, construction saw the greatest absolute growth in jobs—an increase of roughly 10,600 workers—followed by professional and business services. Utilities, by contrast, shed roughly 2,000 jobs from 2018 through 2019. While the sector only added a net 20,000 jobs in 2019, the change from one sub-technology to another and one industry sector to another was significant, as the examples in the utility sector and natural gas, nuclear, and coal sub-sectors cited above illustrate.

Figure 19.
EPG Employment by Industry, 2018-2019[50]



[50] This chart includes all solar jobs, not just majority-time employment as featured in Figure 1.

The median wage in most sub-technologies of the EPG sector is substantially higher than the overall median wage of $19.14 in the United States in 2019, but there are variations in those premiums.[51] Two specific sub-technologies that have experienced job losses in the last three years—nuclear and coal generation—pay the highest premiums of 115 percent and 80 percent, respectively. Jobs in the other renewable generation sector, which includes geothermal, hydropower, bioenergy, and combined heat and power earn roughly $18 per hour, which is about nine percent below the geographically weighted median wage (Table 17).

Table 17.
EPG Hourly Wages by Sub-technology, 2019

Energy Sub-Sector	Median Hourly Wages, 2019	Geographically Weighted Premium/Discount from Median Hourly Wages
Nuclear Generation	$ 41.32	114.6%
Coal Generation	$ 33.64	79.6%
Natural Gas Generation	$ 34.02	76.5%
Wind Generation	$ 25.95	34.9%
Oil Generation	$ 24.49	25.7%
Solar Generation	$ 24.48	20.9%
Other Renewable Generation[52]	$ 17.98	-8.6%

Table 17 highlights median hourly wages by EPG sub-technology. The wage data is weighted by both occupational composition and industry mix within each sub-technology to account for variability across supervisory and non-supervisory roles as well as differences across utilities, construction, manufacturing, trade, and professional services. The third column compares the median hourly wages for each sub-sector to the geographically weighted median. Since some sub-sectors are more highly concentrated in specific states, such as solar jobs in California, the national median wage is weighted by the state-specific sub-technology job concentration to account for the uneven employment distribution across the nation.

[51] A "premium" is defined here as the percentage *above* the comparative wage. A "discount" would indicate that the wage is *below* the comparative wage; this would be portrayed as a negative percentage as seen in "other renewable generation" in Table 19.
[52] Other renewable generation includes geothermal, low-impact and traditional hydropower, bioenergy, and combined heat and power.

Occupational Wages & Benefits

The specific occupations within some declining sub-technologies or industry sectors—highlighted in Table 18—pay premiums that are roughly double to triple the national median hourly wage of $19.14 in 2019.[lvi]

Nuclear power reactor operators, technicians, and engineers earned between $48 to $55 per hour, while power plant and gas plant operators working in the EPG sector[53] earned a respective $49.18 and $42.42 per hour. Wind turbine technicians earn $25.44 per hour, which is 33 percent above the national median of $19.14. Similarly, solar photovoltaic installers earn between 13 to 34 percent above the national median—roughly $22 to $26 per hour, depending on possession of an electrician's license.

Construction trade supervisors within the EPG sector earn a 71 percent premium above the national median hourly wage of $19.14 and a 41 percent premium over the weighted median hourly wage for all construction occupations, which was $23.23 in 2019.[54]

In fact, when comparing these jobs to the national weighted median for all construction occupations, as opposed to the overall national median, plumbers and carpenters within EPG earn a premium of roughly 25 and 15 percent, respectively.

[53] Some power plant or gas plant operators may also be found working in the TDS energy sector. The wages discussed here are for those plant operators that work in the EPG sector.
[54] The median hourly wage for Construction and Extraction Occupations was $22.80 according to the Bureau of Labor Statistics, Occupational Employment Statistics (May 2019). When weighted according to the number of jobs in each specific occupation code, the weighted median comes out to $23.23.

Table 18.
EPG Occupations, 2019 Median Hourly Wages

	2019 National Median Hourly Wages[55]	EPG Wage Premium or Discount Compared to National Median[56]	Employment Trends, 2016-2019
Nuclear Engineers	$ 54.55	185%	↓
Power Plant Operators[57]	$ 49.18	157%	↓
Nuclear Power Reactor Operators	$ 48.33	153%	↓
Gas Plant Operators	$ 42.42	122%	↓
Nuclear Technicians	$ 39.46	106%	↓
First-Line Supervisors of Construction Trades and Extraction Workers	$ 32.68	71%	↑
Plumbers, Pipefitters, and Steamfitters	$ 28.96	51%	↑
Wind Turbine Service Technicians	$ 25.44	33%	↑
Carpenters	$ 25.38	33%	↑
Solar Photovoltaic Installers (Non-Electrician)	$ 21.58	13%	↑
Solar Photovoltaic Installers (Electrician)[58]	$ 25.69	34%	↑
Construction Laborers	$ 19.35	1%	↑

Table 18 depicts the median hourly wages for the typical occupations employed within EPG. The rows highlighted in orange indicate occupations that are in decline while those highlighted in green indicate occupations that are growing.

[55] The median hourly wages for all occupations, with the exception of Power Plant Operators, Gas Plant Operators, Construction Laborers, Carpenters, Plumbers, Pipefitters, and Steamfitters, Solar Photovoltaic Installers (Electrician), and First-Line Supervisors of Construction Trades and Extraction Workers, are from the Bureau of Labor Statistics (BLS), Occupational Employment Statistics (May 2019). Unlike other energy sectors like energy efficiency or motor vehicles, which house non-energy specific occupations, many jobs within EPG, including solar photovoltaic installers or wind turbine technicians, are entirely energy-specific. Because of this, energy-specific wage data does not need to be extrapolated and can be pulled directly from BLS. For construction-related occupations and gas and power plant operators that may be found across other energy sectors, these wages are extrapolated and specific to construction workers and plant operators within EPG, not the overall median wages for the entire occupational group.
[56] The national occupational median hourly wage in 2019 was $19.14 according to the Bureau of Labor Statistics, Occupational Employment Statistics (May 2019).
[57] Although the natural gas generation utility sector is growing, new plants are more efficient and automated, requiring fewer employees. This may be contributing to the decline in gas plant operators, specifically, despite an overall growth in the sector's jobs.
[58] These are solar photovoltaic installers who are licensed electricians. Not all solar photovoltaic installers are required to have an electrician's license, as licensing requirements vary by state.

Between 65 to 94 percent of energy employers for these occupations contribute to a retirement plan, and 77 to 98 provide full or partial healthcare coverage (Table 19).

Table 19.
Healthcare and Retirement Benefits by Occupation, 2019[59]

	Healthcare Benefits			Retirement	
	Full coverage	Partial coverage	No coverage	Firm contribution	No firm contribution
Power Plant Operators	33.5%	64.7%	1.9%	91.4%	8.6%
Gas Plant Operators	34.6%	63.6%	1.9%	92.6%	7.4%
Nuclear Power Reactor Operators	29.5%	69.0%	1.5%	94.0%	6.0%
Nuclear Technicians	36.4%	54.3%	9.3%	83.3%	16.7%
Nuclear Engineers	35.1%	59.2%	5.6%	88.9%	11.1%
Wind Turbine Service Technicians	31.7%	51.2%	17.1%	75.4%	24.6%
Solar Photovoltaic Installers	24.1%	54.8%	21.1%	65.3%	34.7%
Construction Laborers	25.4%	53.8%	20.8%	71.3%	28.7%
Plumbers, Pipefitters, and Steamfitters	28.4%	49.9%	21.7%	73.5%	26.5%
Carpenters	24.4%	53.9%	21.7%	75.2%	24.8%
First-Line Supervisors of Construction Trades and Extraction Workers	39.9%	44.9%	15.2%	84.2%	15.8%

Table 19 provides an overview of healthcare and retirement benefits by occupation. Healthcare benefits are broken out into three categories indicating whether a firm pays all healthcare insurance costs for an employee, some but not all costs, or makes no contributions to an employee's healthcare insurance costs. Retirement contributions may be made to a 401k, pension, or IRA; firms either contribute to some type of retirement plan or do not make any contributions at all.

[59] Specific employment benefits survey data was not gathered for "nuclear power reactor operators", "nuclear technician", and "nuclear engineers". Instead, benefits data reported for these occupations are derived from broader occupations surveyed within the nuclear electric power generation. The proxy occupations include: "power plant operators", "drafters, engineering technicians, and mapping technicians," and "engineers".

Geographic Variability

As discussed in other sections of this report, the U.S. energy system is beginning to rely more heavily on natural gas and renewable electricity generation, with declining coal production and consumption. These disparities in the energy transition become especially clear when comparing resource use changes in specific states across the nation. Ohio, home to the largest number of employees working in coal generation at the end of 2019, also lost the largest number of workers in this sector from 2016 through 2019. In three years, the state shed 25 percent of its coal generation workforce—just over 4,000 workers (Table 20). At the same time, the state's natural gas generation sector only grew by 28 percent, or 690 workers (Table 21). Other states with major job losses in coal electric power generation featured in Table 20 include Arizona (1,373 jobs lost), Colorado (889 jobs lost), and South Carolina (814 jobs lost).

The top five states that accounted for about four in ten (43 percent) new natural gas generation jobs between 2016 and 2019 are California, Texas, Florida, New York, and Massachusetts. This is not surprising given that 38 percent of the nation's natural gas-fired generation capacity is located in four of those five states—Texas, California, Florida, and New York.[lvii]

Table 20.
Top 10 States with Job Losses in Coal Electric Power Generation

State	Total Jobs, 2019	Total Job Losses, 2016-2019	% Job Loss, 2016-2019
Ohio	12,297	(4,078)	-25%
Arizona	4,687	(1,373)	-23%
Colorado	2,922	(889)	-23%
South Carolina	3,092	(814)	-21%
Kansas	2,379	(691)	-23%
Indiana	3,277	(687)	-17%
Missouri	2,321	(535)	-19%
West Virginia	2,035	(481)	-19%
Wisconsin	2,219	(473)	-18%
Kentucky	1,790	(471)	-21%

Table 21.
Top 10 States with Job Growth in Natural Gas Electric Power Generation

State	Total Jobs, 2019	Total Job Growth, 2016-2019	% Job Growth, 2016-2019
California	20,525	3,565	21%
Texas	7,876	2,966	60%
Florida	14,958	2,697	22%
New York	5,371	1,305	32%
Massachusetts	4,711	991	27%
Illinois	4,613	886	24%
Pennsylvania	2,966	884	42%
Michigan	3,591	845	31%
Arizona	4,446	798	22%
Ohio	3,168	690	28%

Demographics

Table 22 provides overall demographics for select EPG sub-technologies that are experiencing the greatest job losses or growth. In terms of ethnic and racial minority representation, natural gas and wind generation tend to have a higher proportion of Hispanic or Latinx workers compared to nuclear and coal generation, but a lower proportion of Black or African American workers (Table 22). This indicates that the EPG sector is becoming more diverse in terms of Hispanic or Latinx representation but less diverse in terms of Black or African American representation.

Natural gas generation also has a higher proportion of women in the workforce compared to the overall EPG sector average, but in general women are significantly underrepresented across all sub-technologies in the EPG sector compared to national workforce demographics.

Table 22.
EPG Demographics by Sub-technology, 2019

	Solar Generation	Nuclear Generation	Coal Generation	Natural Gas Generation	Wind Generation	National Workforce Demographics[lviii]	EPG Overall
Male	70%	64%	66%	64%	69%	**53%**	**68%**
Female	30%	36%	34%	36%	31%	**47%**	**32%**
Hispanic or Latinx	20%	15%	14%	18%	20%	**18%**	**18%**
Not Hispanic or Latinx	80%	85%	86%	82%	80%	**82%**	**82%**
American Indian or Alaska Native	1%	1%	1%	1%	1%	**1%**	**1%**
Asian	9%	10%	10%	10%	10%	**6%**	**10%**
Black or African American	8%	12%	11%	10%	8%	**12%**	**9%**
Native Hawaiian or other Pacific Islander	1%	1%	1%	1%	1%	**1%**	**1%**
White	71%	66%	70%	64%	69%	**78%**	**69%**
Two or more races	9%	10%	7%	14%	11%	**2%**	**10%**
Veterans	9%	6%	7%	8%	9%	**6%**	**9%**
55 and over	11%	14%	17%	15%	15%	**23%**	**14%**

Fuels

Trends Impacting the Fuels Sector

Technological advancements are changing domestic fuel production. Hydraulic fracturing and horizontal drilling in addition to overall improved productivity have increased domestic oil and gas production. Advances in renewable fuel technologies are expanding a market around fuel resources such as corn ethanol and woody and non-woody biomass. In 2019, the fuels sector accounted for more than 1.1 million jobs, with the creation of 46,000 new jobs between 2015 and 2019.

Petroleum & Natural Gas Fuels

Petroleum and natural gas account for the largest source of employment within the fuels sector. Since 2015, these two sub-technologies have created a net 72,100 jobs—a growth rate of almost nine percent in four years (Figure 20). This job growth comes alongside marked increases in domestic production of both fuel sources. Over the last two decades, domestic crude oil production rose by 85 percent while natural gas production rose by 61 percent.[lix] In 2011, the U.S. surpassed Russia as the world's largest producer of natural gas, and in 2018, the U.S. surpassed Saudi Arabia as the largest producer of petroleum.[lx]

The largest increase in employment for petroleum fuel industry sectors was in the mining and extraction industry, which saw the addition of 4,900 jobs in 2019. The construction and manufacturing industries within petroleum fuels also added a respective 2,300 and 2,700 jobs. For natural gas fuel industry sectors, mining and extraction also exhibited the greatest growth in jobs, with 2,700 new workers added in 2019.

Coal & Nuclear Fuels

Given the 37 percent decline of coal production over the last two decades, coal fuels employment has also diminished over the last several years.[lxi] In 2016, coal fuels jobs decreased by almost 17,000 workers, from a total of roughly 92,400 in 2015. Much of this decline is attributable to the closure of many coal-fired units, as discussed previously in the EPG chapter.

Despite the closure of nuclear generation units, nuclear fuel jobs have seen modest growth over recent years. This growth is largely concentrated in professional and business services and wholesale trade—likely the related to the decommissioning of plants—while the mining and extraction industry has seen continuous declines since 2016. Domestic uranium production, the precursor to nuclear fuel, has been diminishing over the last several years. The nation's uranium ore mining industry[60] is already small. In 2016, there were 516 workers in the uranium ore mining industry and between 2016 and 2019, jobs declined by 34 percent—a loss of 180 employees.[lxii]

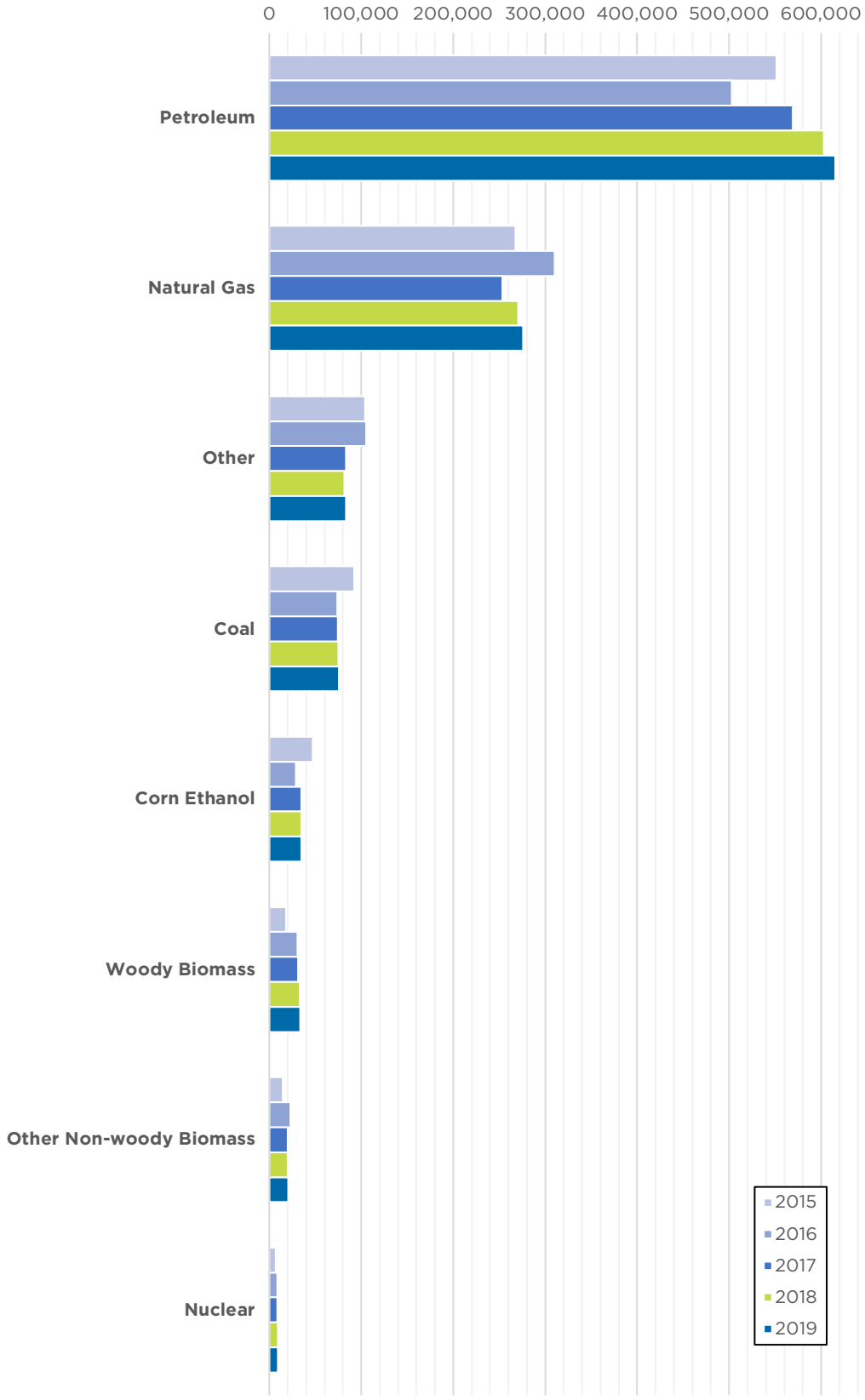
[60] NAICS 212291 (Uranium-Radium-Vanadium Ore Mining)

As domestic uranium production continues to trend towards all-time lows not seen since the 1950s, many owners and operators of remaining nuclear power plants in the U.S. are importing uranium from foreign sources.[lxiii] Declining domestic production and rising imports for nuclear fuel resources are likely to continue the downward trend of mining and extraction jobs in this sub-technology.

Renewable Fuels

A small but growing component of the nation's fuels sector, renewable fuels accounted for almost 89,000 jobs in 2019. Despite job losses in 2016, corn ethanol sub-technologies have since seen employment rebound through 2019 and hold steady at just under 35,000. Woody and non-woody biomass sub-technologies have together created 21,300 new jobs over the last four years, for a total of 54,000.

Figure 20.
Fuels Employment by Sub-technology, 2015-2019



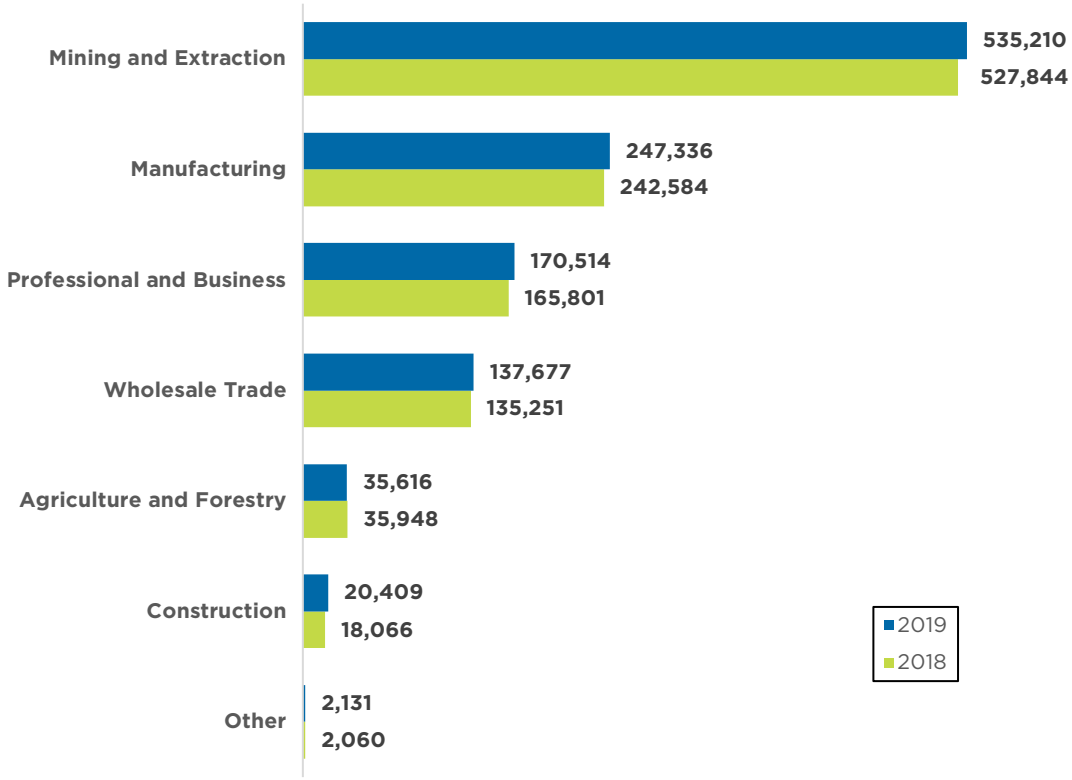
Fuels Sector Employment & Wages

Mining and extraction industries account for the largest segment of jobs within the fuels sector (Figure 21). For petroleum fuels, mining and extraction accounted for more than half of all jobs—about 313,600 at the end of 2019. The same applies for natural gas fuels, where mining and extraction workers accounted for six in ten jobs, or 165,600 workers in total. Following mining and extraction, 22 percent of fuels employment is found in the manufacturing industry.

Renewable fuels like corn ethanol and woody biomass are mostly concentrated in agriculture, manufacturing, trade, and professional services. Other non-woody biomass fuels like straw, manure, or vegetable oil had a higher concentration of profession and business services, likely because of research and development underway for this sub-technology.

Unlike EPG, the only major decline in industry sector employment was experienced in agriculture and forestry, which shed about 300 jobs in 2019, approximately 0.9 percent. Mining and extraction saw the largest absolute growth in jobs—about 7,400 more workers—while construction within the fuels sector saw the largest relative growth—13 percent or 2,300 jobs.

Figure 21.
Fuels Employment by Industry, 2018-2019



All fuels sub-technologies pay a premium over the national median wage of $19.14, though renewable fuels sub-technologies are only

slightly above this median as shown in Table 23 below. In general, coal fuels provided the highest premium over the geographically weighted median wage.

Table 23.
Fuels Hourly Wages by Sub-technology, 2019

Energy Sub-Sector	Median Hourly Wages, 2019	Geographically Weighted Premium/Discount from Median Hourly Wages
Coal Fuels	$ 25.26	37.3%
Nuclear Fuels	$ 25.44	32.0%
Natural Gas Fuels	$ 24.43	32.7%
Petroleum Fuels	$ 24.22	28.9%
Renewable Fuels[61]	$ 19.55	1.5%

Table 23 highlights median hourly wages by fuels sub-technology. The wage data is weighted by both occupational composition and industry mix within each sub-technology to account for variability across supervisory and non-supervisory roles as well as differences across utilities, construction, manufacturing, trade, and professional services. The third column compares the median hourly wages for each sub-sector to the geographically weighted median. Since some sub-sectors are more highly concentrated in specific states, the national median wage is weighted by the state-specific sub-technology job concentration to account for the uneven employment distribution across the nation.

Occupational Wages & Benefits

Many occupations are shared across both oil and gas sub-technologies, such as roustabouts,[62] service unit operators, and pump operators. Table 24 provides wages for common occupations found within the fuels sector, with declining occupations highlighted in orange and growing occupations highlighted in green.

Despite overall job growth in the petroleum fuels sub-technology, the number of petroleum pump system operators shrunk by 2,300 workers between 2016 and 2019, approximately five percent. This occupation paid 85 percent above the national median of $19.14—the highest premium compared to other fuels occupations. Other growing occupations such as continuous mining machine operators, wellhead pumpers, rotary drill operators, and others do not support premiums as high as the petroleum pump operator occupation.

While high-wage jobs with lower education requirements like petroleum pump system operators are on the decline, the number of petroleum engineers, which typically require a bachelor's degree, are rising; between 2016 and 2019, the number of petroleum engineers in the U.S. increased by 1,700 jobs, or five percent.[lxiv]

[61] Renewable fuels include corn ethanol, woody biomass, and non-woody biomass like straw, manure, vegetable oil, and animal fats.
[62] Roustabouts are manual laborers in the oil and gas drilling industries. They are tasked with a variety of jobs to keep oil and gas rigs running safely and efficiently.

Table 24.
Fuels Occupations, 2019 Median Hourly Wages

	2019 National Median Hourly Wages[63]	Fuels Wage Premium/Discount Compared to National Median[64]	Employment Trends, 2016-2019
Petroleum Pump System Operators, Refinery Operators, and Gaugers	$ 35.66	86%	↓
Pump Operators, Except Wellhead Pumpers	$ 21.65	13%	↓
Excavating and Loading Machine and Dragline Operators, Surface Mining	$ 21.54	13%	↓
Helpers—Production Workers	$ 13.99	-27%	↓
Continuous Mining Machine Operators	$ 26.58	39%	↑
Wellhead Pumpers	$ 26.46	38%	↑
Rotary Drill Operators, Oil and Gas	$ 26.43	38%	↑
Geological and Hydrologic Technicians	$ 24.58	28%	↑
Service Unit Operators, Oil and Gas	$ 22.47	17%	↑
Roustabouts, Oil and Gas	$ 18.71	-2%	↑

Table 24 depicts the median hourly wages for the typical occupations employed within fuels. The rows highlighted in orange indicate occupations that are in decline while those highlighted in green indicate occupations that are growing.

More than 90 percent of employers for many occupations within the fuels sector provide either full or partial healthcare coverage, while 80 to 90 percent of employers for these same occupations make contributions to some type of retirement plan (Table 25).

[63] The median hourly wages for all occupations are from the Bureau of Labor Statistics (BLS), Occupational Employment Statistics (May 2019). Unlike other energy sectors like energy efficiency or motor vehicles, which house non-energy specific occupations, these jobs within fuels are entirely energy-specific. Because of this, energy-specific wage data does not need to be extrapolated and can be pulled directly from BLS.
[64] The national occupational median hourly wage in 2019 was $19.14 according to the Bureau of Labor Statistics, Occupational Employment Statistics (May 2019).

Table 25.
Healthcare and Retirement Benefits by Occupation, 2019

	Healthcare Benefits			Retirement	
	Full coverage	Partial coverage	No coverage	Firm contribution	No firm contribution
Petroleum Pump System Operators, Refinery Operators, and Gaugers	29.8%	53.6%	16.5%	88.0%	12.0%
Pump Operators, Except Wellhead Pumpers	17.3%	79.3%	3.3%	84.2%	15.8%
Excavating and Loading Machine and Dragline Operators, Surface Mining	16.7%	80.0%	3.3%	86.2%	13.8%
Helpers—Production Workers	33.8%	60.6%	5.6%	83.1%	16.9%
Continuous Mining Machine Operators	37.1%	57.3%	5.6%	83.1%	16.9%
Wellhead Pumpers	17.3%	79.3%	3.3%	84.2%	15.8%
Rotary Drill Operators, Oil and Gas	38.8%	55.6%	5.6%	80.6%	19.4%
Geological and Hydrologic Technicians	37.5%	62.5%	0.0%	87.5%	12.5%
Service Unit Operators, Oil and Gas	38.8%	55.6%	5.6%	80.6%	19.4%
Roustabouts, Oil and Gas	37.8%	54.6%	7.6%	79.1%	20.9%

Table 25 provides an overview of healthcare and retirement benefits by occupation. Healthcare benefits are broken out into three categories indicating whether a firm pays all healthcare insurance costs for an employee, some but not all costs, or makes no contributions to an employee's healthcare insurance costs. Retirement contributions may be made to a 401k, pension, or IRA; firms either contribute to some type of retirement plan or do not make any contributions at all.

Geographic Variability

The shifting energy mix and trends described above for the EPG sector carry over into the fuels sector as well, since fossil fuel resources have varying concentrations across the nation. Kentucky experienced the largest losses in coal fuel jobs, shedding almost 4,400 coal fuel jobs between 2016 and 2019—a 36 percent decline in three years (Table 26). The state did not see significant growth in other sub-technologies like petroleum or natural gas fuels. In fact, natural gas fuels jobs declined by 400 jobs, and petroleum fuel jobs increased by only 640 workers.

Table 26.
Top 10 States with Job Losses in Coal Fuels

State	Total Jobs, 2019	Total Job Losses, 2016-2019	% Job Loss, 2016-2019
Kentucky	7,839	(4,396)	-36%
Illinois	3,622	(1,714)	-32%
Wyoming	5,742	(1,003)	-15%
Texas	4,798	(870)	-15%
Louisiana	857	(561)	-40%
Colorado	1,936	(334)	-15%
Pennsylvania	6,268	(260)	-4%
Ohio	1,939	(218)	-10%
Indiana	2,957	(162)	-5%
Mississippi	460	(73)	-14%

While coal fuels jobs are declining on the whole, petroleum fuels employment is growing across the nation. Texas, in particular, saw petroleum fuels employment increase by just over 39,000 jobs from 2016 through 2019; the state accounted for about four in ten (36 percent) new petroleum fuel jobs during this time. This is not surprising, given that Texas is the top producer of crude oil in the United States. However, despite growth in petroleum fuels employment, the state also saw the loss of 31,000 natural gas fuels jobs.

Additional states with significant growth in petroleum fuels include California, Louisiana, and Oklahoma—all of which saw petroleum fuels employment increased by more than 6,500 workers in three years. Altogether, the top 10 states featured in Table 27 below represented 71 percent of petroleum fuels employment growth from 2016 through 2019.

Table 27.
Top 10 States with Job Growth in Petroleum Fuels

State	Total Jobs, 2019	Total Job Growth, 2016-2019	% Job Growth, 2016-2019
Texas	214,715	39,257	22%
California	57,303	8,737	18%
Louisiana	51,802	6,679	15%
Oklahoma	40,403	6,547	19%
Colorado	17,153	3,422	25%
North Dakota	13,872	3,099	29%
Pennsylvania	18,550	3,096	20%
New Mexico	15,020	2,580	21%
Illinois	21,286	2,547	14%
Florida	4,678	2,303	97%

Demographics

Fuels mining and extraction jobs are geographically concentrated, generally in rural parts of the country. As a result, 83 percent of natural gas fuels' jobs are located in just 10 states. The same is true for coal and petroleum mining and extraction employment with 72 percent of coal jobs and 74 percent of petroleum jobs located in the top ten states where those resources are found. Renewable fuels employment is similarly concentrated in agricultural states with 67 percent of corn ethanol jobs in ten predominantly Midwestern states. The exception is nuclear fuels which has the most racially diverse workforce and the highest proportion of Hispanic or Latinx individuals (Table 28).

African Americans are underrepresented in all fuels' sub-technologies with their highest representation in the petroleum fuels sector—about one point above the overall fuels average—and lowest representation in coal fuels.

Table 28.
Fuels Demographics by Sub-technology, 2019

	Coal Fuels	Nuclear Fuels	Natural Gas Fuels	Petroleum Fuels	Renewable Fuels	National Workforce Demo-graphics[lxv]	Fuels Overall
Male	77%	70%	74%	76%	70%	**53%**	**75%**
Female	23%	30%	26%	24%	30%	**47%**	**25%**
Hispanic or Latinx	10%	14%	11%	13%	9%	**18%**	**12%**
Not Hispanic or Latinx	90%	86%	89%	87%	91%	**82%**	**88%**
American Indian or Alaska Native	2%	1%	2%	2%	1%	**1%**	**2%**
Asian	4%	9%	4%	6%	6%	**6%**	**5%**
Black or African American	4%	6%	7%	8%	6%	**12%**	**7%**
Native Hawaiian or other Pacific Islander	0%	1%	1%	1%	1%	**1%**	**1%**
White	84%	69%	76%	76%	80%	**78%**	**77%**
Two or more races	6%	15%	11%	8%	5%	**2%**	**8%**
Veterans	9%	9%	9%	9%	14%	**6%**	**10%**
55 and over	25%	16%	21%	20%	20%	**23%**	**21%**

Transmission, Distribution, and Storage

Trends Impacting the TDS Sector

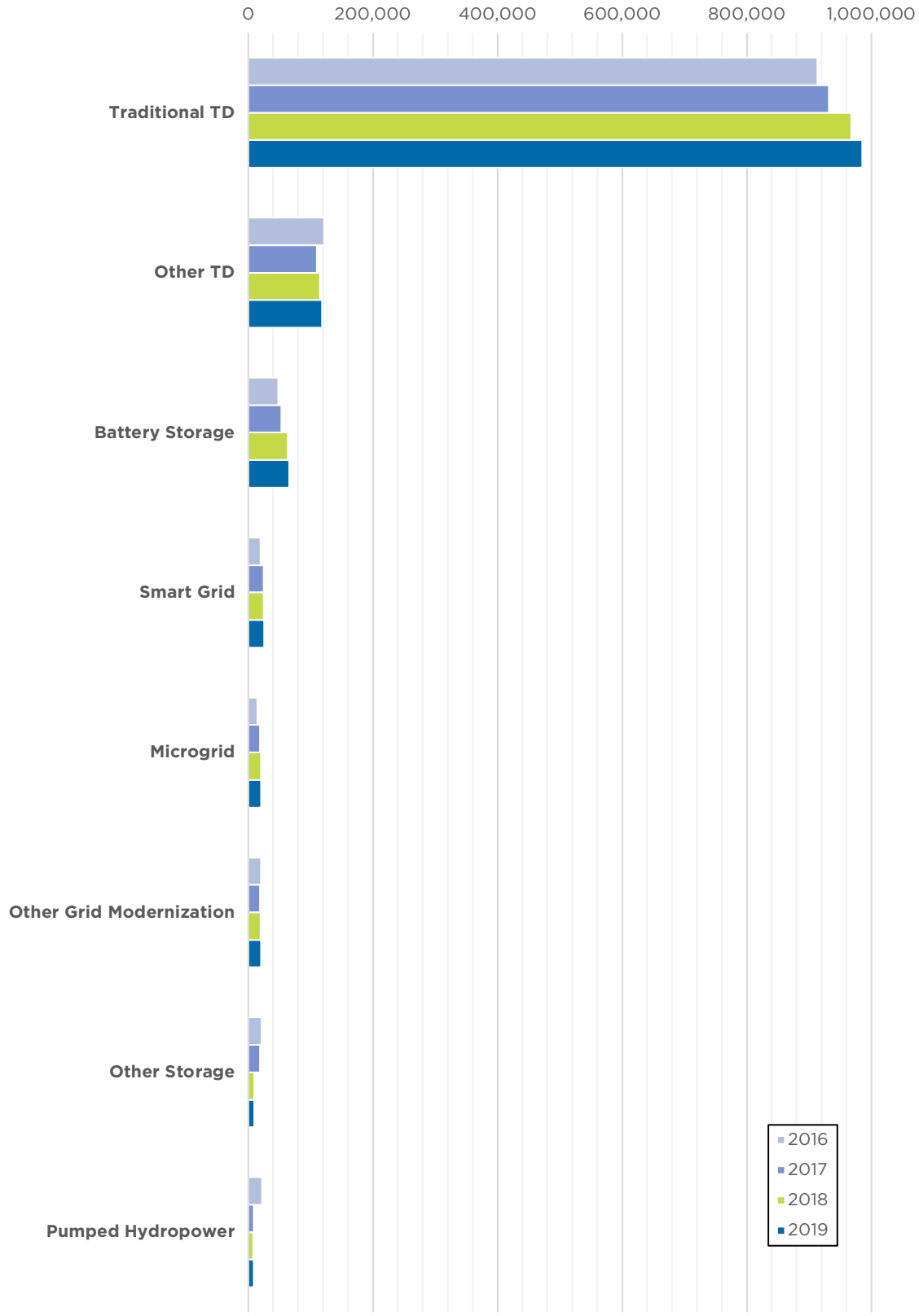
The nation's transmission, distribution, and storage (TDS) sector has seen significant employment growth. TDS jobs include the construction, operations, and maintenance of the systems that store energy and deliver electricity and fuels from producers to end-users. They remain a sizable and growing component of energy jobs in the United States, with emerging technologies in grid modernization resulting in additional job growth within this sector. Since 2016, traditional transmission and distribution jobs have grown by almost eight percent—roughly 72,000 new jobs in three years (Figure 22).

The implementation of new grid modernization technologies like smart grids and microgrids is resulting in an employment boom in these sub-sectors as well. Between 2016 and 2019, smart grid and microgrid firms added 11,800 jobs to the TDS labor force—a growth rate of more than 21 percent. In fact, grid modernization activity across the nation is increasing in general; between 2018 and 2019, there was a 53 percent increase in grid modernization activity, defined as policy action, utility reform, deployment, research and development, and financial incentives. As of 2019, the top states to take grid modernization action include New York, California, Massachusetts, Minnesota, New Jersey, Hawaii, and New Hampshire.[lxvi]

Energy storage technologies overall have seen a decline of roughly seven percent since 2016, shedding just over 6,500 jobs. Much of this decline is attributable to losses in pumped hydropower storage, which shed more than 13,000 jobs. Other storage technologies like mechanical flywheel storage, thermal storage, compressed air, and fossil fuel and nuclear storage lost more than 11,000 jobs since 2016. Despite these declines, battery storage[65] technologies created jobs between 2016 and 2019; this sub-technology saw a remarkable 38 percent job growth, resulting in more than 18,000 new energy jobs and slightly offsetting the major losses in other storage technologies.

[65] Battery storage technologies include the following: lithium batteries, lead-based batteries, other solid-electrode batteries, vanadium redox flow batteries, and other flow batteries. The battery storage sub-sector also includes any battery storage for solar electric power generation.

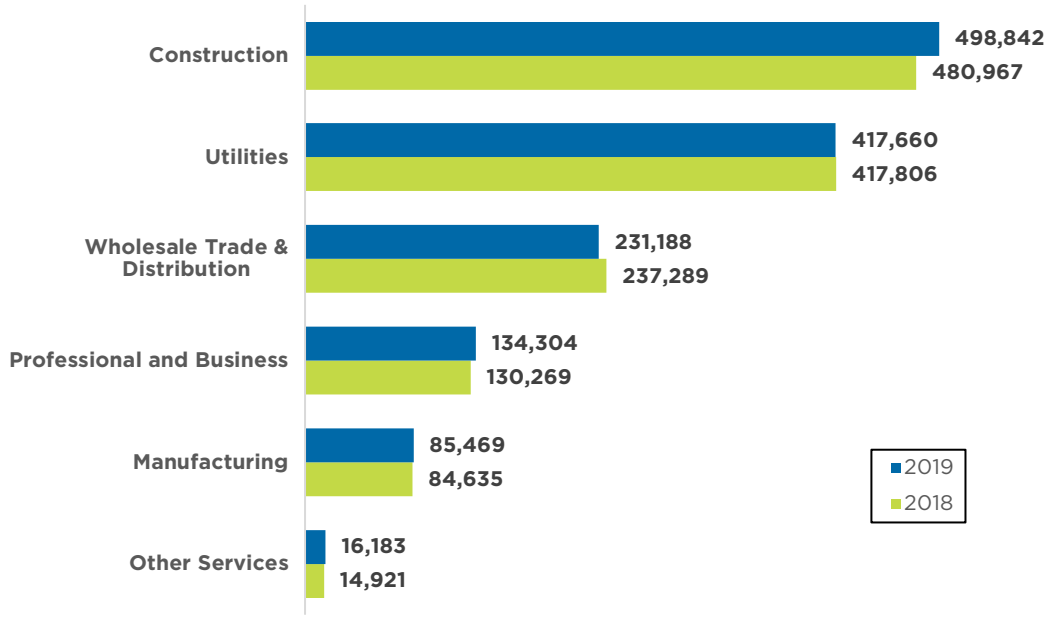
Figure 22.
TDS Employment by Sub-technology, 2016-2019



TDS Sector Employment & Wages

Much of the work in TDS is concentrated in construction and utilities, as illustrated in Figure 23. In fact, construction jobs within the TDS sector grew by 17,900 workers in 2019 alone—an increase of four percent over 12 months. The utilities sector declined slightly by 150 jobs, while TDS wholesale trade saw jobs decline by 6,100 workers.

Figure 23.
TDS Employment by Industry, 2018-2019[66]



Overall, traditional TDS provides the highest premium over the geographically weighted median wage. At $32.24 per hour, traditional TDS jobs support an hourly wage that is 68 percent higher than the geographically weighted median. Grid modernization and storage jobs also support wage premiums at a respective 34 and 24 percent (Table 29).

[66] TDS Employment by Industry includes commodity flows, such as truck, rail, air, and water transportation. This adds an additional 129,252 jobs. As such, the sum of 2019 employment in Figure 23 will be slightly higher than the sum of 2019 employment reported in Figure 22.

Table 29.
TDS Hourly Wages by Sub-technology, 2019

Energy Sub-Sector	Median Hourly Wages, 2019	Geographically Weighted Premium/Discount from Median Hourly Wages
Traditional Transmission and Distribution	$ 32.24	68.2%
Grid Modernization[67]	$ 25.40	33.7%
Storage[68]	$ 24.36	23.8%

Table 29 highlights median hourly wages by TDS sub-technology. The wage data is weighted by both occupational composition and industry mix within each sub-technology to account for variability across supervisory and non-supervisory roles as well as differences across utilities, construction, manufacturing, trade, and professional services. The third column compares the median hourly wages for each sub-sector to the geographically weighted median. Since some sub-sectors are more highly concentrated in specific states, the national median wage is weighted by the state-specific sub-technology job concentration to account for the uneven employment distribution across the nation.

Occupational Wages & Benefits

Since 36 percent of TDS jobs are concentrated in construction, common TDS occupations include construction-related trades such as electricians, carpenters, and operating engineers. Another 30 percent of TDS employees are in the utility sector and largely work with gas and electricity distribution systems. A common occupation would include control and valve installers and repairers. However, there is significant occupational crossover between the construction and utility sectors of TDS.

Two of the most common occupations within TDS have seen job losses since 2016; the number of electrical power-line installers and repairers declined by 7,800 jobs, while electrical and electronics repairers have declined by 400 workers.[lxvii] Power distributors and dispatchers and utility meter readers have also been on the decline since 2016, resulting in a combined loss of 4,000 jobs.

Occupations that grew include other construction-related trades such as electricians and construction laborers (Table 30).

[67] Grid modernization encompasses both smart grid and microgrid technologies.
[68] Storage technologies include pumped hydropower storage, battery storage, mechanical storage like flywheels or compressed air, fossil fuel and nuclear storage, and thermal storage.

Table 30.
TDS Occupations, 2019 Median Hourly Wages

	2019 National Median Hourly Wages[69]	TDS Wage Premium or Discount Compared to National Median[70]	Employment Trends, 2016-2019
Power Distributors and Dispatchers	$ 53.87	181%	↓
Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	$ 43.87	129%	↓
Electrical Power-Line Installers and Repairers	$ 41.27	116%	↓
Meter Readers, Utilities	$ 21.68	13%	↓
First-Line Supervisors of Mechanics, Installers, and Repairers	$ 32.59	70%	↑
Electricians	$ 29.35	53%	↑
Operating Engineers and Other Construction Equipment Operators	$ 25.59	34%	↑
Construction Laborers	$ 19.26	1%	↑

Table 30 depicts the median hourly wages for the typical occupations employed within TDS. The rows highlighted in orange indicate occupations that have declined since 2016 while those highlighted in green indicate occupations that are growing.

Between 87 and 95 percent of TDS occupations in Table 31 have access to full or partial health insurance from their employers, significantly better than the national private sector average of 69 percent. The range of employer contributions to retirement plans for these occupations—73 to 89 percent—is also much higher than the national private sector average of 67 percent.[lxviii]

[69] The median hourly wages for these occupations are extrapolated to be specific for jobs within the TDS sector.
[70] The national occupational median hourly wage in 2019 was $19.14 according to the Bureau of Labor Statistics, Occupational Employment Statistics (May 2019).

Table 31.
Healthcare and Retirement Benefits by Occupation, 2019

	Healthcare Benefits			Retirement	
	Full coverage	Partial coverage	No coverage	Firm contribution	No firm contribution
Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	34.8%	58.9%	6.3%	86.7%	13.3%
Electrical Power-Line Installers and Repairers	38.7%	56.0%	5.3%	87.4%	12.6%
First-Line Supervisors of Mechanics, Installers, and Repairers	37.3%	56.7%	6.0%	89.0%	11.0%
Electricians	37.3%	51.4%	11.3%	77.9%	22.1%
Operating Engineers and Other Construction Equipment Operators	36.0%	53.5%	10.5%	76.5%	23.5%
Construction Laborers	35.4%	51.5%	13.1%	73.0%	27.0%

Table 31 provides an overview of healthcare and retirement benefits by occupation. Healthcare benefits are broken out into three categories indicating whether a firm pays all healthcare insurance costs for an employee, some but not all costs, or makes no contributions to an employee's healthcare insurance costs. Retirement contributions may be made to a 401k, pension, or IRA; firms either contribute to some type of retirement plan or do not make any contributions at all.

Geographic Variability

Job gains in the traditional transmission and distribution sub-sector sector were largely concentrated across the following states: West Virginia, Louisiana, Pennsylvania, Oklahoma, and Texas (Table 32). Together, these five states accounted for 47 percent of all job growth in traditional transmission and distribution sub-technologies.

Only five states saw job losses in traditional transmission and distribution, and these include Nebraska, Washington, Kansas, Missouri, and Tennessee (Table 33).

Table 32.
Top 10 States with Job Growth in Traditional Transmission & Distribution

State	Total Jobs, 2019	Total Job Growth, 2016-2019	% Job Growth, 2016-2019
West Virginia	14,098	9,263	192%
Louisiana	32,110	8,304	35%
Pennsylvania	33,173	7,242	28%
Oklahoma	21,442	4,509	27%
Texas	159,233	4,396	3%
California	102,656	2,691	3%
Virginia	14,448	2,570	22%
New York	65,066	2,506	4%
Alabama	18,290	2,318	15%
New Mexico	9,631	2,082	28%

Table 33.
Top 5 States with Job Losses in Traditional Transmission & Distribution[71]

State	Total Jobs, 2019	Total Job Losses, 2016-2019	% Job Loss, 2016-2019
Nebraska	10,662	(489)	-4%
Washington	22,218	(261)	-1%
Kansas	15,149	(136)	-1%
Missouri	23,774	(134)	-1%
Tennessee	20,520	(73)	-0.4%

Demographics

In general, the TDS sector has a below average representation of women, Hispanic or Latinx workers, and Black or African Americans. The proportion of individuals 55 years of age and over in the TDS sector is also below the national average.

In 2019, women represented 24 percent of the TDS workforce, which is below the national average. Seventeen percent of employees were Hispanic or Latinx, just below the national workforce average, and representation of Black or African American workers was also two points below the national average (Table 34).

[71] Only five states experienced job losses in the TDS sector.

Table 34.
TDS Demographics, 2019

	National Workforce Demographics[lxix]	TDS Overall
Male	53%	76%
Female	47%	24%
Hispanic or Latinx	18%	17%
Not Hispanic or Latinx	82%	83%
American Indian or Alaska Native	1%	2%
Asian	6%	9%
Black or African American	12%	10%
Native Hawaiian or other Pacific Islander	1%	1%
White	78%	69%
Two or more races	2%	9%
Veterans	6%	8%
55 and over	23%	18%

Energy Efficiency

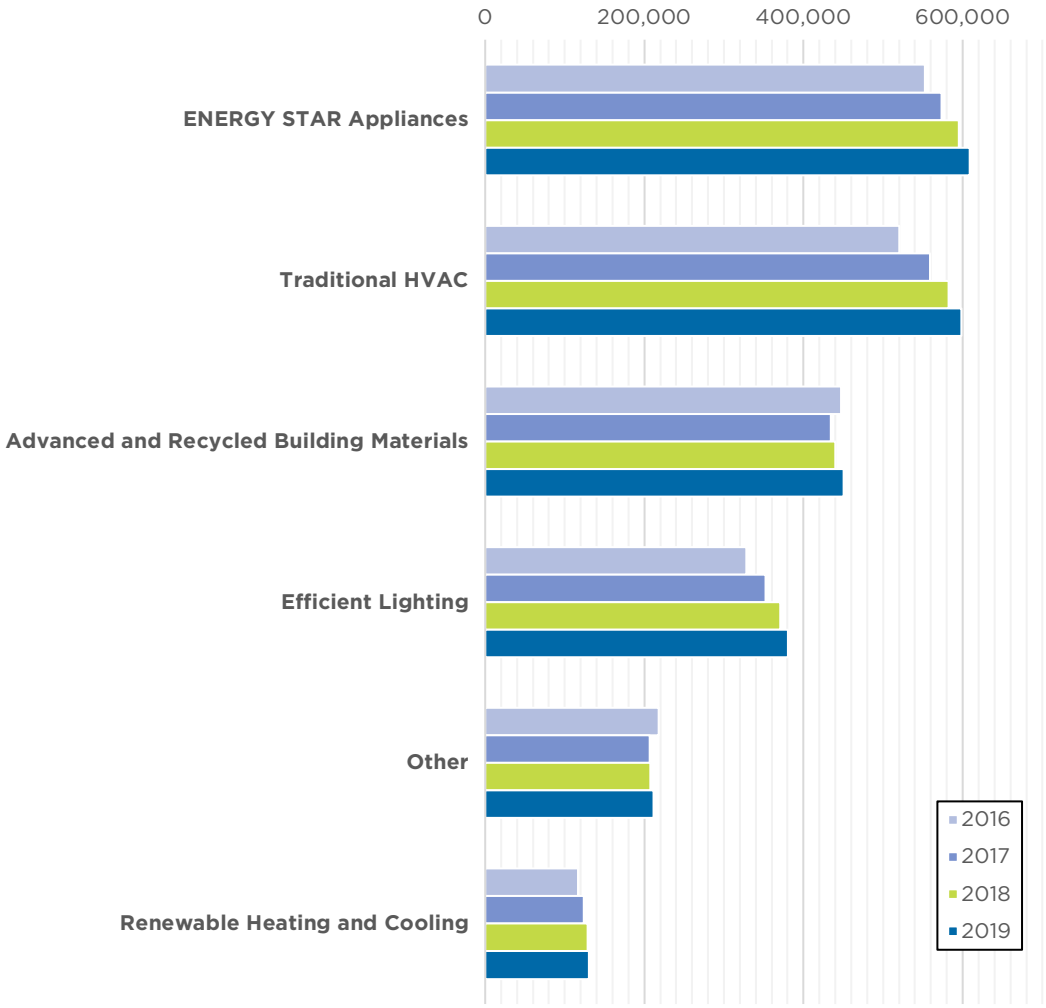
Trends Impacting the Energy Efficiency Sector

Energy efficiency employment covers both the production and installation of energy-saving products and the provision of services that reduce end-use energy consumption. These jobs include the manufacture of ENERGY STAR®-labeled products, as well as building design and contracting services that provide insulation, improve natural lighting, and reduce overall energy consumption across homes and businesses.[72]

The energy efficiency sector is the fastest growing technology sector within the *USEER* survey, adding just over 400,000 new jobs in three years. Traditional HVAC work and ENERGY STAR appliances (including high efficiency HVAC) have grown the most, adding 77,800 and 56,300 new energy efficiency workers respectively in the last three years. Efficient lighting jobs have also grown at a rate of 16 percent, or roughly 52,500 jobs, while renewable heating and cooling saw jobs grow by 13,500 workers and advanced and recycled building materials added 3,700 new jobs (Figure 24).

[72] 2020 *USEER*. Estimates do not include retail employment. ENERGY STAR® is a registered trademark of the U.S. Environmental Protection Agency.

Figure 24.
Energy Efficiency Employment by Sub-Technology, 2016-2019



Energy Efficiency Sector Employment & Wages

A majority of the work in the energy efficiency sector—56 percent—is concentrated in the construction industry, followed by professional and business services (Figure 25). Overall, the sector supports wages that are roughly 23 to 26 percent above the geographically weighted median wage (Table 35). There is less variability in energy efficiency sub-technologies compared to EPG as much of the work is similar and concentrated in the deployment—installation, maintenance, or repair—of energy efficiency goods and services.

Figure 25.
Energy Efficiency Employment by Industry, 2018-2019

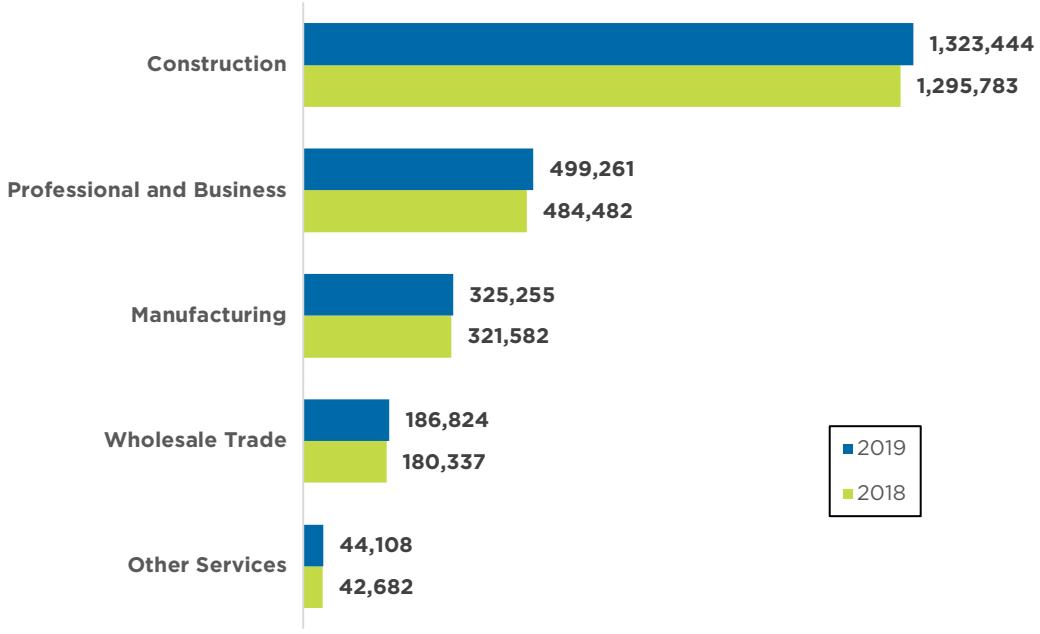


Table 35.
Energy Efficiency Hourly Wages by Sub-technology, 2019

Energy Sub-Sector	Median Hourly Wages, 2019	Geographically Weighted Premium/Discount from Median Hourly Wages
ENERGY STAR Appliances	$ 24.63	25.3%
Renewable Heating and Cooling	$ 24.91	26.4%
Efficient Lighting	$ 24.21	23.1%
Traditional and High Efficiency HVAC	$ 24.43	22.8%

Table 35 highlights median hourly wages by energy efficiency sub-technology. The wage data is weighted by both occupational composition and industry mix within each sub-technology to account for variability across supervisory and non-supervisory roles as well as differences across utilities, construction, manufacturing, trade, and professional services. The third column compares the median hourly wages for each sub-sector to the geographically weighted median. Since some sub-sectors are more highly concentrated in specific states, the national median wage is weighted by the state-specific sub-technology job concentration to account for the uneven employment distribution across the nation.

Occupational Wages & Benefits

In general, nearly all construction workers who are engaged in energy efficiency work, with the exception of construction laborers and insulation workers, earn a premium over both the national median wage and the overall median wage for all construction and extraction occupations. For non-supervisory roles, these wage premiums range from two to 55 percent. Construction laborers and insulation workers have lower requirements compared to carpenters, HVAC mechanics, plumbers, and electricians, which typically require apprenticeships, licensing, nationally-accredited and manufacturer-specific certifications. When taking construction laborers and insulation workers out, the wage premium range is smaller, from 34 to 55 percent.

Supervisory roles, such as managers and first-line supervisors, earn a higher premium than that earned by other construction trades in the energy efficiency sector, such as carpenters, laborers, electricians, HVAC mechanics, insulation workers, or plumbers and pipefitters (Table 36).

Table 36.
Energy Efficiency Occupations, 2019 Median Hourly Wages

	2019 National Median Hourly Wages[73]	Energy Efficiency Wage Premium or Discount Compared to National Median[74]	Energy Efficiency Wage Premium Compared to Weighted Construction Median[75]
Construction Managers	$ 45.97	140%	98%
First-Line Supervisors of Construction Trades and Extraction Workers	$ 31.47	64%	35%
Electricians	$ 29.76	55%	28%
Plumbers, Pipefitters, and Steamfitters	$ 29.22	53%	26%
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	$ 28.32	48%	22%
Carpenters	$ 25.60	34%	10%
Insulation Workers, Floor, Ceiling, and Wall	$ 21.38	12%	-8%
Construction Laborers	$ 19.52	2%	-16%

Table 36 depicts the median hourly wages for the typical occupations employed within Energy Efficiency.

[73] The median hourly wages for these occupations are extrapolated to be specific to jobs within the energy efficiency sector.
[74] The national occupational median hourly wage in 2019 was $19.14 according to the Bureau of Labor Statistics, Occupational Employment Statistics (May 2019).
[75] The median hourly wage for Construction and Extraction Occupations was $22.80 according to the Bureau of Labor Statistics, Occupational Employment Statistics (May 2019). When weighted according to the number of jobs in each specific occupation code, the weighted median comes out to $23.23.

Access to employer-paid healthcare benefits fluctuate in occupations in the energy efficiency sector from a high of 87 percent for construction managers to 74 percent for electricians and 65 percent for carpenters. Most occupations are above the national private sector average of 69 percent.[lxx] Employer contributions to retirement programs fluctuate even more by occupation from a high of 80 percent to a low of 55 percent (Table 37).

Table 37.
Healthcare and Retirement Benefits by Occupation, 2019

	Healthcare Benefits			Retirement	
	Full coverage	Partial coverage	No coverage	Firm contribution	No firm contribution
Construction Managers	36.6%	49.9%	13.6%	79.9%	20.1%
First-Line Supervisors of Construction Trades and Extraction Workers	37.0%	48.3%	14.7%	76.3%	23.7%
Electricians	29.3%	44.9%	25.8%	62.3%	37.7%
Plumbers, Pipefitters, and Steamfitters	31.9%	45.8%	22.3%	67.3%	32.7%
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	26.5%	47.8%	25.6%	60.1%	39.9%
Carpenters	18.8%	46.6%	34.6%	54.6%	45.4%
Insulation Workers, Floor, Ceiling, and Wall	23.6%	56.0%	20.4%	68.9%	31.1%
Construction Laborers	26.1%	52.5%	21.4%	66.4%	33.6%

Table 37 provides an overview of healthcare and retirement benefits by occupation. Healthcare benefits are broken out into three categories indicating whether a firm pays all healthcare insurance costs for an employee, some but not all costs, or makes no contributions to an employee's healthcare insurance costs. Retirement contributions may be made to a 401k, pension, or IRA; firms either contribute to some type of retirement plan or do not make any contributions at all.

Geographic Variability

Energy efficiency jobs are found across 99.8 percent of all counties in the United States. The largest gains in energy efficiency employment were in Texas, California, New York, Florida, and Pennsylvania (Table 38). In total, these five states accounted for 43 percent of all job growth within the sector from 2016 through 2019.

States with the lowest energy efficiency job growth include Vermont, Alaska, Delaware, and Wyoming. Michigan was the only state in the U.S. that had job losses from 2016 through 2019; over this time period, the state shed almost 1,700 energy efficiency jobs for a decline of two percent.

Table 38.
Top 10 States with Job Growth in Energy Efficiency

State	Total Jobs, 2019	Total Job Growth, 2016-2019	% Job Growth, 2016-2019
Texas	169,398	22,676	15%
California	323,529	22,181	7%
New York	126,739	16,157	15%
Florida	123,560	14,890	14%
Pennsylvania	71,443	9,012	14%
Massachusetts	88,231	7,858	10%
Illinois	91,024	7,037	8%
North Carolina	88,001	7,030	9%
Colorado	36,092	6,336	21%
New Jersey	37,982	6,304	20%

Demographics

In 2019, women represented 25 percent of the workforce in the energy efficiency sector, which is significantly lower than the national average. Similarly, the proportion of Hispanic or Latinx and Black or African American individuals was below the national average

The proportion of Black or African American individuals in the energy efficiency workforce was four points below the national average while the proportion of Hispanic or Latinx individuals in the energy efficiency workforce was three points below the national average (Table 39).

Table 39.
Energy Efficiency Demographics, 2019

	National Workforce Demographics[lxxi]	Energy Efficiency Overall
Male	53%	75%
Female	47%	25%
Hispanic or Latinx	18%	15%
Not Hispanic or Latinx	82%	85%
American Indian or Alaska Native	1%	1%
Asian	6%	6%
Black or African American	12%	8%
Native Hawaiian or other Pacific Islander	1%	1%
White	78%	77%
Two or more races	2%	7%
Veterans	6%	9%
55 and over	23%	13%

Motor Vehicles

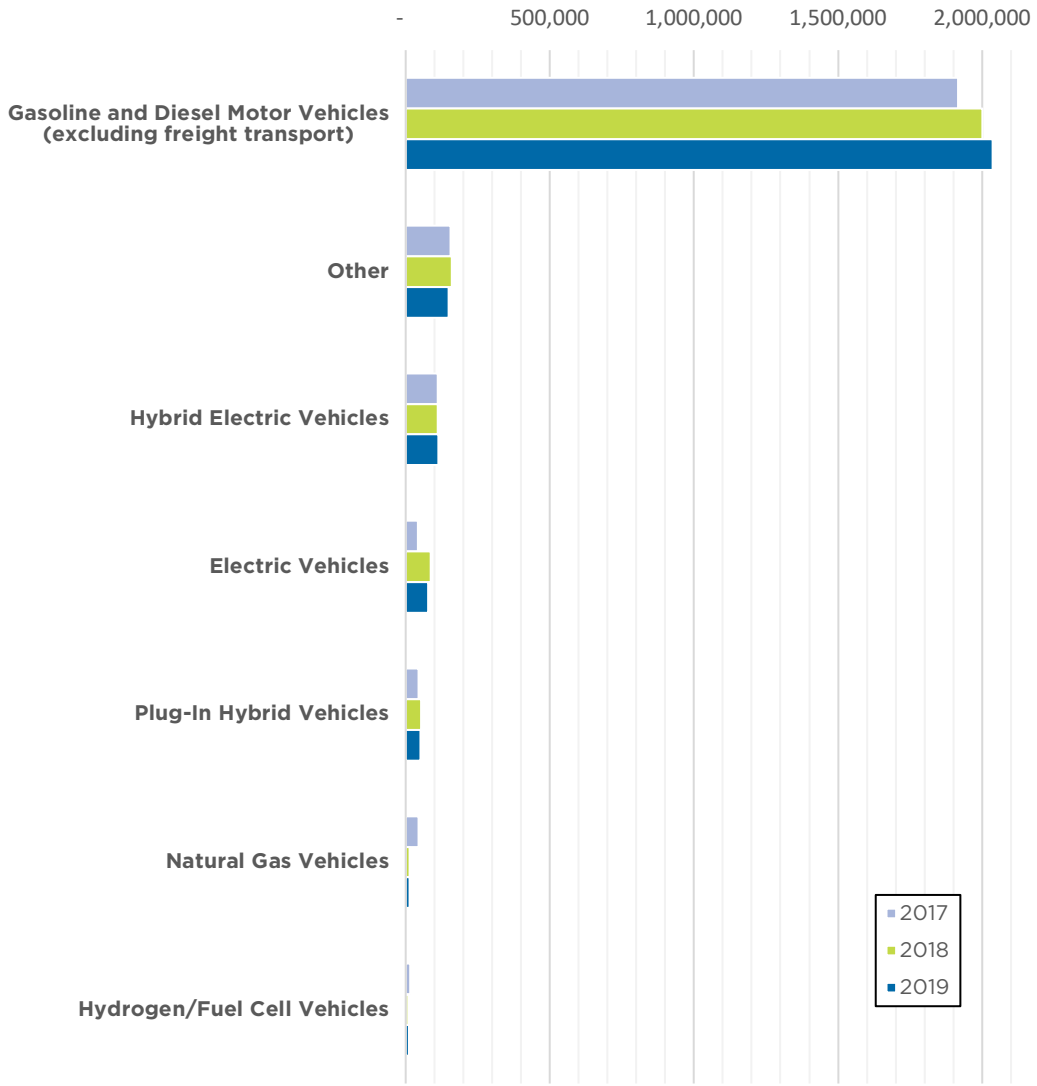
Trends Impacting the Motor Vehicles Sector

Though not considered a sector of the Traditional Energy industry, the motor vehicle and component parts sector,[76] which includes cars, light-duty and heavy-duty trucks, trailers, and component parts of the foregoing, are included in this report, given both the high energy consumption of their manufacture and their contribution to end-use energy consumption.

The motor vehicle sector is also a significant source of employment within the U.S. economy, totaling almost 2.6 million workers at the end of 2019. Gasoline and diesel motor vehicles, the largest sub-sector within the motor vehicles industry, created almost 121,000 new jobs between 2016 and 2019. Electrified alternative transportation vehicles, which include plug-in hybrid, electric, and hybrid vehicle technologies, grew by just over 22 percent—roughly 44,000 new jobs in three years—while jobs in other alternative transportation vehicles, such as natural gas and hydrogen and fuel cell technologies, declined by more than 37,400 workers, or 61 percent (Figure 26).

[76] Motor vehicle and component parts employers are defined as any firm that contributes to the manufacture, wholesale distribution, transport, and repair and maintenance of gasoline, diesel, hybrid, electric, natural gas, hydrogen and fuel cell, or other vehicle technologies.

Figure 26.
Motor Vehicles Employment by Sub-technology, 2017-2019



Motor Vehicles Sector Employment & Wages

Seventy-seven percent of the work within the motor vehicles sector is concentrated in manufacturing and repair and maintenance, 39 and 38 percent, respectively. Since 2016, the nation's motor vehicle manufacturing industry grew by 70,900 jobs while repair and maintenance created 42,500 new jobs over the same time frame (Figure 27).

Overall, gasoline and diesel motor vehicles and alternative transportation sub-technologies support a wage premium that is roughly 16 to 21 percent above the geographically weighted median. Other alternative transportation such as natural gas and hydrogen and fuel cell vehicles pay a slightly higher hourly premium at $22.84 (Table 40).

Figure 27.
Motor Vehicles Employment by Industry, 2018-2019

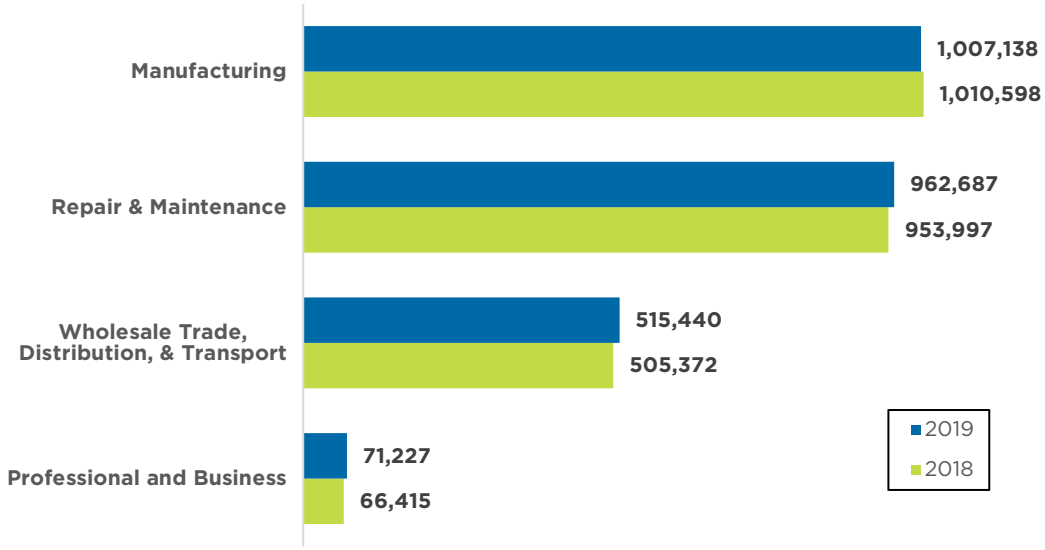


Table 40.
Motor Vehicles Hourly Wages by Sub-technology, 2019

Energy Sub-Sector	Median Hourly Wages, 2019	Geographically Weighted Premium/Discount from Median Hourly Wages
Other Alternative Transportation[77]	$ 22.84	20.8%
Gasoline and Diesel Motor Vehicles (excluding freight transport)	$ 22.30	17.9%
Alternative Transportation[78]	$ 22.13	15.6%

Table 40 highlights median hourly wages by motor vehicles sub-technology. The wage data is weighted by both occupational composition and industry mix within each sub-technology to account for variability across supervisory and non-supervisory roles as well as differences across utilities, construction, manufacturing, trade, and professional services. The third column compares the median hourly wages for each sub-sector to the geographically weighted median. Since some sub-sectors are more highly concentrated in specific states, the national median wage is weighted by the state-specific sub-technology job concentration to account for the uneven employment distribution across the nation.

[77] Other alternative transportation includes natural gas and hydrogen and fuel cell vehicles.
[78] Alternative transportation includes plug-in hybrid, electric, and hybrid electric vehicle technologies.

Occupational Wages & Benefits

Given that motor vehicle employment is concentrated in manufacturing, repair and maintenance, and wholesale trade, the most common occupations found within the sector include production, repair, and sales positions. As shown in Table 41, sales representatives within the motor vehicle sector earn the highest wage premium—104 percent above the national median, or $39.11; this is followed by supervisory positions of production workers.

Automotive repair technicians and mechanics earn a premium that is six to nine percent above the national median. Meanwhile, assemblers and fabricators within the motor vehicles industry have a discount of 16 percent below the national median wage. This is not surprising, as the median hourly wage for assemblers and fabricators overall sits at $16.21, which is six percent lower than the median wage for all production-related occupations.[lxxii]

Table 41.
Motor Vehicles Occupations, 2019 Median Hourly Wages

	2019 National Median Hourly Wages[79]	Fuels Wage Premium Above National Median[80]
Sales Representatives, Wholesale and Manufacturing	$ 38.82	103%
First-Line Supervisors of Production and Operating Workers	$ 28.87	51%
Welders, Cutters, Solderers, and Brazers	$ 22.04	15%
Automotive Body and Related Repairers	$ 20.95	9%
Automotive Service Technicians and Mechanics	$ 20.24	6%
Assemblers and Fabricators	$ 16.13	-16%

Table 41 depicts the median hourly wages for the typical occupations employed within motor vehicles.

[79] The median hourly wages for Automotive Body and Related Repairers and Automotive Service Technicians and Mechanics are from the Bureau of Labor Statistics (BLS), Occupational Employment Statistics (May 2019), as these jobs fall entirely within the motor vehicles sector. For the remaining non-Motor Vehicle specific occupations such as sales representatives, supervisors, assemblers and fabricators, or welders, these wages are extrapolated and specific to workers within the motor vehicles sector.
[80] The national occupational median hourly wage in 2019 was $19.14 according to the Bureau of Labor Statistics, Occupational Employment Statistics (May 2019).

Access to employer-subsidized health care in motor vehicle occupations ranges between 86 and 91 percent, significantly above the national private sector average of 69 percent.[lxxiii] Employer contributions to retirement programs range from over 85 percent for assemblers and fabricators to 67 percent for automotive service technicians and mechanics. The national private sector average is 67 percent (Table 42).[lxxiv]

Table 42.
Healthcare and Retirement Benefits by Occupation, 2019

	Healthcare Benefits			Retirement	
	Full coverage	Partial coverage	No coverage	Firm contribution	No firm contribution
Sales Representatives, Wholesale and Manufacturing	32.3%	56.9%	10.8%	81.5%	18.5%
First-Line Supervisors of Production and Operating Workers	34.0%	57.0%	9.0%	85.4%	14.6%
Welders, Cutters, Solderers, and Brazers	40.0%	47.5%	12.5%	84.7%	15.3%
Automotive Body and Related Repairers	21.8%	65.6%	12.6%	71.2%	28.8%
Automotive Service Technicians and Mechanics	25.0%	63.4%	11.6%	66.9%	33.1%
Assemblers and Fabricators	35.6%	50.5%	13.8%	85.7%	14.3%

Table 42 provides an overview of healthcare and retirement benefits by occupation. Healthcare benefits are broken out into three categories indicating whether a firm pays all healthcare insurance costs for an employee, some but not all costs, or makes no contributions to an employee's healthcare insurance costs. Retirement contributions may be made to a 401k, pension, or IRA; firms either contribute to some type of retirement plan or do not make any contributions at all.

Geographic Variability

Overall, California, Texas, and Michigan had the greatest growth in total motor vehicle employment from 2016 through 2019 (Table 43), while Iowa, Vermont, and Kansas saw the greatest declines (Table 44). The most significant growth in gasoline and diesel motor vehicle employment between 2016 and 2019 was in Michigan, which experienced a growth of 15,400 new jobs over three years. This is not surprising, as the state is a hub for automotive manufacturing. In fact, the state is home to more than 1,600 automotive manufacturing establishments. In 2017 alone, the state produced two million cars.[lxxv] Over the same time period, Indiana added almost 9,000 traditional gasoline and diesel motor vehicle jobs while Ohio lost just over 6,000 gasoline and diesel motor vehicle jobs.

Meanwhile, California saw the greatest growth in alternative transportation employment. Between 2016 and 2019, the state added

19,500 new jobs, followed by Massachusetts with 1,800 new alternative transportation jobs.

Table 43.
Top 10 States with Job Growth in Motor Vehicles

State	Total Jobs, 2019	Total Job Growth, 2016-2019	% Job Growth, 2016-2019
California	220,719	22,598	11%
Texas	182,695	16,659	10%
Michigan	247,682	13,840	6%
Indiana	169,677	13,724	9%
South Carolina	61,446	9,976	19%
Georgia	78,412	9,224	13%
Tennessee	103,631	6,575	7%
Florida	94,581	5,980	7%
Virginia	55,061	5,898	12%
Massachusetts	31,533	4,720	18%

Table 44.
Top 10 States with Job Losses in Motor Vehicles

State	Total Jobs, 2019	Total Job Losses, 2016-2019	% Job Loss, 2016-2019
Iowa	31,139	(6,129)	-16%
Vermont	3,683	(2,977)	-45%
Kansas	19,495	(2,204)	-10%
New Mexico	7,842	(1,990)	-20%
Ohio	168,060	(1,951)	-1%
Wyoming	3,166	(1,279)	-29%
North Dakota	7,890	(1,208)	-13%
Pennsylvania	80,130	(1,141)	-1%
West Virginia	9,000	(1,139)	-11%
Alaska	2,334	(1,125)	-33%

Demographics

In 2019, women represented 23 percent of all employees in the motor vehicles sector. In terms of race and ethnicity, the motor vehicles sector is as equally diverse as the U.S. workforce. While Black or African American workers are underrepresented in the industry as a whole (eight percent) they make up a larger proportion of its manufacturing sector (17 percent). Hispanic or Latinx workers represent 10 percent of the motor vehicle manufacturing labor force, while women comprise 24 percent.

Within the automotive repair and maintenance industry, women only account for 10 percent of workers, while Black or African American workers were seven percent—five points below the national average. However, Hispanic or Latinx workers are more highly represented in automotive repair and maintenance at almost 25 percent of the workforce (Table 45).[lxxvi]

Table 45.
Motor Vehicle Demographics, 2019

	National Workforce Demographics[lxxvii]	Motor Vehicles Overall
Male	53%	77%
Female	47%	23%
Hispanic or Latinx	18%	17%
Not Hispanic or Latinx	82%	83%
American Indian or Alaska Native	1%	2%
Asian	6%	5%
Black or African American	12%	8%
Native Hawaiian or other Pacific Islander	1%	1%
White	78%	77%
Two or more races	2%	8%
Veterans	6%	9%
55 and over	23%	19%

Appendix A
Energy Wages by State

The following table provides energy wages by state, both overall and for each major energy technology sector. Due to data availability, state energy wages are derived using a different methodology from the national energy wages presented throughout the report. As such, caution is advised when making direct comparisons in state wage data and national-level data. The methodology for state energy wages uses an occupational lens, while the wages used in the report take an industry approach. BW Research has tied the wages using the occupational methodology to the national industry wages in order to provide more consistent results.

	Electric Power Generation	Transmission, Distribution, and Storage	Energy Efficiency	Fuels	Motor Vehicles	Overall
Alabama	$24.56	$28.96	$21.93	$22.37	$20.78	**$23.49**
Alaska	$29.99	$35.13	$26.84	$26.89	$25.74	**$28.87**
Arizona	$24.87	$29.24	$22.51	$22.88	$21.23	**$24.14**
Arkansas	$21.45	$25.07	$19.63	$20.11	$18.79	**$21.03**
California	$29.85	$35.39	$26.89	$26.93	$25.36	**$28.91**
Colorado	$28.38	$33.47	$25.60	$26.01	$23.72	**$27.51**
Connecticut	$31.01	$36.44	$27.82	$28.08	$25.71	**$29.36**
Delaware	$28.28	$33.45	$25.51	$25.96	$23.39	**$26.90**
DC	$34.81	$41.05	$30.92	$31.50	$28.47	**$32.90**
Florida	$23.60	$27.78	$21.27	$21.48	$19.97	**$22.70**
Georgia	$24.87	$29.27	$22.35	$22.75	$20.80	**$23.68**
Hawaii	$28.48	$33.36	$25.55	$25.31	$24.24	**$27.74**
Idaho	$22.99	$26.92	$20.79	$21.12	$19.78	**$22.35**
Illinois	$27.68	$32.46	$25.14	$24.80	$23.87	**$26.66**
Indiana	$24.38	$28.54	$22.33	$22.70	$21.21	**$23.37**
Iowa	$24.87	$29.12	$22.68	$22.84	$21.58	**$24.09**
Kansas	$24.51	$28.64	$22.15	$22.54	$21.00	**$23.96**
Kentucky	$23.39	$27.34	$21.28	$21.66	$20.49	**$22.57**
Louisiana	$24.67	$29.12	$22.11	$22.48	$21.61	**$24.11**
Maine	$24.64	$28.82	$22.53	$22.90	$21.43	**$23.84**
Maryland	$28.80	$33.96	$25.83	$26.34	$23.72	**$27.23**
Massachusetts	$30.65	$35.95	$27.83	$27.79	$25.40	**$29.50**
Michigan	$26.23	$30.75	$23.58	$23.77	$22.32	**$24.69**

	Electric Power Generation	Transmission, Distribution, and Storage	Energy Efficiency	Fuels	Motor Vehicles	Overall
Minnesota	$28.13	$33.00	$25.73	$25.86	$23.93	**$27.22**
Mississippi	$21.87	$25.58	$19.66	$19.99	$19.15	**$21.15**
Missouri	$24.92	$29.17	$22.72	$22.82	$21.47	**$23.97**
Montana	$23.92	$28.00	$21.66	$21.94	$21.15	**$23.46**
Nebraska	$24.10	$28.31	$21.99	$22.26	$21.12	**$23.72**
Nevada	$26.15	$30.74	$23.23	$23.54	$22.42	**$25.88**
New Hampshire	$27.15	$31.94	$24.63	$24.84	$23.01	**$26.13**
New Jersey	$30.71	$36.21	$27.64	$27.97	$25.15	**$29.34**
New Mexico	$24.25	$28.63	$21.94	$22.38	$21.10	**$23.91**
New York	$30.39	$35.75	$27.30	$27.45	$24.93	**$29.16**
North Carolina	$25.69	$30.22	$23.12	$23.58	$21.16	**$24.20**
North Dakota	$26.30	$30.67	$23.63	$24.17	$22.72	**$25.61**
Ohio	$25.43	$29.83	$23.14	$23.38	$21.91	**$24.36**
Oklahoma	$23.90	$28.06	$21.58	$21.97	$20.78	**$23.29**
Oregon	$26.73	$31.30	$24.23	$24.28	$22.99	**$25.69**
Pennsylvania	$26.83	$31.50	$24.28	$24.47	$22.61	**$25.69**
Rhode Island	$29.61	$34.88	$26.88	$27.17	$24.34	**$28.07**
South Carolina	$23.95	$28.09	$21.68	$22.05	$20.48	**$23.04**
South Dakota	$24.61	$28.85	$22.19	$22.68	$20.76	**$23.51**
Tennessee	$23.66	$27.81	$21.32	$21.71	$20.29	**$22.61**
Texas	$25.83	$30.54	$23.37	$23.72	$22.05	**$25.15**
Utah	$24.10	$28.29	$21.73	$22.03	$20.91	**$23.13**
Vermont	$24.79	$28.82	$22.46	$22.71	$21.27	**$23.81**
Virginia	$28.23	$33.27	$25.35	$25.95	$22.92	**$26.59**
Washington	$30.39	$35.88	$27.33	$27.30	$25.60	**$29.22**
West Virginia	$22.89	$26.86	$20.84	$21.41	$19.95	**$22.72**
Wisconsin	$26.06	$30.58	$23.88	$24.13	$22.50	**$25.09**
Wyoming	$26.74	$31.22	$24.23	$24.67	$24.14	**$26.20**
U.S.	**$27.19**	**$31.25**	**$24.44**	**$23.89**	**$22.29**	**$25.60**

References

[i] National employment estimates are from the Bureau of Labor Statistics, Quarterly Census of Employment and Wages. Energy employment estimates are from the 2020 United States Energy and Employment Report (USEER).

[ii] Bureau of Labor Statistics, Labor Force Statistics, Current Population Survey, 2020. https://www.bls.gov/cps/cpsaat08.htm.

[iii] Bureau of Labor Statistics, National Industry-Specific Occupational Employment and Wages Estimates, May 2019. https://www.bls.gov/oes/current/oessrci.htm.

[iv] BW Research. https://bwresearch.com/covid/.

[v] Bureau of Labor Statistics, National Industry-Specific Occupational Employment and Wages Estimates, May 2019. https://www.bls.gov/oes/current/oessrci.htm.

[vi] Id.

[vii] National median hourly wages are from the Bureau of Labor Statistics, National Industry-Specific Occupational Employment and Wage Estimates, May 2019. https://www.bls.gov/oes/current/oessrci.htm.

[viii] U.S. Energy Information Administration. Table 7.2a Electricity Net Generation. https://www.eia.gov/totalenergy/data/browser/?tbl=T07.02A#/?f=A.

[ix] U.S. Energy Information Administration. More than 100 coal-fired plants have been replaced or converted to natural gas since 2011. August 2020. https://www.eia.gov/todayinenergy/detail.php?id=44636.

[x] https://www.usenergyjobs.org/

[xi] Bureau of Labor Statistics, National Industry-Specific Occupational Employment and Wages Estimates, May 2019. https://www.bls.gov/oes/current/oessrci.htm.

[xii] For more information on the geographic distribution of energy jobs see generally: 2020 U.S. Energy and Employment Report and State Reports. https://www.usenergyjobs.org/.

[xiii] U.S. Energy Information Administration. Table 1.2 Primary Energy Production by Source, 2000 – 2019. https://www.eia.gov/totalenergy/data/browser/?tbl=T01.02#/?f=A&start=1949&end=2018&charted=1-2-3-4-6-13

[xiv] 2020 U.S. Energy and Employment Five-Year Trends Report. https://www.usenergyjobs.org/fiveyears.

[xv] For more information on the geographic distribution of energy jobs see generally: 2020 U.S. Energy and Employment Report and State Reports. https://www.usenergyjobs.org/.

[xvi] Energy Information Administration. U.S. Energy Production, Consumption has Changed Significantly since 1908. November 2016. https://www.eia.gov/todayinenergy/detail.php?id=28592

[xvii] https://www.wvgazettemail.com/news/food-pantry-struggles-to-feed-growing-need-in-isolated-clay-communities/article_29cbb7d0-29fe-5c80-80e0-c98d0d92a5ea.html

[xviii] Id.

[xix] https://www.cnn.com/2021/01/23/opinions/biden-climate-change-gillette-wyoming-coal-sutter/index.html

[xx] Id.

[xxi] Id.

[xxii] https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/27/fact-sheet-president-biden-takes-executive-actions-to-tackle-the-climate-crisis-at-home-and-abroad-create-jobs-and-restore-scientific-integrity-across-federal-government/#:~:text=The%20order%20establishes%20an%20Interagency,assist%20coal%2C%20oil%20and%20natural

[xxiii] https://www.energy.gov/ne/articles/whats-lifespan-nuclear-reactor-much-longer-you-might-think; http://www.beyondnuclear.org/reactors-are-closing/

[xxiv] https://decommissioningcollaborative.org/wp-content/uploads/2020/10/Socioeconomic-Impacts-from-Nuclear-Power-Plant-Closure-and-Decommissioning-9134571934561398.pdf

[xxv] https://pressofatlanticcity.com/news/breaking/when-the-nuclear-era-ends-struggling-zion-ill-a-lesson-for-lacey-township/article_373d825c-4ae6-5c00-b75b-90f3bd50149c.html

[xxvi] https://stateimpact.npr.org/pennsylvania/2019/03/26/in-illinois-the-town-of-zion-is-still-trying-to-recover-from-a-nuclear-plant-closure/

[xxvii] https://pressofatlanticcity.com/news/breaking/when-the-nuclear-era-ends-struggling-zion-ill-a-lesson-for-lacey-township/article_373d825c-4ae6-5c00-b75b-90f3bd50149c.html

[xxviii] Id.

[xxix] https://www.the74million.org/article/it-just-becomes-like-a-ghost-town-as-nuclear-plants-close-in-record-numbers-across-u-s-small-town-school-districts-brace-for-catastrophic-tax-loss/

[xxx] https://decommissioningcollaborative.org/wp-content/uploads/2020/10/Socioeconomic-Impacts-from-Nuclear-Power-Plant-Closure-and-Decommissioning-9134571934561398.pdf

[xxxi] Id.

[xxxii] https://smartgrowthamerica.org/new-assistance-program-will-serve-the-dozens-of-communities-facing-the-economic-challenges-of-nuclear-power-plant-closure/

[xxxiii] Pennsylvania Department of Environmental Protection. Pennsylvania's Surface Mining Control and Reclamation Act Funded Abandoned Mine Lands Program, 2019. http://files.dep.state.pa.us/Mining/Abandoned%20Mine%20Reclamation/AbandonedMinePortalFiles/AML_Fact_Sheet_Final_2019_03_11.pdf.

[xxxiv] Downstream Strategies. An Economic Benefit Analysis for Abandoned Mine Drainage Remediation in the West Branch Susquehanna River Watershed, Pennsylvania. July 2008. https://www.downstreamstrategies.com/docume

nts/reports_publication/AMD_remediation_%20West_Branch_Susquehanna_Jul2008.pdf.
[xxxv] Id.
[xxxvi] Governor Wolf Announces $30 Million for Abandoned Mine Reclamation Projects. July 2016. https://www.governor.pa.gov/newsroom/governor-wolf-announces-30-million-for-abandoned-mine-reclamation-projects/.
[xxxvii] Columbia Center on Global Energy Policy. Green Stimulus for Oil and Gas Workers: Considering a Major Federal Effort to Plug Orphaned and Abandoned Wells, July 2020. https://www.energypolicy.columbia.edu/research/report/green-stimulus-oil-and-gas-workers-considering-major-federal-effort-plug-orphaned-and-abandoned.
[xxxviii] Columbia Center on Global Energy Policy. Green Stimulus for Oil and Gas Workers: Considering a Major Federal Effort to Plug Orphaned and Abandoned Wells, July 2020. https://www.energypolicy.columbia.edu/research/report/green-stimulus-oil-and-gas-workers-considering-major-federal-effort-plug-orphaned-and-abandoned.
[xxxix] MassCEC. 2018 Massachusetts Offshore Wind Workforce Assessment.https://files.masscec.com/2018%20MassCEC%20Workforce%20Study.pdf.
[xl] BW Research. https://bwresearch.com/covid/.
[xli] Id.
[xlii] Bureau of Labor Statistics, National Industry-Specific Occupational Employment and Wages Estimates, May 2019. https://www.bls.gov/oes/current/oessrci.htm.
[xliii] National median hourly wages are from the Bureau of Labor Statistics, National Industry-Specific Occupational Employment and Wage Estimates, May 2019. https://www.bls.gov/oes/current/oessrci.htm.
[xliv] Id.
[xlv] Bureau of Labor Statistics, Current Population Survey, 2019. https://www.unionstats.com/.
[xlvi] U.S. Energy Information Administration. Annual Coal Report, 2019. https://www.eia.gov/coal/annual/pdf/table20.pdf.
[xlvii] U.S. Energy Information Administration. Table 7.2a Electricity Net Generation. https://www.eia.gov/totalenergy/data/browser/?tbl=T07.02A#/?f=A.
[xlviii] U.S. Energy Information Administration. More U.S. coal-fired power plants are decommissioning as retirements continue. 26 July 2019. https://www.eia.gov/todayinenergy/detail.php?id=40212.
[xlix] U.S. Energy Information Administration. Decommissioning nuclear reactors is a long-term and costly process. 17 November 2017. https://www.eia.gov/todayinenergy/detail.php?id=33792.
[l] Emsi Q3 2020, Occupational Staffing Pattern within Nuclear Electric Power Generation (NAICS 221113), 2016-2019.
[li] U.S. Energy Information Administration. Table 7.2a Electricity Net Generation. https://www.eia.gov/totalenergy/data/browser/?tbl=T07.02A#/?f=A.
[lii] Wagman, David. Automation is Engineering the Jobs out of Power Plants. August 2017. https://spectrum.ieee.org/energywise/energy/fossil-fuels/automation-is-engineering-the-jobs-out-of-power-plants.
[liii] U.S. Energy Information Administration. More than 100 coal-fired plants have been replaced or converted to natural gas since 2011. August 2020. https://www.eia.gov/todayinenergy/detail.php?id=44636.
[liv] Emsi Q3 2020.
[lv] 2020 USEER, page 57 and 2017 USEER, page 38.
[lvi] Bureau of Labor Statistics, Occupational Employment Statistics, May 2019.
[lvii] U.S. Energy Information Administration. Natural gas generators make up the largest share of overall U.S. generation capacity. 18 December 2017. https://www.eia.gov/todayinenergy/detail.php?id=34172.
[lviii] National workforce demographic information in this table and subsequent demographic tables in this report are from the 2019 Bureau of Labor Statistics, Current Population Survey. https://www.bls.gov/cps/demographics.htm.
[lix] U.S. Energy Information Administration. Table 1.2 Primary Energy Production by Source, 2000 – 2018. https://www.eia.gov/totalenergy/data/browser/?tbl=T01.02#/?f=A&start=1949&end=2018&charted=1-2-3-4-6-13.
[lx] U.S. Energy Information Administration. The U.S. leads global petroleum and natural gas production with record growth in 2018. August 2019. https://www.eia.gov/todayinenergy/detail.php?id=40973#:~:text=The%20United%20States%20surpassed%20Russia,world's%20largest%20producer%20of%20petroleum.
[lxi] U.S. Energy Information Administration. Table 1.2 Primary Energy Production by Source, 2000 – 2018. https://www.eia.gov/totalenergy/data/browser/?tbl=T01.02#/?f=A&start=1949&end=2018&charted=1-2-3-4-6-13.
[lxii] Emsi Q3 2020.
[lxiii] U.S. Energy Information Administration. U.S. uranium production in 2018 was the lowest in nearly 70 years. May 2019. https://www.eia.gov/todayinenergy/detail.php?id=39352#:~:text=Uranium%20production%20in%20the%20United,for%20more%20than%2020%20years.&text=The%20production%20of%20uranium%20concentrate,the%20nuclear%20fuel%20production%20process.
[lxiv] Emsi Q3 2020.
[lxv] National workforce demographic information in this table and subsequent demographic tables in this report are from the 2019 Bureau of Labor Statistics, Current Population Survey. https://www.bls.gov/cps/demographics.htm.
[lxvi] NC Clean Energy Technology Center. 50 States of Grid Modernization, Q1 2019 Quarterly Report, May 2019.
[lxvii] Emsi Q4 2020.

[lxviii] Bureau of Labor Statistics. Employee Benefits in the United States, March 2019. https://www.bls.gov/news.release/pdf/ebs2.pdf.
[lxix] National workforce demographic information in this table and subsequent demographic tables in this report are from the 2019 Bureau of Labor Statistics, Current Population Survey. https://www.bls.gov/cps/demographics.htm.
[lxx] Bureau of Labor Statistics. Employee Benefits in the United States, March 2019. https://www.bls.gov/news.release/pdf/ebs2.pdf.
[lxxi] National workforce demographic information in this table and subsequent demographic tables in this report are from the 2019 Bureau of Labor Statistics, Current Population Survey. https://www.bls.gov/cps/demographics.htm.
[lxxii] Bureau of Labor Statistics, Occupational Employment Statistics, May 2019.
[lxxiii] Bureau of Labor Statistics. Employee Benefits in the United States, March 2019. https://www.bls.gov/news.release/pdf/ebs2.pdf.
[lxxiv] Id.
[lxxv] Detroit Regional Chamber. https://www.detroitchamber.com/econdev/chamber-initiatives/michauto-universal-name/the-auto-industry-in-michigan/.
[lxxvi] U.S. Bureau of Labor Statistics, Labor Force Statistics from the Current Population Survey, 2019. https://www.bls.gov/cps/cpsaat18.htm.
[lxxvii] National workforce demographic information in this table and subsequent demographic tables in this report are from the 2019 Bureau of Labor Statistics, Current Population Survey. https://www.bls.gov/cps/demographics.htm.