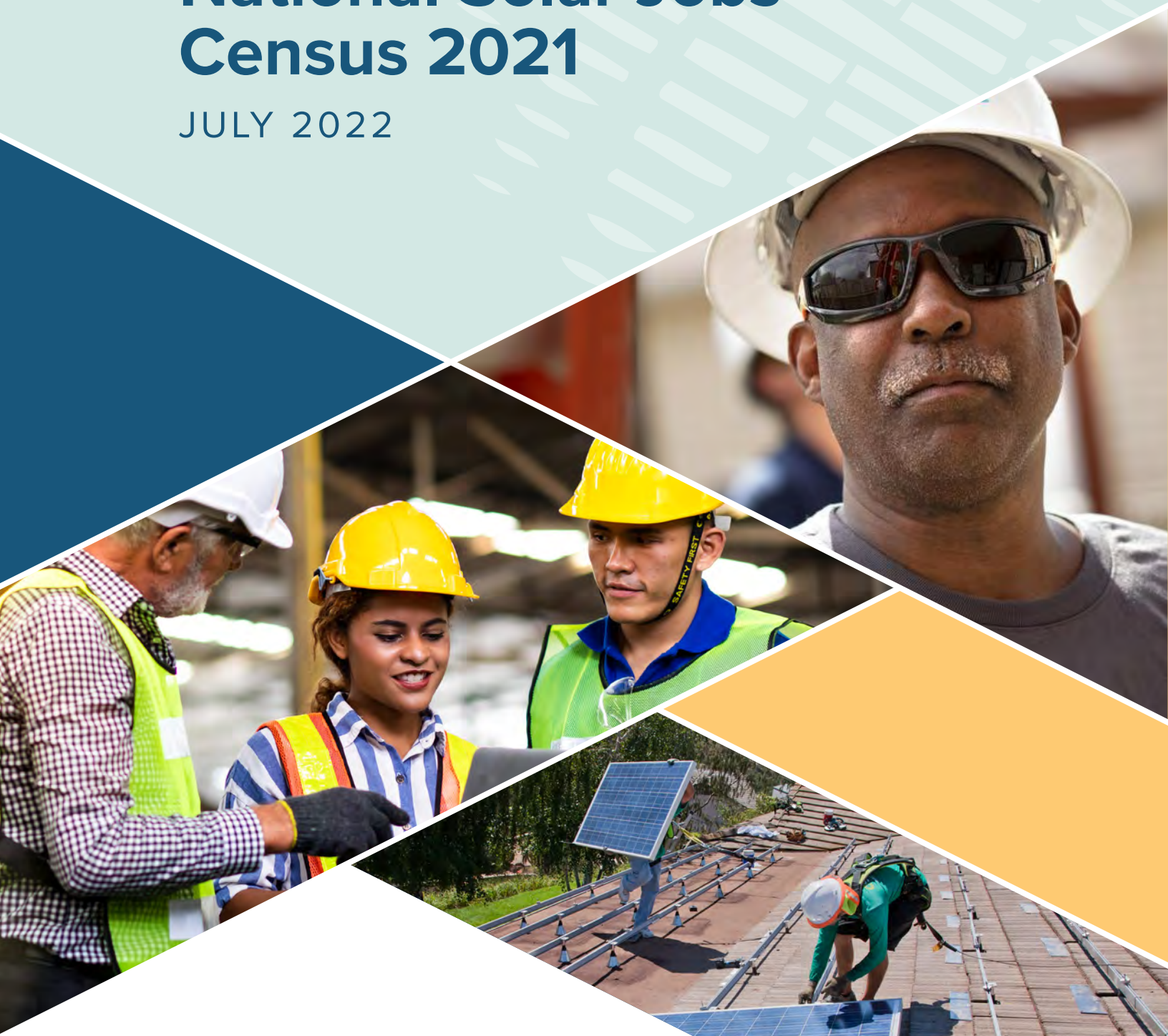
12TH ANNUAL

National Solar Jobs Census 2021

JULY 2022



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The Interstate Renewable Energy Council (IREC) builds the foundation for rapid adoption of clean energy and energy efficiency to benefit people, the economy, and our planet. Its vision is a 100% clean energy future that is reliable, resilient, and equitable. IREC develops and advances the regulatory reforms, technical standards, and workforce solutions needed to enable the streamlined integration of clean, distributed energy resources. IREC has been trusted for its independent clean energy expertise for 40 years, since its founding in 1982. For more information, visit www.irecusa.org or follow IREC on Twitter, LinkedIn, or Facebook.

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Unless otherwise indicated, all solar jobs data from 2010-2020 derive from the *National Solar Jobs Census* report series, available at http://www.solarjobscensus.org.

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"The National Solar Jobs Census provides an invaluable record of the solar industry's role as a career creator over the past 12 years. Sunrun is proud to be part of this economic success story as we help our customers access secure and affordable energy through solar and battery storage."
Mary Powell, Chief Executive Officer, Sunrun

"The National Solar Jobs Census demonstrates that solar careers are available in software, engineering, installation, research and development, and many other fields. At Aurora Solar, we're proud to be a rapidly growing company creating new job opportunities to expand America's solar industry and help take on the climate crisis by making solar more accessible to everyone."
Chris Hopper, CEO and Co-Founder, Aurora Solar

"Solar energy is an economic growth engine, creating new jobs while it helps us confront the climate crisis. There is vast and untapped potential to expand solar installations and related jobs across the United States, in an environmentally sustainable manner, as we help businesses and families access this renewable energy source."
Dan Reicher, Senior Scholar, Stanford Woods Institute and former U.S. Assistant Secretary of Energy

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"The solar industry is strengthening communities and local economies across the U.S. by creating good-paying jobs and providing affordable, reliable clean energy. In just the last six months, SOLV Energy has hired 105 new employees at every level of the value chain, from on-site solar technicians and project engineers to in-office and remote staff in technology, HR, finance and marketing roles. As we advocate for smart policy that will drive the continued growth of our SOLV Energy team and solar energy in the U.S., we are able to lean on the Solar Census as a useful tool in generating awareness for the wide range of career opportunities available within the industry."
George Hershman, CEO of SOLV Energy and Board Chair for SEIA

"The clean energy sector faces an urgent need to rapidly scale the workforce to meet climate and equity challenges. IREC's National Solar Jobs Census reflects the importance of a high quality and diverse workforce and provides guideposts to help educators, companies, and communities reach their workforce development goals."
Dr. Debra Rowe, Director, SEED Center, National Council for Workforce Education and President, US Partnership for Education for Sustainable Development

"These 2021 findings highlight that we can create family-sustaining jobs at the same time that we reduce carbon emissions. They also highlight the critical importance of supportive policies to unlock the full potential of the solar industry to drive employment, foster local energy resilience, and confront climate change."
Tom Starrs, Vice President, Government and Public Affairs, EDP Renewables

Executive Summary

The *National Solar Jobs Census* is the annual review of employment in the U.S. solar energy industry, nationwide and by state. Now published by the Interstate Renewable Energy Council (IREC), this report is the most comprehensive and rigorous analysis of solar labor market trends in the United States.

As of December 2021, the solar industry supported 255,037 jobs at 29,019 locations in all 50 states, the District of Columbia, and Puerto Rico. This represents an increase of 9.2%, or 21,563 more jobs compared to 2020. This jobs total includes all employees who spent 50% or more of their time on solar-related work.

The majority of this growth was in the installation and project development sector, which now includes a total of 168,960 workers. This sector grew by 9.3% in 2021, adding 14,350 jobs. Demand-side sectors (installation and project development combined with wholesale trade and distribution) made up almost 77% of overall solar industry employment. In contrast, the manufacturing sector comprised only 13% of U.S. solar jobs, and operations and maintenance (O&M) and the "other" sectors each comprised about 5%.

These job gains occurred in a year of record solar installations, with 24 GW in new solar energy capacity added in 2021. These capacity gains were primarily driven by growth in consumer, business, and utility demand. Residential demand grew in the face of rising electricity prices and increased concerns over resilience. Both corporations and utilities are viewing solar as a low-cost, low-risk energy investment over the long term.

Solar jobs increased in 47 states in 2021, reflecting the industry's nationwide impact. California continues to lead in solar industry employment with 75,712 jobs, followed by Florida (11,761 jobs), Massachusetts (10,548 jobs), New York (10,524 jobs), and Texas (10,346 jobs). These are followed by Arizona, Colorado, Ohio, and Nevada, each with 7,000 to 9,000 jobs.

In 2021, California also led for the number of jobs added (7,035 new jobs), followed by Massachusetts (+1,053 jobs), Nevada (+1,019 jobs), and Arizona (+932 jobs). Other strong growth states were Ohio, North Carolina, New Jersey, and Georgia, each with 800–900 new jobs.

Since 2011, solar energy has grown dramatically in terms of both jobs and electricity generation capacity as installation costs have plummeted and supportive policies have driven growth. Over the last decade, solar employment has more than doubled from 105,145 jobs in 2011 to 255,037 jobs in 2021. The most significant growth has taken place in the installation and project development sector, which has grown 247% to reach 168,960 jobs, or 3.5 times the number of jobs in 2011.

Looking back to 2019, solar jobs grew a net 2% over the two-year period, including a 5% growth in the installation sector. As such, the 2021 growth

represents a recovery from a decline in solar jobs that can be largely attributed to the pandemic. During the same period, annual installed capacity grew by 78%. This trend indicates significant gains in productivity over the last few years and the recent dominance of the utility-scale market segment, which is more labor-efficient and requires fewer jobs per megawatt (MW) of installed capacity.

The solar industry employs over twice as many workers as the coal industry, and ranks third in total employment among energy industry sectors. The solar industry's high growth rate requires more workers to construct these new projects.

This report represents U.S. solar jobs as of 2021. Since then, the supply chain shortages that have developed since the pandemic have slowed growth and the solar industry has faced new policy challenges, notably a market-disrupting trade petition in the first part of 2022. **Looking to the years ahead, federal, state, and local policy developments will have a pivotal impact on the growth of the solar industry and workforce.** If U.S. solar installations do ramp up over the coming years, significant job growth can be expected to follow. Above all, the *U.S. Solar Jobs Census* series has shown that the clean energy transition represents a historic opportunity for American workers.

Solar Workforce Characteristics

Like other comparable industries, the solar industry still has more work to do to meet its goals for diversity, equity, and inclusion. Women made up just under 30% of solar employees in 2021, well below the 47% of women in the overall U.S. workforce. Black employees made up 8% of the solar workforce in 2021, which is below their 12% representation in the national workforce.

A majority of solar firms have not developed a strategy to increase the diversity of their workforce. Only 31% of firms reported strategies, policies, or programs to increase the number of female hires, while 26% had a strategy to increase ethnic or racial minority hires, and 8% had a strategy to increase LGBTQ+ hires.

The solar industry can be a path to rapid career advancement, including for those without a two- or four-year college degree. Less than one-third of entry-level solar jobs (31%) require a bachelor's degree and less than 20% require previous experience or knowledge.

Solar firms take an active role in helping employees increase their skill levels and develop their careers. Two-thirds of the firms surveyed (65%) provide on-the-job training.

Eighty-nine percent of firms surveyed in 2021 reported difficulty finding qualified applicants, including 35% that said it was "very difficult" and 54% reporting it was "somewhat difficult." When asked for the most significant reasons for difficulty hiring, half (49%) of solar firms noted competition and a small applicant pool, while 30% mentioned lack of experience, training, or technical skills.

Solar Employment Trends

The *National Solar Jobs Census* is the annual review of employment in the U.S. solar energy industry, now published by the Interstate Renewable Energy Council (IREC).[i] This report provides original data on the solar industry's role as a job creator and economic engine over the past 12 years, along with detailed information on the U.S. solar workforce. It represents the most comprehensive and rigorous analysis of solar labor market trends in the United States.

As of December 2021, the solar industry supported 255,037 jobs in all 50 states, the District of Columbia, and Puerto Rico. This represents an increase of 9.2%, or 21,563 more jobs, since the 2020 *Solar Jobs Census*.[ii] This jobs total includes all employees who spent 50% or more of their time on solar-related work. Looking back to 2019, solar jobs grew 2% over the two-year period, including a 5% growth in the installation sector. As such, the 2021 growth represents a recovery from a decline in solar jobs that can be largely attributed to the pandemic.

The majority of the growth between 2020 and 2021 was in the installation and project development sector, which added more than 14,000 jobs to reach a total of 168,960 workers, representing 9.3% growth (see Solar Jobs by Sector, p. 19). Solar jobs also increased in 47 states compared to 2021 (see Solar Jobs by State, p. 16).

Since 2010, solar energy has grown dramatically in terms of both jobs and electricity generation capacity as plummeting installation costs and supportive policies have driven growth (Figure 1). Costs for residential solar dropped by half from above $6/watt to just over $3/watt in 2021. Similarly, nonresidential and utility-scale solar costs are about a fourth of what they were in 2010.[iii] These cost declines have driven solar deployment and jobs. Solar employment grew by 173% from 2010 to 2021, adding 161,535 jobs. The solar industry added more than 28 times the amount of solar capacity in 2021 (24 GWdc) compared to 2010 (849 MWdc).[1] In 2021, solar energy provided 3.9% of the nation's electricity.[2]

Since 2011, solar employment has more than doubled from about 105,000 to 255,000 jobs. The most significant growth has taken place in the installation and project development sector, which has grown 247%, or 3.5 times the number of jobs in 2011 (Figure 2). Complete data for solar jobs by sector since 2010 is available at https://irecusa.org/programs/solar-jobs-census/.

In 2021, in addition to the 255,037 workers spending the majority of their time on solar, there were an additional 78,850 workers who spent less than half their time on solar-related work. This results in a total of 333,887 workers who spent all or part of their time on solar, a 5.4% increase from 2020 (17,212 more jobs). However, it marks a 3.4% decrease from the 345,939 workers who spent all or part of their time on solar in 2019.[iv] These trends suggest that a greater portion of the workforce has shifted to working full-time or nearly full-time in solar.

i The *National Solar Jobs Census* reports for 2010-2019 were published by The Solar Foundation, which merged with IREC in 2021. The 2020 *National Solar Jobs Census* was published by the Solar Energy Industries Association, The Solar Foundation, and IREC. Reports for all previous years can be downloaded at SolarJobsCensus.org.

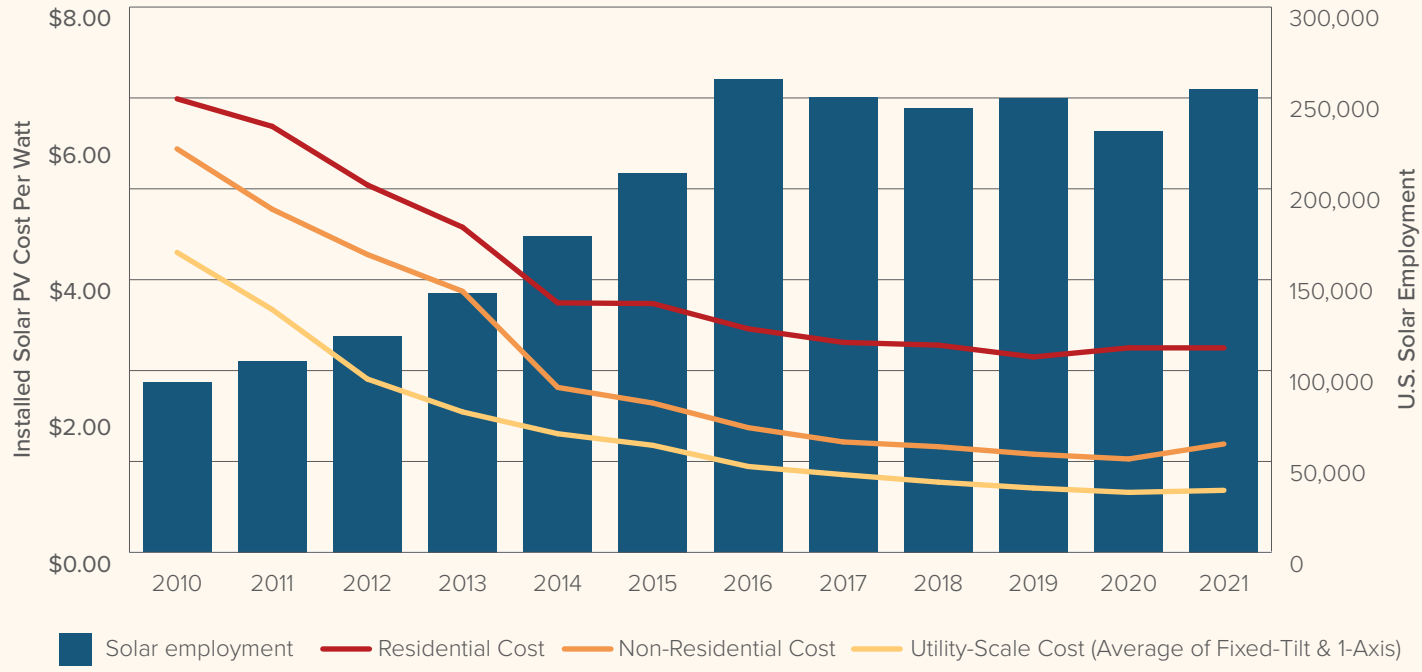
ii Puerto Rico had roughly 2,000 jobs in both 2019 and 2021. Puerto Rico jobs were not counted in 2020. Assuming 2,000 Puerto Rico jobs in 2020, the 2021 increase in total solar jobs is 9.2%.

iii The report covers four market segments: 1. Residential: Solar that supports a residential load (electricity use); 2. Commercial: Solar that supports a business, industrial, agricultural, school, government, or nonprofit load; 3. Community solar: Solar available to multiple customers who can subscribe to receive the power; and 4. Utility-scale: Solar that is provided to a utility, third-party power supplier, or commercial entity. Utility-scale projects are only classified as such if the power is supplied directly to the grid and not directly to the entity.

iv These figures represent solar jobs totals in the *U.S. Energy and Employment Report 2022* (USEER), published by the U.S. Department of Energy. The USEER methodology counts all workers who spend a portion of their time on solar work; USEER uses the same methodology for other energy industries. Since 2010, *Solar Jobs Census* totals have counted only those workers who spend 50% or more of their time on solar-related work.

Figure 1

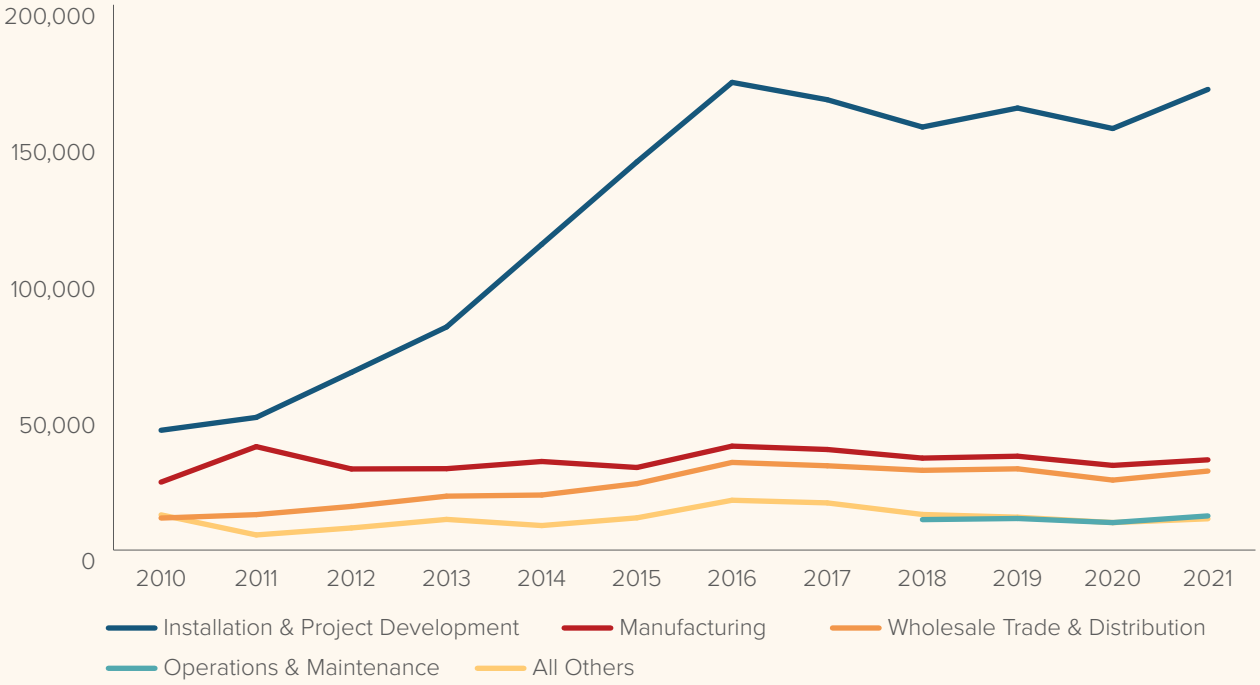
INSTALLED SOLAR PV COSTS BY SEGMENT COMPARED TO SOLAR EMPLOYMENT GROWTH, 2010-2021



Note: Puerto Rico employment figures were included in the overall solar jobs counts for 2018, 2019, and 2021, but were not available for any other years.
Sources: Interstate Renewable Energy Council, National Solar Jobs Census; Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), U.S. Solar Market Insight Q2 2022

Figure 2

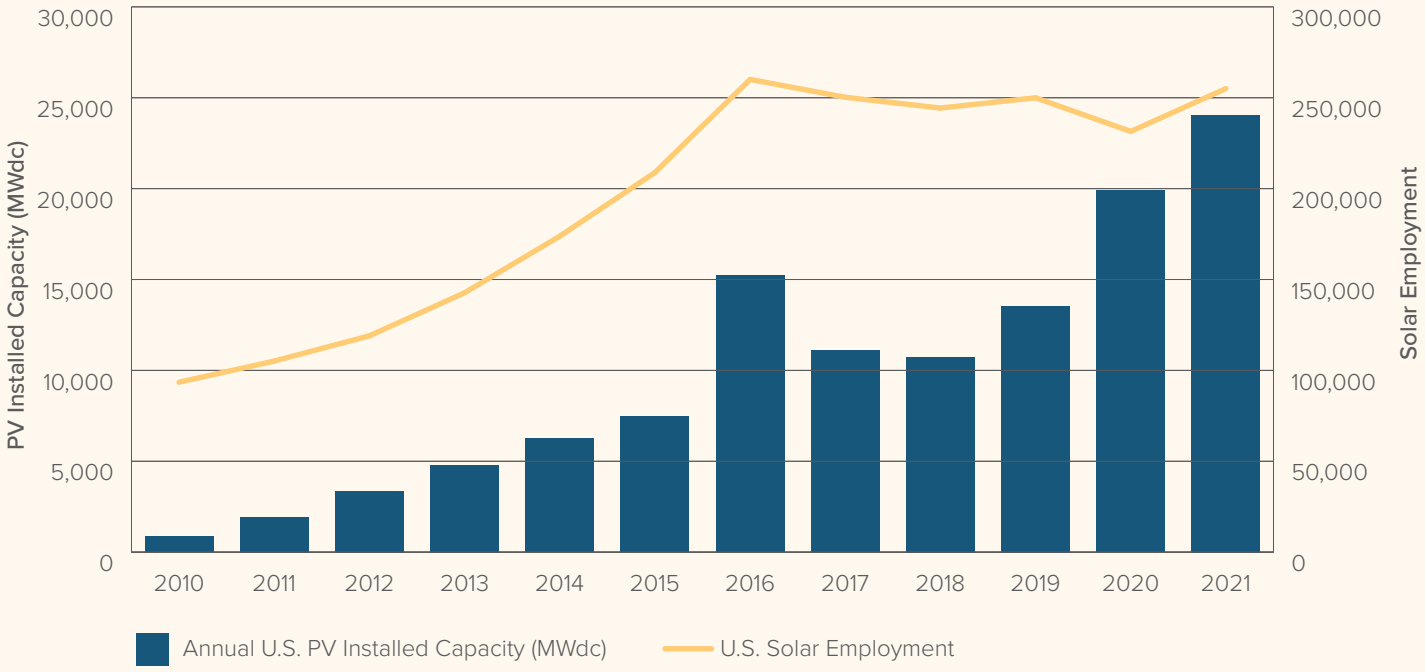
U.S. SOLAR EMPLOYMENT GROWTH BY SECTOR, 2010-2021



Note: Prior to 2018, O&M jobs were included in the "all others" category. Sector-level data for Puerto Rico were only included for 2019 and 2021.

The increase in solar jobs tracked closely with the level of newly installed solar generating capacity through 2016, but less so thereafter (Figure 3). While employment grew a net 2% from 2019 to 2021, installed capacity grew by 78%. This trend reflects significant gains in productivity over the last few years and the recent dominance of utility-scale solar, which requires fewer jobs per MW of installed capacity. In 2018, the utility-scale segment represented 57% of all solar deployment. By 2021, it represented 71% of total installed capacity.[3] During the pandemic lockdown periods, utility-scale solar development was seen as an essential business so most of these projects continued.

Figure 3
ANNUAL INSTALLED SOLAR PV CAPACITY COMPARED TO SOLAR EMPLOYMENT GROWTH, 2010-2021



Note: Puerto Rico employment figures were included in the overall solar jobs counts for 2018, 2019 and 2021, but were not available for any other years.
Sources: Interstate Renewable Energy Council, National Solar Jobs Census; Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), U.S. Solar Market Insight Q2 2022

In addition to the 255,037 workers spending the majority of their time on solar, there were an additional 78,850 workers who spent less than half their time on solar-related work.

The 24 GW in new solar energy capacity added in 2021 was 21% above the 19.9 GW total for 2020.[4] This growth reflects an increase in all solar industry segments, but especially for residential rooftop and utility-scale development. The more labor-intensive residential sector grew by 31% in 2021 to a record 4.2 GW. The utility-scale segment also experienced a bump in growth with 17 GW of solar deployed, a 19% increase over 2020. The nonresidential market only grew 2.5%, although if community solar is included, it experienced growth of 13% over 2020.[5]

Reasons for Growth

Several factors are behind the solar jobs growth for 2021. First, there was an overall economic recovery because of declining concerns about the COVID-19 pandemic. Solar firms, like many other businesses, hired staff as the economy recovered and related business activity grew. As we have discussed, there was significant growth in installed capacity, including in the more labor-intensive residential sector. Growth in installed capacity was primarily driven by growth in consumer, business, and utility demand. Residential demand grew in the face of rising electricity prices and uncertainty about future price increases. Resiliency was also a concern in states such as California, which has experienced power outages related to severe weather or fires.

Utility-scale demand growth was also pushed by growing corporate interest in renewable energy. Many companies are seeking to improve their brands and appeal to Environmental, Social, and Governance (ESG) investors by setting and achieving aggressive clean energy goals and investing in solar to power their facilities. Both corporations and utilities are viewing solar as a low-cost, low-risk energy investment over the long term. A decrease in the cost of batteries made solar and storage systems more appealing (see box, p. 22).

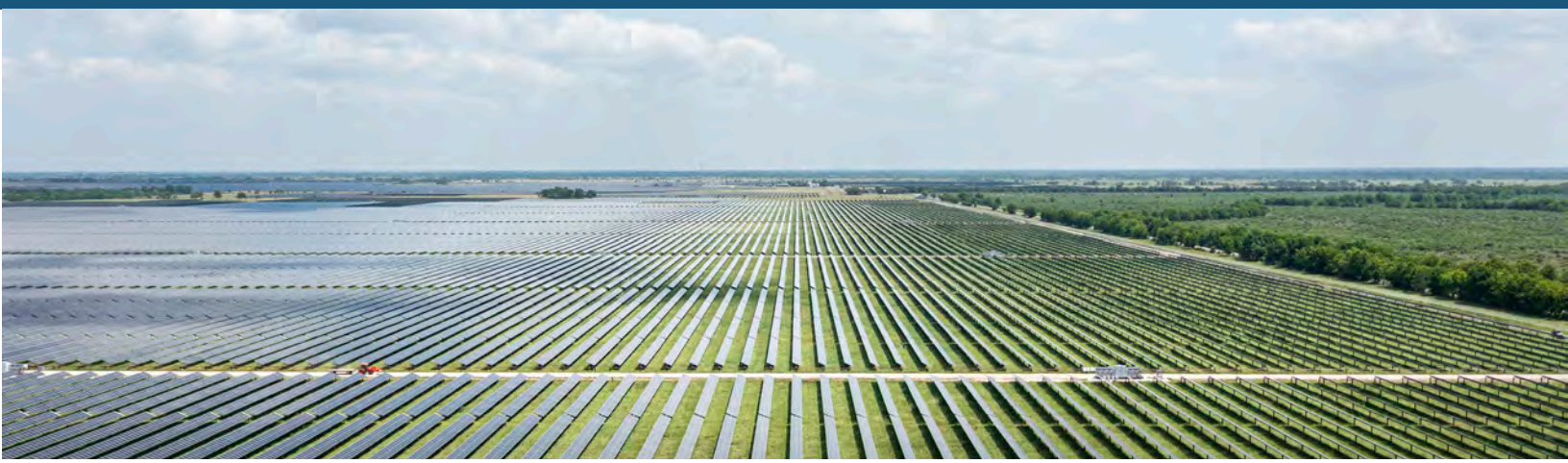
Policy action also influences growth. Developers continue to pursue new projects while the national solar investment tax credit (ITC) remains a strong incentive. After dropping from 30% to 26% in January 2020, the ITC is scheduled to drop to 22% in January 2023 for all segments. Absent new legislation, the ITC is scheduled to further drop to 10% for commercial and utility-scale and zero for residential in January 2024. Therefore, developers continue to push new projects in order to be able to claim a favorable ITC while it lasts.

Other factors favor growth. Coal plants are retiring in the face of declining profits, uncompetitive prices, and preferences for cleaner energy. Meanwhile, projects have been slowed by pandemic-induced supply chain issues. Supply chain constraints have slowed the flow of needed parts, and given the growing demand, resulted in increased prices. In

2021, solar prices increased about 5% for residential and 14%–18% for commercial and utility-scale solar, depending on system configuration.[6]

While impactful in 2021, these supply chain constraints are expected to impose a more significant barrier to growth in 2022. Solar deployment declined in Q1 2022 with supply chain constraints cited as a factor.

Despite the supply chain headaches, solar costs remain below those of fossil fuels. The unsubsidized levelized cost of energy for utility-scale solar ranged from $28–$41/MWh. By comparison, the lowest-cost fossil fuel option, gas combined cycle, ranged from $45–$74/MWh.[7] Since Russia's invasion of Ukraine in February 2022, the prices for fossil fuels have risen dramatically, making solar even more cost competitive.



Solar Jobs by State

While solar jobs are found in all 50 states, many of them are concentrated in some key locations (Figure 4). With 75,712 jobs, California continues to lead in solar employment, followed by Florida (11,761 jobs), Massachusetts (10,548 jobs), New York (10,524 jobs), and Texas (10,346 jobs). These are followed by Arizona, Colorado, Ohio, and Nevada, each with 7,000 to 9,000 jobs.

In 2021, solar jobs grew in 47 states, as shown in Figure 5. California led with 7,035 new jobs, followed by Massachusetts (+1,053 jobs), Nevada (+1,019 jobs), and Arizona (+932 jobs). Other strong growth states were Ohio, North Carolina, New Jersey, and Georgia, each with 800–900 new jobs, as shown in Table 1. Georgia also experienced a significant percentage gain in jobs (19%), although Alabama was the state with the largest proportional job growth (43%). A cohort of states with small but growing solar markets, including Nebraska, North Dakota, Idaho, West Virginia, Kentucky, and Montana, grew 18–24%.

Figure 4
2021 SOLAR JOBS BY STATE

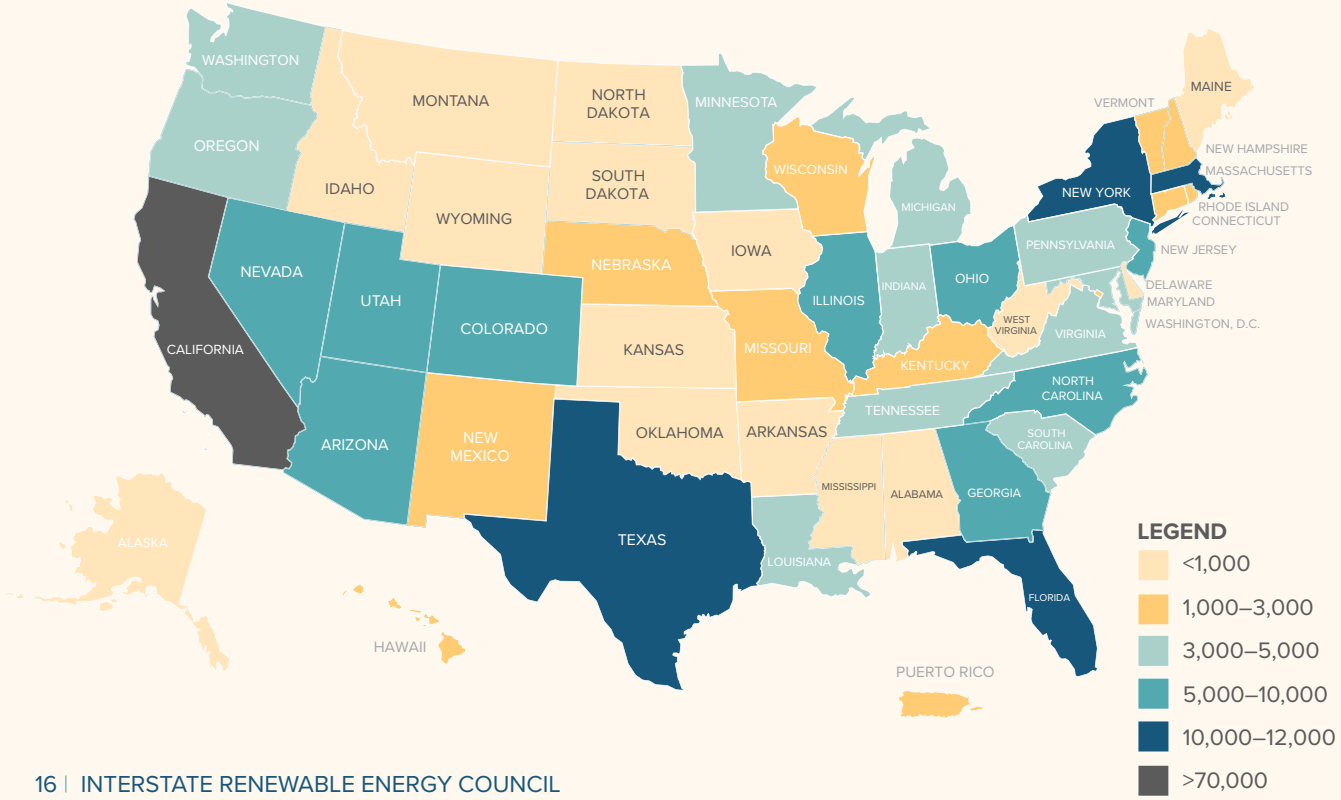


Figure 5

2021 SOLAR JOB GROWTH BY STATE

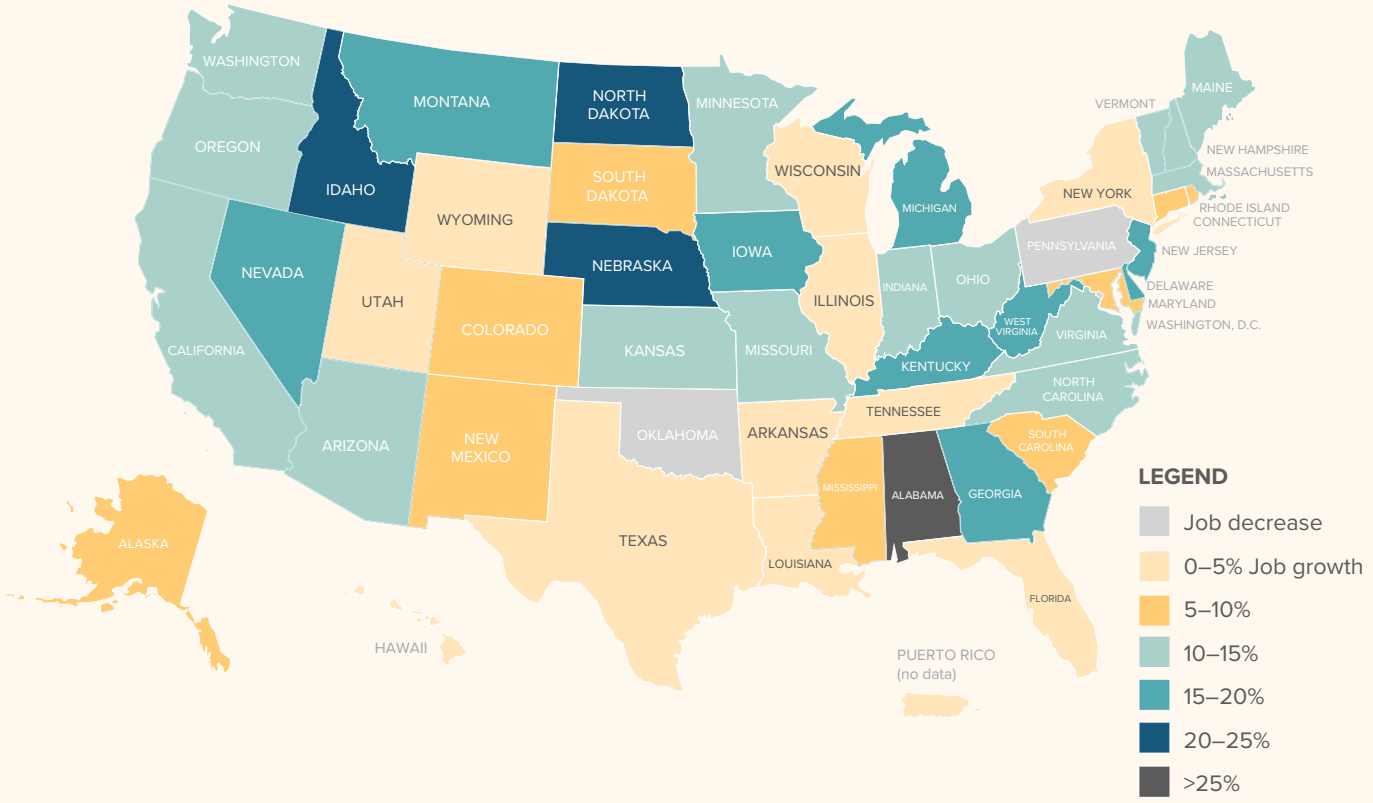


Table 1

TOP 10 STATES FOR SOLAR JOB GROWTH, 2021

State	2021 Jobs	2020 Jobs	Jobs Added 2020–2021	% Increase
California	75,712	68,677	7,035	10.2%
Massachusetts	10,548	9,495	1,053	11.1%
Nevada	7,193	6,174	1,019	16.5%
Arizona	8,278	7,346	932	12.7%
Ohio	7,411	6,532	879	13.5%
North Carolina	6,978	6,107	871	14.3%
New Jersey	6,237	5,384	853	15.8%
Georgia	5,314	4,466	848	19.0%
Colorado	7,426	6,771	655	9.7%
Minnesota	4,570	3,993	577	14.4%

A table listing solar jobs in all 50 states, the District of Columbia, and Puerto Rico, along with the gains or losses compared to 2020, can be found in Appendix A (p. 40).

In general, state policies continued to support solar energy growth in 2021. States continue to implement aggressive clean energy programs to help meet their clean energy goals. For example, New York enacted legislation in 2019 that requires a doubling of distributed solar deployment to 6,000 MW by 2025.[8] Illinois passed a law requiring 40% of electricity to come from renewable sources by 2030.[9] South Carolina reached a multi-party agreement among regulators, the solar industry, and utilities on net metering, which will add much needed certainty for solar investment.[10] Nonetheless, utilities and state regulatory and political leaders continue to challenge net metering policies nationwide, with significant changes expected in California (see box, p. 26).

Puerto Rico at a Crossroads

Five years after Hurricanes Maria and Irma, Puerto Rico has reached a turning point on its path to a clean energy future. Policymakers and regulators have the opportunity to use billions of dollars in reconstruction funds to invest in renewable energy sources like solar energy, battery storage, and energy efficiency. The direction Puerto Rico takes could set an example for other U.S. jurisdictions and vulnerable regions around the world.

Solar energy is an abundant resource in Puerto Rico with the potential to drive job creation and economic growth. The island has 1,985 solar industry jobs as of 2021, a figure largely unchanged from 2019.[v] However, a law enacted in 2019 requires Puerto Rico to obtain 40% of its electricity from renewable sources by 2025, and 100% by 2050.[11] Our research shows that meeting these goals would lead to 20,000 solar jobs by 2030.[12]

Nonetheless, officials with the Puerto Rico Electric Power Authority (PREPA) have already said they will be unable to meet the 2025 goal (only 4% of the island's electricity now comes from renewables).[13] Chronic underinvestment in the modernization of the electrical grid has reduced the capacity for rapid investment in distributed energy resources and battery storage. Puerto Rico also faces an urgent electricity reliability crisis. A private company, LUMA Energy, took over management of the transmission and distribution system from PREPA in June 2021 and recently proposed a 17% rate increase, on top of about five other increases already implemented.[14] Blackouts remain frequent, and in April 2022 a fire at a power plant left over a million people without power.[15]

Fortunately, solar paired with battery storage is rapidly gaining popularity as a way to provide affordable electricity and offer emergency backup power independent from the grid. Rooftop solar capacity has more than doubled since the 2017 hurricanes, now totaling over 315 MW, with most recent installations including battery storage.[16] PREPA has also committed to provide contracts for 3.5 GW of renewable energy and 1.5 GW of storage.[17]

In February 2022, three federal agencies announced a memorandum of understanding with Puerto Rico to accelerate the clean energy transition. The agreement, which includes the U.S. Department of Energy, Department of Homeland Security, and Department of Housing and Urban Development, clarifies that $12 billion in reconstruction spending must be in line with the clean energy law, which could set the stage for a historic level of resources to support clean energy development.[18] Meanwhile, nonprofit organizations including IREC are leading innovative solar microgrid projects to promote energy security in rural communities, along with training programs that encourage the growth of a skilled and diverse workforce.[19] There are also ongoing initiatives to increase accessibility to solar financing for business and residential customers.

v The *Solar Jobs Census* did not survey Puerto Rico in 2020.

Solar Jobs by Sector

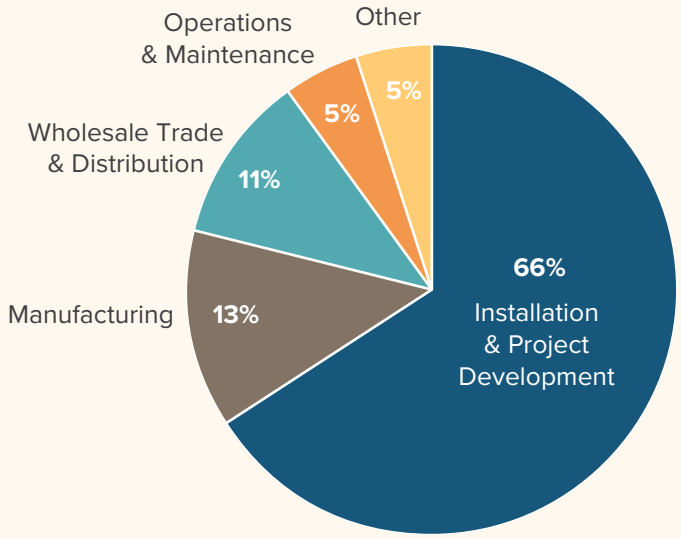
The *National Solar Jobs Census* reports on jobs by industry sector: installation (including project development), wholesale trade and distribution, manufacturing, operations and maintenance (O&M), and the "other" category.[vi] In 2021, demand-side sectors (installation and project development combined with wholesale trade and distribution) made up almost 77% of overall solar industry employment (Figure 6). In contrast, the manufacturing sector comprised only 13% of U.S. solar jobs, and O&M and the "other" sectors each comprised about 5%.

The installation and project development sector was responsible for most of the job gains between 2020 and 2021. This sector added more than 14,000 jobs to reach a total of 168,960 workers, representing 9.3% growth (Table 2). Meanwhile, the manufacturing sector grew by just over 2,000 jobs, the wholesale trade and distribution sector grew by just over 3,300 jobs, and the "other" category grew by just under 1,400 jobs.[vii] Finally, operations and maintenance (O&M) grew at the largest rate of any sector (24.3%), with an increase of just over 2,400 jobs. As solar deploys at record amounts, there will be more need for O&M staff. (*A spreadsheet with complete data on solar jobs by sector since 2010 can be found at https://irecusa.org/programs/solar-jobs-census/*.

vi The jobs per industry sector are calculated based on the type of solar establishment, rather than an individual employee's work activities. For example, a sales representative at a solar installation establishment would be classified within the installation sector.

vii The main types of firms included in the "other" category include research & development and related services, consulting, engineering, finance, legal, and other professional and support services. Until 2018, the "other" category also included O&M.

Figure 6
U.S. SOLAR EMPLOYMENT BY SECTOR, 2021



Note: Figures are rounded to the nearest whole number.

The *Solar Jobs Census* further breaks down the installation and project development sector into market segments: residential, commercial, community solar, and utility-scale (Figure 7). Although utility-scale represents the largest segment by solar capacity (64% of the total), it has considerably fewer installation and project development jobs than the other two segments. The reason is that the utility-scale sector has higher labor productivity and greater economies of scale due to the relatively low transaction costs per unit of capacity deployed. The more labor-intensive residential sector represents just over half of all jobs (85,305). Commercial and utility-scale each represent about 20% of the total installation and development jobs with 34,329 and 33,808 jobs, respectively. Community solar represented about 9%, or 15,517, of the total installation jobs.

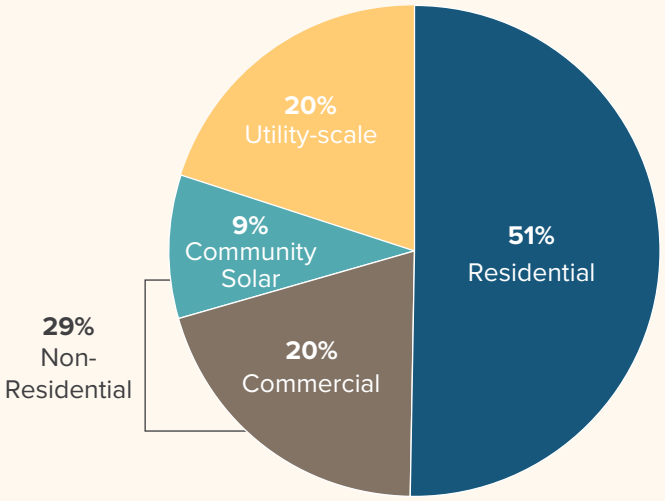
Table 2
U.S. SOLAR EMPLOYMENT GROWTH BY SECTOR, 2021

Sector	2021 Employment	2020 Employment	2019 Employment	Jobs Added, 2020-2021	% Growth, 2020-2021	% Growth, 2019-2021
Installation & Project Development	168,960	154,610	162,126	14,350	9.3%	4.2%
Manufacturing	33,099	31,050	34,423	2,049	6.6%	-3.8%
Wholesale Trade & Distribution	28,978	25,663	29,798	3,315	12.9%	-2.8%
Operations & Maintenance	12,530	10,077	11,583	2,453	24.3%	8.2%
All Others	11,471	10,073	12,053	1,398	13.9%	-4.8%
TOTAL*	**255,037**	**231,474**	**249,983**	**23,563**	**10.2%**	**2.0%**
REVISED TOTAL*	**255,037**	**233,474**	**249,983**	**21,563**	**9.2%**	**2.0%**

Note: Puerto Rico jobs were not included in the 2020 National Solar Jobs Census. The revised total assumes 2,000 Puerto Rico solar jobs in 2020, consistent with the number of jobs in 2019 and 2021.
**The overall totals presented in the table above may be slightly off due to rounding.*

Figure 7

SOLAR INSTALLATION AND PROJECT DEVELOPMENT JOBS BY SEGMENT, 2021



Note: Figures are rounded to the nearest whole number.

Solar installers were also asked to identify jobs in their organizations that primarily work on battery storage. Establishments working in the broader solar industry reported that in addition to the 255,037 jobs focused primarily on solar, another 21,910 installation jobs are focused on storage.[viii] When battery storage jobs outside the solar sectors are included, there are a total of 69,698 jobs related to storage, including employment in the electric vehicle industry (see box, p. 22).

viii These jobs are not included in the solar industry job counts.

State Interconnection Reforms Encourage Growth of Distributed Solar

Interconnection regulations—the "rules of the road" for integrating distributed energy resources (DERs) onto the grid—can have a critical impact on the growth of residential and commercial solar energy and associated job growth. A growing number of states are recognizing the role of interconnection in supporting the rapid and cost-efficient scale-up of DERs. While each state's rules and each utility's distribution system include unique features, they face a number of common regulatory and technical barriers, along with common solutions.

1. **Timeline and Process Delays.** Inefficiencies throughout the interconnection process can cause significant delays and added costs. Solutions include revising timelines to reflect best practices, updating screening and study processes to make reviews more efficient, and including penalties and rewards for under-/overachievement of performance metrics. Illinois, for example, recently adopted new interconnection rules that improve the way projects are screened in order to reduce the need for lengthy studies.[20]

2. **Unsupportable Grid Upgrade Costs.** As DER market penetration grows, interconnection customers in many states are often facing hefty grid upgrade costs in areas where there is little to no remaining hosting capacity (the amount of additional DER capacity the grid can support without upgrades). Solutions include grid transparency tools, such as hosting capacity analysis maps, which enable customers to design their systems in a way that minimizes grid impacts or to select areas of the grid that are less likely to require upgrades.[21] In June 2022, California regulators issued a landmark decision to base the review of DER projects on such maps, in a ruling that could be a model for other states.[22]

3. **Special Considerations for Energy Storage.** Most state interconnection rules do not address storage in a way that enables its valuable operating capabilities, which often creates delays and added costs in the storage interconnection process. Solutions include updating interconnection procedures to be inclusive of storage, which IREC and a team of partners addressed in a new *Toolkit and Guidance for the Interconnection of Energy Storage and Solar-Plus-Storage*.[23]

The *National Solar Jobs Census* survey also compares employment by occupational category. While the solar jobs by sector are based on the primary category of the surveyed *company*, occupational categories data report on *individual job roles* (Table 3). For example, while 66% of solar jobs are in the installation sector (firms that primarily engage in installation and project development), only 37% of installation and project development firm staff work directly in installation or repair. Similarly, the manufacturing sector comprises 13% of solar jobs, but those in manufacturing occupations make up only 7.7% of jobs across all sectors (and a third of those in manufacturing). Manufacturing and production occupations can include an array of titles such as assemblers, fabricators, welders, cutters, solderers, and machinists, some of which can be found in non-manufacturing firms. And some manufacturing firm employees may work in areas such as sales, management, or other occupations.

Table 3

U.S. SOLAR WORKERS BY OCCUPATIONAL CATEGORY, 2021

	Production/ Manufacturing	Installation or Repair	Administrative	Management/ Professional	Sales	Other
Installation & Project Development	2.7%	37.1%	19.3%	15.0%	21.0%	4.9%
Wholesale Trade & Distribution	9.1%	16.8%	26.8%	20.9%	19.0%	7.4%
Operations & Maintenance	7.0%	22.1%	17.5%	29.5%	15.2%	8.7%
Manufacturing	32.7%	12.0%	17.4%	14.6%	13.2%	10.2%
All Others	7.9%	9.8%	17.7%	42.3%	10.0%	12.3%
Overall	**7.7%**	**29.7%**	**19.7%**	**17.5%**	**19.0%**	**6.4%**

SOLAR MANUFACTURING TRENDS

Manufacturing of solar balance of system (BoS) components such as racking, trackers, and mounting systems makes up the bulk of the domestic solar manufacturing employment. Many of these supplies are sourced domestically (in contrast to solar panels, the majority of which are sourced overseas). When asked to identify the primary source of their supply chains, installation and project development firms reported that 83% of their supplies came from within the U.S. Only 17% of their supplies were from outside of the U.S. In contrast, manufacturers report that 39% of their supplies were from overseas (Table 4). Wholesale trade and distribution firms reported about a third of their supplies were from overseas.

Table 4

SOURCE OF SOLAR INDUSTRY SUPPLY CHAIN PURCHASES BY SECTOR

	In-State	Out of State but in the United States	Outside of the United States
Installation & Project Development	41.7%	41.4%	16.9%
Manufacturing	23.7%	37.3%	39.0%
Wholesale Trade & Distribution	22.3%	45.1%	32.6%
Operations & Maintenance	39.7%	45.4%	15.0%
All Others	35.5%	39.1%	25.5%
Total	**48.2%**	**33.4%**	**18.4%**

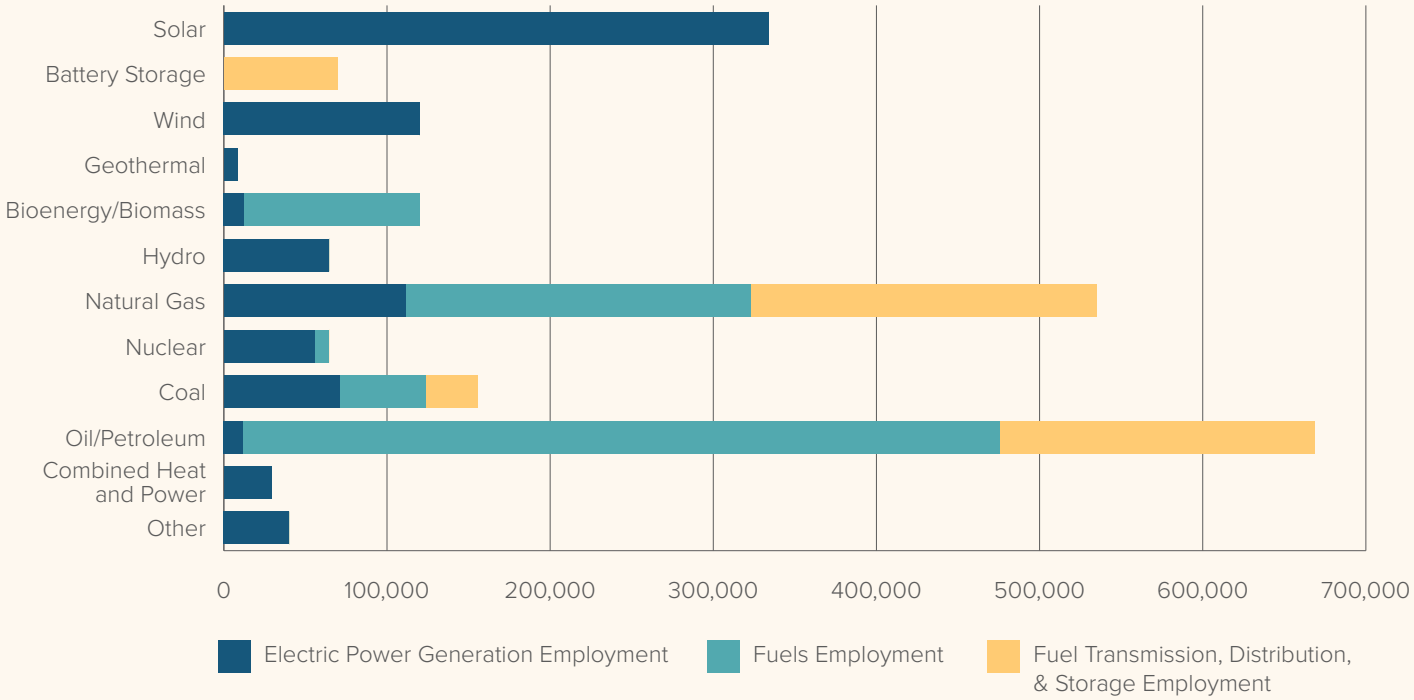
While solar modules are primarily imported, U.S. module production has been growing. Domestic module production has grown from 966 MW in 2017 to 3,551 MW in 2019 and 4,755 MW in 2021. Wood Mackenzie reports that more than 7 GW in potential new domestic module manufacturing capacity has been announced within the past year.[24]

Solar Jobs Compared to Other Energy Industries

The solar industry employs over twice as many workers as the coal industry, and ranks third in total employment among energy industries, behind only petroleum and natural gas (Figure 8).[ix] Unlike petroleum and natural gas, solar employment is primarily needed to develop the infrastructure to generate renewable energy sources, and there are no fuel-related costs. Therefore, solar currently employs more workers per unit of generation compared to fossil fuel sources. The solar industry's high growth rate requires more workers to construct these new projects.

ix This comparison is based on data from the *U.S. Energy and Employment Report 2022*. This report includes solar workers who spent less than half of their time on solar-related work, for a total of 333,887 solar employees.

Figure 8
U.S. SOLAR JOBS COMPARED TO OTHER ENERGY RESOURCES, 2021



Note: For comparison purposes, the number of solar jobs includes all workers who spent any portion of their time on solar-related work. The National Solar Jobs Census only includes workers who spend 50% of their time or more on solar-related work.
Source: U.S. Department of Energy, United States Energy & Employment Report 2022

Energy Storage on a Tear

The battery energy storage market is experiencing dramatic growth. In 2021, U.S. storage deployment grew by over 3.5 GW, which is double the 2020 deployment and seven times the 2019 level.[25] As with solar PV, this growth is driven by declining costs and favorable policies. In 2021, four-hour duration batteries for utility-scale projects averaged $287/kWh ($1,148 per kW), down from about $400/kWh several years ago.[26] The price honeymoon may be ending, at least temporarily, as raw material prices are skyrocketing. For example, lithium prices have shot up almost five-fold from September 2021 to July 2022 and 71% since the beginning of 2022.[27]

On the policy front, the bipartisan infrastructure law enacted in November 2021 directs over $7 billion in support of the U.S. battery supply chain.[28] In May 2022, the U.S. Department of Energy announced the pending release of $3.1 billion of that funding to support the "creation of new, retrofitted, and expanded commercial facilities as well as manufacturing demonstrations and battery recycling."[29] This follows the recent Biden Administration announcement to invoke the Defense Production Act to support the mining of rare earth metals needed for battery production.[30]

Long-Term Trends for Solar Jobs

Solar energy has rapidly taken hold in the United States. With about 120 GW of total capacity nationwide, solar energy is the nation's fastest growing electric energy source. In 2021, new solar energy installations accounted for 46% of all new electricity generating capacity, followed closely by wind energy at 44%.[31] Alongside this expansion in solar energy use has been the growth of hundreds of thousands of jobs in all regions of the country.

As we have seen, however, labor efficiency gains in the industry caused the number of jobs per MW of installed capacity to decline over recent years.[32] The past five years (2016-2021) have seen a net decline in solar jobs, in part because 2016 was an anomaly, when solar jobs increased by 25% to 260,077 workers. That year, solar developers had rushed to complete projects ahead of an expected sunset of the ITC. This activity led to what was then a record amount of installed capacity and the highest solar job total of any year.[x] Installed capacity did not exceed the 2016 level until 2020 (and again in 2021).

The growth in solar installations is expected to slow down in 2022 given the challenges with the supply chain that were exacerbated by a series of trade petitions that disrupted the market. In the second half of 2021, the U.S. Department of Commerce considered an anonymous petition for a tariff circumvention investigation that was ultimately rejected.[33] Then in March 2022, based on a petition filed by Auxin Solar, the Commerce Department announced an anti-dumping investigation into solar cells and modules imported from Malaysia, Thailand, Cambodia, and Vietnam.[34] The resulting uncertainty caused major disruptions in the market and led the solar industry to delay or cancel projects.

In June 2022, the Biden Administration placed a two-year moratorium on any yet-to-be determined tariffs, while authorizing use of the Defense Production Act to support domestic manufacturing of solar components. Nevertheless, Wood Mackenzie Power and Renewables expects 2022 installed capacity to drop about 28% from 2021 to about 17.2 GW in 2022.[35] While residential growth is expected to continue with modest gains, this growth is expected to be offset by a decline in other segments (particularly utility-scale) that are more sensitive to trade disruptions and supply chain impacts.[36]

x The ITC was extended in December 2015, but not until after many projects were well into the development process.

Responses from *National Solar Jobs Census* survey suggest the solar industry expects employment growth of 3.8% in 2022, bringing the total to about 265,000 jobs. Firms focused on installation also expect 3.8% growth, adding just over 6,400 jobs—by far the most of any sector. Wholesale trade and distribution is expected to grow 6.6% or 1,900 jobs, and manufacturing is expected to experience 6.1% growth, adding about 2,000 jobs over the coming year. Jobs in the "other" category are expected to grow by 1.1%. **It is important to note that these are only survey projections based on responses collected between January and April in 2022, prior to respondents seeing the full effects of the circumvention investigation.** Future employment trends will be influenced by many unpredictable factors, including economic conditions, access to capital, and policy shifts at the federal and state levels.

Looking to the years ahead, policy developments could have a pivotal impact on the growth of the solar industry and workforce. In 2021, Congress considered but failed to enact Build Back Better legislation that could have included far-reaching incentives to reduce carbon emissions and expand renewable energy use.[37] This year, lawmakers may take up more limited clean energy policies such as an extended ITC and new tax credits for solar manufacturing; at this writing, however, new federal incentives appear unlikely to pass as part of a comprehensive package.[38] The *U.S. Solar Market Insight* estimates that adopting the ITC extension and other incentives could lead to nearly 700 GW of solar installed by 2032, or 66% above business as usual.[39] State and local policies including renewable energy targets, grid interconnection reforms, and workforce development programs will also be crucial to future growth, particularly in the absence of new federal policies.

If U.S. solar installations do ramp up over the coming years, job growth can be expected to follow. The Solar Energy Industries Association has estimated that if solar energy reaches 30% of U.S. electricity generation (or 850 GW in total capacity), the industry could employ more than one million Americans by 2030.[40] Above all, the *U.S. Solar Jobs Census* series has shown that the clean energy transition represents a historic opportunity for American workers.

A Note on the Methodology

The *National Solar Jobs Census 2021* includes data gathered from the *U.S. Department of Energy's U.S. Energy and Employment Report (USEER) 2022* survey between January 13, 2022 and April 18, 2022. A supplemental follow-up survey of solar establishments that participated in the USEER survey was administered in order to collect additional information, along with solar jobs data for Puerto Rico. Full information on the methodology is in Appendix B (p. 42).

The *National Solar Jobs Census* applies a rigorous test in counting solar jobs across the United States. Since 2010, this report has defined a solar job as one held by an employee spending at least 50% of their time on solar-related work. *Census* findings have consistently shown that roughly 90% of these workers (91.7% in 2021) spend 100% of their time on solar-related work.

A New Era for Net Metering

Over the last two decades, net metering or net energy metering (NEM) has been a major economic engine for rooftop solar and other forms of distributed generation (DG), which refers to power generated to meet an onsite load. Under NEM, unused or excess power is returned to the grid and credited to the home or business at the same retail rate that it is charged.

As of August 2021, 39 states, the District of Columbia, and four territories required some of their utilities to offer NEM for solar (down from 44 states in 2015).[41] Net metering has undergone more scrutiny in the last few years, especially in states where solar penetration levels are high. Utilities are lobbying regulators and state legislators to reduce compensation or add fees for customers who export solar power to the grid. In 2021, there were 98 DG compensation policy actions, 43 residential fixed charge or minimum bill increase actions, and 25 DG valuation or net metering study actions across U.S. states.[42] Most of these actions were intended to weaken NEM benefits for solar customers.

To the degree that utilities are successful, weakened NEM regulations will likely reduce the investment return for distributed solar and curtail the industry's growth. Sometimes, however, states reject such proposals; in April 2022, Florida Governor Ron DeSantis vetoed legislation that would have phased out net metering and added new charges for solar customers.[43]

The most high-profile of these battles is underway in California. In December 2021, the California Public Utilities Commission (PUC) released a proposal known as NEM 3.0, which would reduce the rate paid for exported solar DG by 75-80% and tack on monthly fees for residential customers. California's residential and commercial solar markets were projected to decline by half in 2023 or 2024 once the current rule (NEM 2.0) expired.[44] The proposal led to considerable public opposition, so the PUC is reconsidering it. Nonetheless, it is expected that the final rule will significantly reduce investment returns for solar.

Other approaches have the potential to benefit both utilities and solar customers. More utilities are enacting variable rates which provide lower reimbursements for daytime power than for evening power, encouraging customers to co-locate batteries with their solar systems and store excess power during the day for use during the evening.[xi] California began compensating DG customers at variable rates (known as time of use rates) in 2016. By 2021, about 20% of new residential solar customers were adding batteries to their purchases.[45] South Carolina adopted a plan to enact time of use rate policies in 2021.

Hawaii has taken a more unique approach and offers cash for existing and new solar customers who add batteries to their system.[46] The utility also pays the retail rate for customer-exported power for a two-hour period (6:00–8:30 p.m.) as determined by the utility. Customers with solar and battery storage can participate.

xi Variable rates are already common for commercial customers.

DEMOGRAPHICS AND DIVERSITY

As of the *2021 Solar Jobs Census* survey, the demographic makeup of the solar industry by gender, race, and ethnicity was largely unchanged from 2020. The solar industry still has more work to do to reflect the diversity of the overall workforce and provide more equitable and inclusive work experiences for historically underrepresented groups, including women, the LGBTQ+ community, and Black, indigenous, and people of color (BIPOC) individuals.

Diversity, equity, and inclusion (DEI) has become a common term used by solar companies and many other industries. The *Solar Jobs Census* measures some aspects of the "diversity" part of DEI, mainly race, ethnicity, veteran status, union membership, and age. This year's report includes new data looking into the industry's DEI efforts and strategies.

Women made up just under 30% of solar employees in 2021, well below the 47% of women in the overall U.S. workforce (Table 5). Nonetheless, this marks a substantial increase since 2014, the first year the *Solar Jobs Census* tracked employee demographics, when women made up only 22% of the workforce. Black employees made up 8% of the solar workforce in 2021, which is below their 12% representation in the national workforce but an increase from 6% of the solar workforce in 2014. *A spreadsheet of solar industry demographics since 2014 is available at https://irecusa.org/programs/solar-jobs-census/.*

On the other hand, Hispanic or Latino workers made up 20% of the solar workforce compared to 18% nationwide. This is also an increase from making up 16% of the workforce in 2014. Asian employees made up 9% of the solar workforce compared to 7% of the overall economy. Representation of Asian employees has increased from 7% of the solar workforce in 2014.

Table 5
U.S. SOLAR WORKFORCE DEMOGRAPHIC BREAKDOWN, 2019-2021

	2019 % of Workforce	2020 % of Workforce	2021 % of Workforce	2021 Jobs
Women	26.0%	29.9%	29.6%	75,491
Hispanic or Latino	17.2%	19.6%	19.8%	50,497
American Indian or Alaska Native	1.2%	1.2%	1.2%	3,060
Asian	8.5%	9.2%	9.2%	23,463
Black or African American	7.7%	7.9%	8.2%	20,913
Native Hawaiian or other Pacific Islander	1.2%	1.3%	1.3%	3,315
White	73.2%	67.9%	72.0%	183,626
Two or more races	8.2%	8.7%	8.2%	20,913
Veterans	7.6%	8.7%	7.9%	20,148
55 and over	10.4%	11.4%	10.9%	27,799
Represented by a Union	-	-	10.1%	25,759

Veterans continue to be well-represented in the solar industry, where the technical and leadership skills acquired in the military can make them a good fit for both entry-level and advanced positions.[47] Eight percent of solar workers are veterans, compared to 6% in the overall workforce. The solar industry is predominantly made up of younger employees, with only 11% aged 55 and older. Ten percent of solar workers are represented by a union, above the 7% national private sector average.[48]

These findings show that when it comes to representation across gender, racial, and ethnic backgrounds, the solar industry can point to some successes and some areas to improve. When it comes to the areas for improvement, these challenges are by no means unique to solar and are shared by comparable industries. In construction, for example, only 11% of industry employees are female, compared to 28% in the solar installation sector. The solar manufacturing sector is 31% female, compared to 29% across all U.S. manufacturers (Table 6). Solar workforce demographics are comparable to the overall U.S. energy workforce, which is 25% female, 8% Black, and 17% Hispanic.[49]

Table 6

SOLAR WORKFORCE DEMOGRAPHICS BY SECTOR AND IN COMPARISON TO OTHER INDUSTRIES

	Female	Hispanic or Latino	American Indian or Alaska Native	Asian	Black or African American	Native Hawaiian or Other Pacific Islander	White	Two or More Races	Veterans	55 and Over
Solar Installation & Project Development	27.8%	20.0%	1.2%	7.8%	8.3%	1.1%	73.8%	7.8%	7.8%	10.0%
U.S. Construction	11.0%	32.6%	-	2.1%	6.3%	-	87.9%	-	4.6%	21.9%
Solar Wholesale Trade & Distribution	36.8%	19.7%	1.4%	10.4%	7.1%	2.4%	68.3%	10.4%	7.3%	10.4%
U.S. Wholesale Trade	29.8%	19.1%	-	5.4%	9.1%	-	82.6%	-	6.1%	27.3%
Solar Operations & Maintenance	28.5%	18.7%	0.7%	8.8%	8.6%	0.6%	77.1%	4.1%	8.1%	9.9%
U.S. General Repair & Maintenance	11.6%	25.0%	-	3.9%	7.8%	-	85.2%	-	-	23.7%
Solar Manufacturing	31.1%	19.6%	1.1%	15.0%	9.6%	1.3%	62.2%	10.9%	10.0%	14.3%
U.S. Manufacturing	29.2%	17.4%	-	7.1%	10.3%	-	79.5%	-	6.9%	25.6%
Solar All Others	35.2%	18.6%	1.4%	10.8%	6.0%	1.0%	75.1%	5.8%	6.0%	16.1%
Solar Overall	**29.6%**	**19.8%**	**1.2%**	**9.2%**	**8.2%**	**1.3%**	**72.0%**	**8.2%**	**7.9%**	**10.9%**
U.S. Workforce Overall	**47.0%**	**18.0%**	**-**	**6.6%**	**12.3%**	**-**	**77.5%**	**-**	**5.2%**	**22.4%**

Sources: Solar industry data from the National Solar Jobs Census, other industry data from U.S. Bureau of Labor Statistics

For the first time in 2021, the *Solar Jobs Census* included a demographic breakdown for solar employees in management and professional positions.[xii] Looking at these numbers helps us get a glimpse into how much this industry provides equitable opportunities for high-level positions. The percentage of white employees in the management and professional category (85%) is substantially higher than their representation in the industry overall (72%). Black employees made up 6% of management and professional positions, and Latino or Hispanic employees made up 11%, both well below their representation in the industry overall. Women made up 26% of management employees, also below their representation in the industry more broadly (Table 7).

Table 7

U.S. SOLAR MANAGEMENT STAFF DEMOGRAPHIC BREAKDOWN, 2021

	2021 % of Management Staff	% of Solar Workforce
Women	26.2%	29.6%
Hispanic or Latino	11.0%	19.8%
American Indian or Alaska Native	1.2%	1.2%
Asian	7.9%	9.2%
Black or African American	5.6%	8.2%
Native Hawaiian or other Pacific Islander	0.4%	1.3%
White	85.0%	72.0%

xii As defined in the survey, management and professional positions do not include sales managers or those who spend the majority of their time at project sites.

Diversity and Inclusion Strategies

In recent years, DEI has become a management priority for a growing number of solar companies and related organizations. Nonetheless, *Solar Jobs Census* data shows a majority of solar firms have not developed a strategy to increase the diversity of their workforce. Only 31% of firms reported strategies, policies, or programs to increase the number of female hires, while 26% had a strategy to increase ethnic or racial minority hires, and 8% had a strategy to increase LGBTQ+ hires. The survey also found that 32% of firms offered a diversity and inclusion training program.

For those firms that do have strategies to increase hiring of women and BIPOC individuals, by far the most common approach identified was targeted recruiting, including at educational institutions. This approach was noted by 49% of those with a strategy to increase female hires, and 46% of those with a strategy to increase the ethnic or racial diversity of their workforce. For those with a strategy to increase LGBTQ+ hires, the most common approach (cited by 34%) was the creation of a DEI committee or policy.

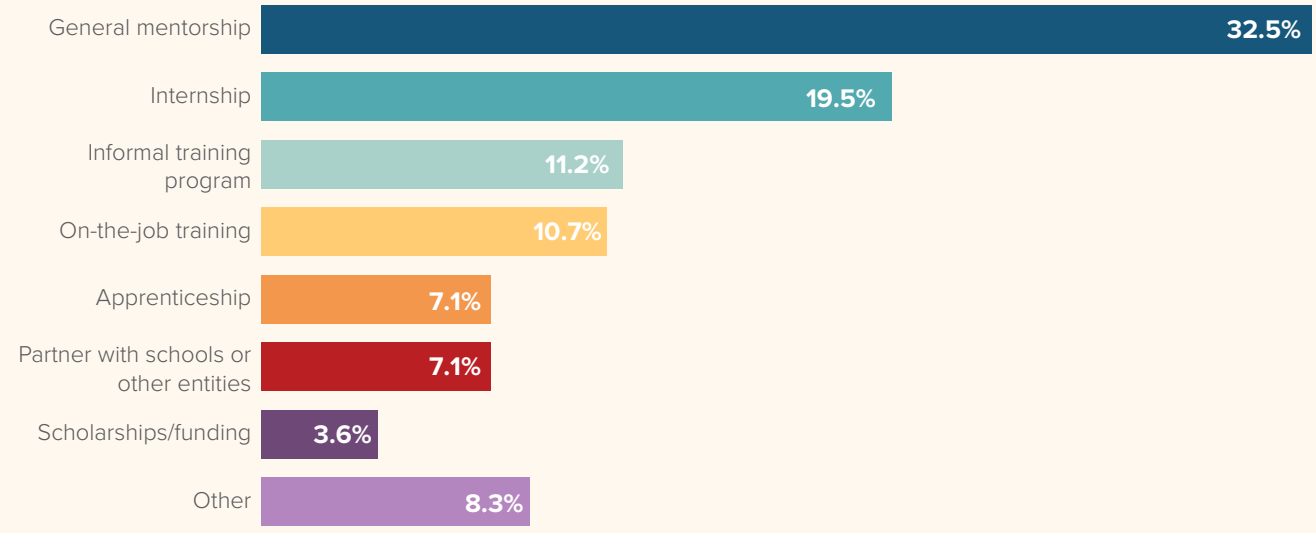
Mentorship programs can be very important avenues for women or people of color to advance their careers in solar.[50] However, the survey found that only 37% of solar firms have a mentorship program. Among those that did, the nature of the program varied widely and could include general mentorships, internships, or apprenticeships and training programs (Figure 9).

The good news is that solar industry leaders are providing many resources to help companies set and achieve DEI goals. These tools can be helpful for all types of solar companies, including smaller firms that may not have dedicated resources to pursue these strategies. The Solar Energy Industries Association (SEIA) has launched a diversity, equity, inclusion, and justice certification program that allows members to showcase their progress and reward achievement.[51] Separately, a number of companies and organizations formed the Renewables Forward initiative to advance DEI priorities (see box, p. 31).

Other aspects of diversity, inclusion, and equitable access to career opportunities are not represented in this report but are being addressed by some companies, organizations, or legislative proposals. Examples include efforts to create equitable access for individuals with disabilities, opportunity youth, and individuals impacted by the justice system.[52]

A commitment to diversity and inclusion will do more than expand opportunities for women, people of color, and other underrepresented groups; it will also help companies expand their pool of qualified workers and ultimately improve the bottom line. Rather than viewing it as a side concern, solar companies have every reason to make DEI priorities an integral part of their businesses.

Figure 9
TYPES OF MENTORSHIP/TRAINING PROGRAMS OFFERED AT SOLAR COMPANIES



Renewables Forward Seeks to Advance DEI Priorities

Renewables Forward was founded in 2020 by leaders in the clean energy industry with the goal to take action toward a just clean energy transition. The group's mission is to identify concrete steps and commit to clear, measurable actions that address diversity, equity, inclusion, and justice (DEIJ) within workforce systems (hiring, STEM support, candidate development and more); in boards, suppliers and vendor systems; and in community partnering for wealth sharing. Renewables Forward requires commitment from CEOs of all members to drive change within their own companies while partnering for industry impact.

"Renewables Forward members aim to lead the clean energy industry in DEIJ performance," says Executive Director Chris Nichols. Current programs include mentoring for women and BIPOC-owned clean energy start-ups; operationalizing the Renewables Forward DEI Playbook; training on inclusion and unconscious bias; company-specific DEI planning and measurement; member match-ups for best practice development; and career opportunity outreach and a commitment to hire from DEIJ-aligned training partners and affiliate programs.

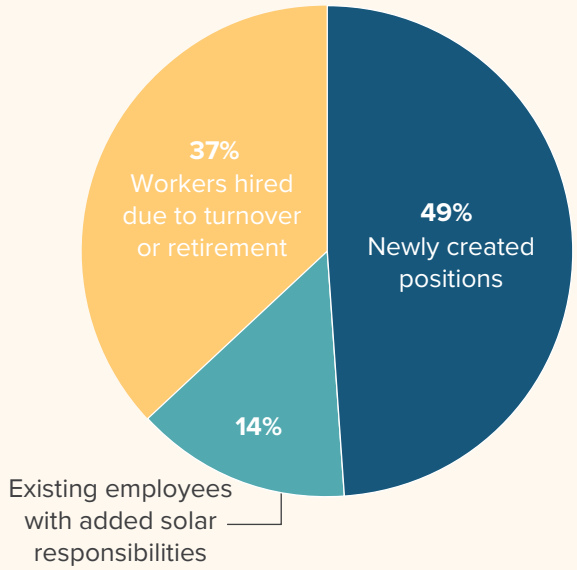
WORKFORCE DEVELOPMENT

In a few short years, the solar industry has emerged as one of the nation's leading job creators, offering wide-ranging career opportunities across diverse educational backgrounds. The solar PV installer will be one of the nation's fastest growing occupations in the coming decade, according to the Bureau of Labor Statistics.[53]

Entry-level installation jobs can lead to rapid advancement to crew lead positions or advanced electrical work.[54] However, the career possibilities extend well beyond putting solar panels on rooftops. Solar professions include sales representatives, site surveyors, project developers, engineers, system designers, and IT specialists, to name just a few. (The full range of occupations can be explored through IREC's interactive Solar Career Map.)

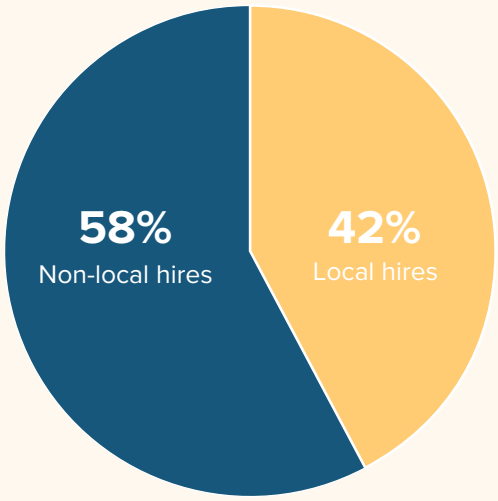
In 2021, many solar companies were able to add new positions as the industry recovered from pandemic job losses. *The Solar Jobs Census* survey found half (49%) of new hires were newly created positions, while 37% were hired due to turnover or replacement (Figure 10).

Figure 10
SOLAR INDUSTRY NEW HIRES, 2021



Note: Figures are rounded to the nearest whole number.

Figure 11
AVERAGE PERCENTAGE OF ONSITE EMPLOYEES HIRED LOCALLY FOR UTILITY-SCALE SOLAR PROJECTS



Note: Figures are rounded to the nearest whole number.

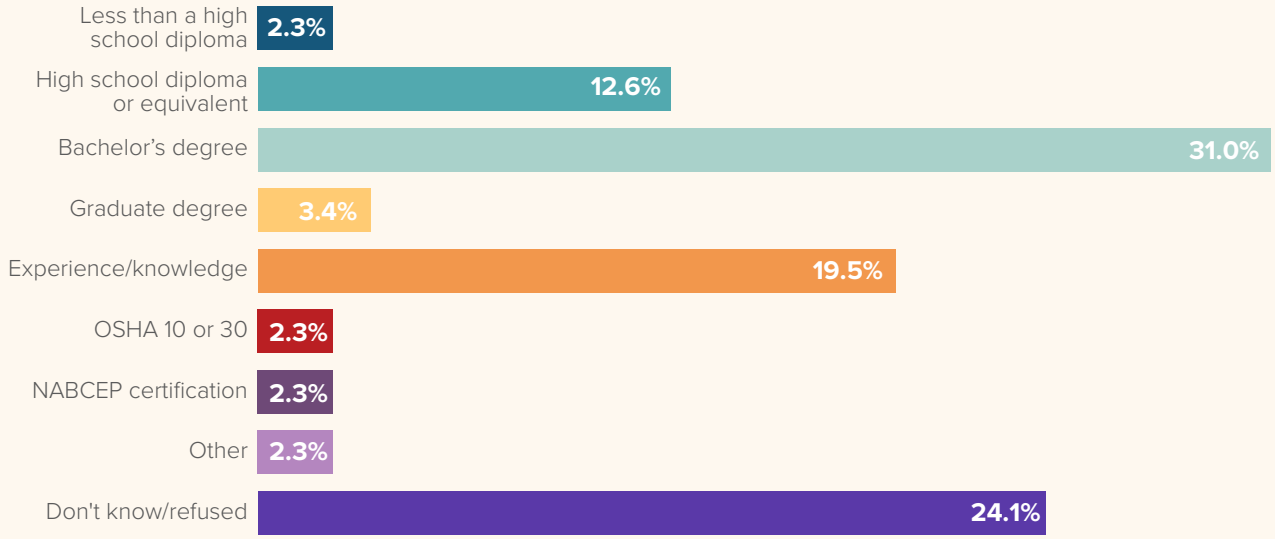
As noted in the Employment Trends section of this report, two-thirds of solar workers (66%) work for installation firms (Figure 5, p. 17). Half (49%) of installation workers are in the residential sector (Figure 6, p. 19). Another 34,000 installation employees (20% of the total) work on utility-scale solar farms, which sometimes require extended travel for the duration of the project. Survey results show that 42% of utility-scale solar workers were hired locally (within 50 miles of the project location), while the other 58% traveled from their home base to the project site (Figure 11).

While solar companies require a lot of hands-on labor, this is an inherently high-tech industry with an important role for IT professionals. The survey found that 12% of all solar workers are engaged in software development or distribution.

Education, Credentials, and Wages

The solar industry can be a path to rapid career advancement, including for those without a two- or four-year college degree. Less than one-third of entry-level solar jobs (31%) require a bachelor's

Figure 12
EDUCATIONAL/TRAINING REQUIREMENTS FOR ENTRY-LEVEL SOLAR POSITIONS



Note: NABCEP refers to the North American Board of Certified Energy Practitioners.

degree and less than 20% require previous experience or knowledge (Figure 12). Particularly in a tight labor market (as discussed below), many employers are open to hiring entry-level workers with a strong work ethic who are willing to learn on the job.

While not always required, solar training courses can help entry-level job candidates acquire foundational skills and enhance their qualifications. For entry-level jobs, courses aligned with national skills standards, with a focus on hands-on training, are available in many markets and increasingly in the online learning environment. Training programs are offered through community colleges, trade associations, technical and vocational schools, private training organizations, and other sources. Professional credentials, such as North American Board of Certified Energy Practitioners (NABCEP) certification, are usually not required for entry-level jobs but can be helpful for career advancement.[55] Solar employers have shown increased interest in direct training partnerships with educational institutions in order to align the curriculum with industry needs.

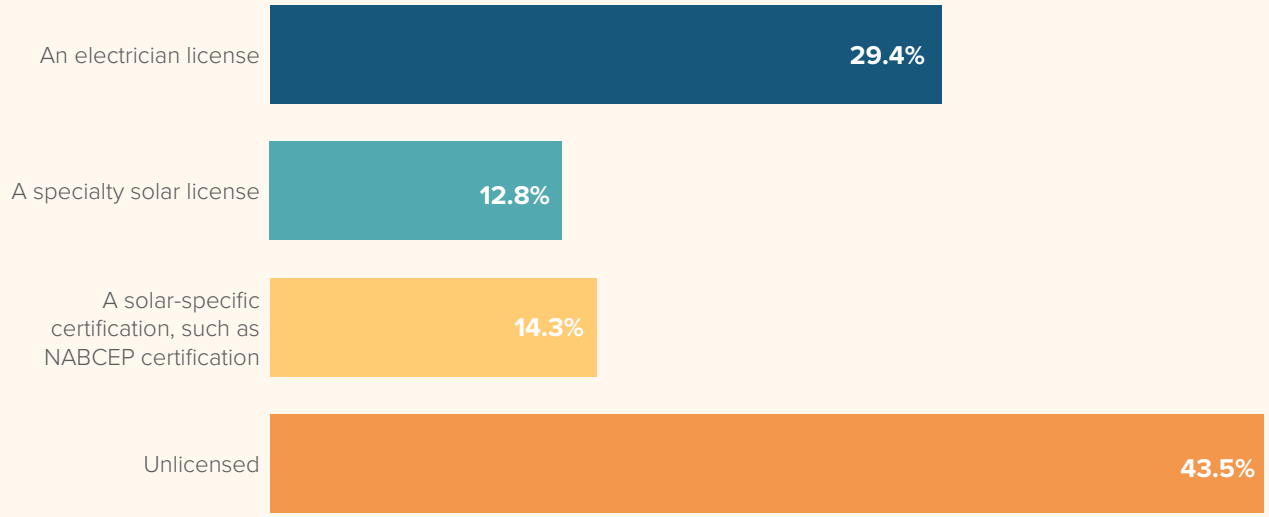
Solar firms required previous experience for 65% for all new hires (both entry-level and non-entry level) in 2021, and 37% of these positions filled required a bachelor's degree or higher. The job sector with the highest percentage of new hires requiring previous experience was manufacturing (78%), while the operations and maintenance sector had the highest percentage requiring a bachelor's degree or higher (77%) (Table 8).

Table 8
PERCENTAGE OF SOLAR FIRMS REQUIRING EXPERIENCE AND EDUCATION FOR NEW HIRES, 2021

	% Requiring Previous Experience	% Requiring Bachelor's Degree or Higher	% Requiring Vocational or Technical Certificate or Credential	% Requiring Associate's Degree or Certificate from Accredited College
Installation & Project Development	61.8%	24.1%	7.1%	6.4%
Wholesale Trade & Distribution	72.1%	54.6%	2.3%	26.4%
Operations & Maintenance	69.9%	77.2%	2.6%	5.6%
Manufacturing	78.3%	56.6%	6.7%	12.5%
All Others	73.7%	70.2%	7.2%	31.1%
Overall	**65.2%**	**36.8%**	**6.4%**	**9.4%**

Particularly at the entry level, many solar jobs do not require industry credentials. However, some states require electrical or other state licensure to install solar. These requirements vary widely and can be referenced by state through IREC's Solar Licensing

Figure 13
PERCENTAGE OF SOLAR INSTALLERS BY TYPE OF CREDENTIAL HELD

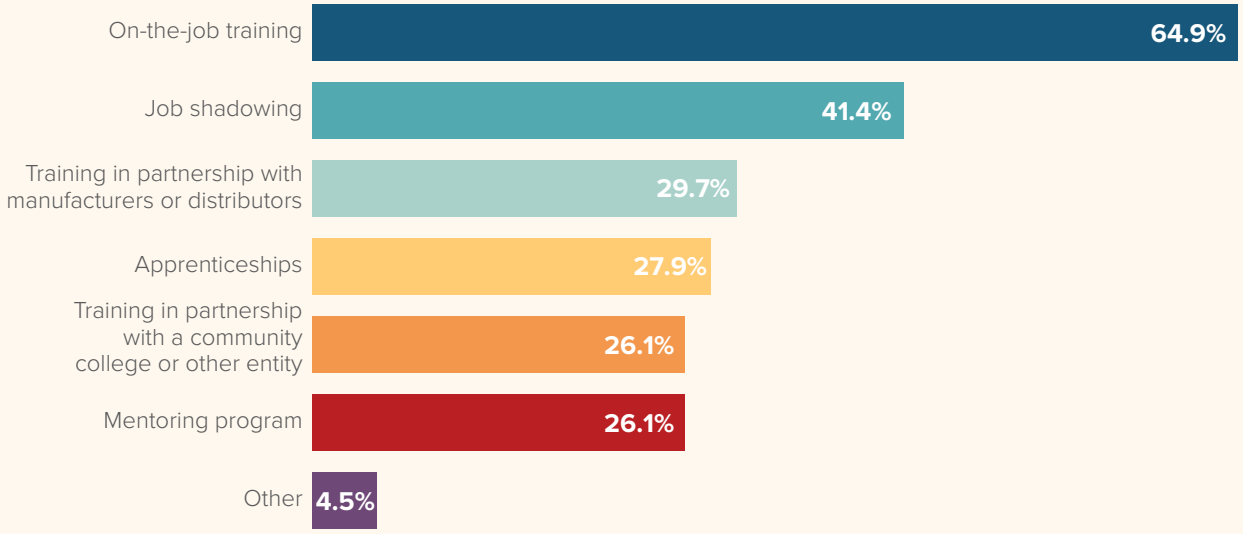


Note: NABCEP refers to the North American Board of Certified Energy Practitioners.

Database. Nationwide, the *Solar Jobs Census* survey found that 29% of solar installers have an electrician license, 13% have a specialty solar license, and 14% have a solar-specific credential such as NABCEP certification. However, nearly half (44%) of solar installation workers are unlicensed (Figure 13).

Solar firms take an active role in helping employees increase their skill levels and develop their careers. Two-thirds of the firms surveyed (65%) provide on-the-job training. In addition, 41% use job shadowing techniques where employees closely observe an expert performing a task. Other common workforce development strategies include training in partnership with manufacturers or distributors (30%), apprenticeships (28%), training in partnership with a community college (26%), and mentorships (26%) (Figure 14).

Figure 14
SOLAR WORKFORCE DEVELOPMENT METHODS



Solar Apprenticeship Programs

Registered Apprenticeship Programs (RAPs) can be mutually beneficial for firms and their employees. For example, an apprenticeship can allow workers to earn an entry-level salary while learning on the job, allow veterans to obtain GI Bill housing stipends, and allow employers to access tax credits and other financial incentives. However, there is no national apprenticeship standard for solar installers and the occupation is not yet recognized as "apprenticeable" by the U.S. Department of Labor.

In 2022, a statewide solar apprenticeship program, aligned with the state solar contractor license, launched in Florida thanks to the efforts of the Florida Solar Energy Center and the Florida Solar Energy Industries Association.[57] While a few other apprenticeship programs have been used to train solar workers around the country, this is the first program to offer apprenticeships for the federally defined occupations of Solar Photovoltaic Installer and Solar Thermal Installer, and can serve as a model for other states to support the development of a qualified solar workforce.

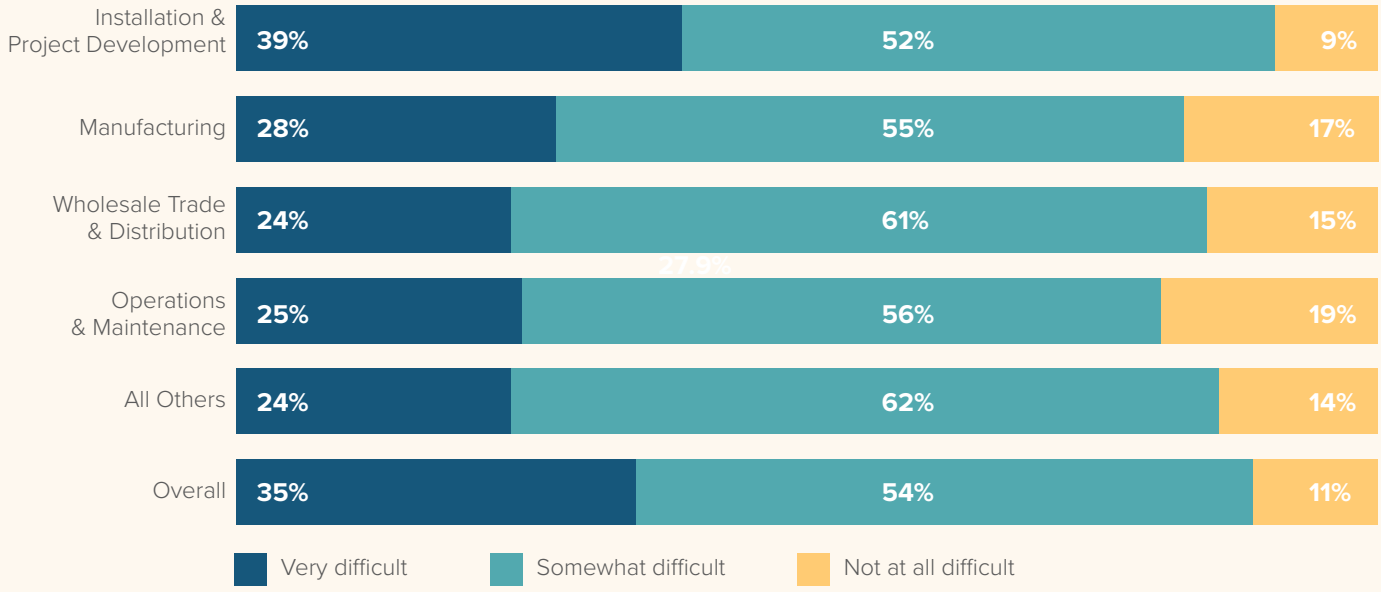
IREC and the Solar Energy Industries Association (SEIA) are leading a working group to document and develop National Standards of Apprenticeship for solar industry jobs. Companies, unions, or other stakeholders can get involved by signing up here.[58]

Solar industry wages compare favorably with similar industries and reflect the low barriers to entry among many installation jobs, while compensation increases as workers advance and acquire more training. The median hourly wage for solar installers is $22.92, according to the Bureau of Labor Statistics. For comparison, the median hourly wage for construction laborers in 2021 was $18.16, and the median wage for roofers was $22.65. The median hourly wage for all U.S. occupations was $22.00.[56]

Hiring Challenges

Each year, the *Solar Jobs Census* consistently finds that solar firms have difficulty hiring for open positions. Eighty-nine percent of firms in 2021 reported difficulty finding qualified applicants, including 35% that said it was "very difficult" and 54% reporting it was "somewhat difficult." The industry sector with the highest level of difficulty was installation, where 39% of firms said finding qualified applicants was "very difficult." (Figure 15)

Figure 15
PERCENTAGE OF SOLAR FIRMS REPORTING HIRING DIFFICULTY



These responses mark an increase from 2019, when 26% of solar firms said finding qualified applicants was very difficult, and 57% reported it was somewhat difficult.[59] This likely reflects the nation's tight job market and low unemployment rate throughout 2021.[60]

When asked for the most significant reasons for difficulty hiring, half (49%) of solar firms noted competition and a small applicant pool, while 30% mentioned lack of experience, training, or technical skills among applicants (Figure 16). In addition, 21% noted that they could not provide competitive wages.[xiii] When asked to name the most difficult positions to fill, firms listed a broad range of occupations including installation workers, electricians or construction workers, engineers or scientists, and management (Figure 17). For some positions, such as electricians and engineers, the length of training and education needed is a barrier. Licensed electricians typically have 4-5 years of training. Other barriers, such as lack of awareness of clean energy pathways, also contribute to recruitment challenges.

xiii The National Clean Energy Workforce Alliance (see box, p. 38) surveyed members and found the top reason for difficulty hiring was salary expectations or levels.

Figure 16

MOST SIGNIFICANT REASONS FOR DIFFICULTY HIRING AT SOLAR COMPANIES

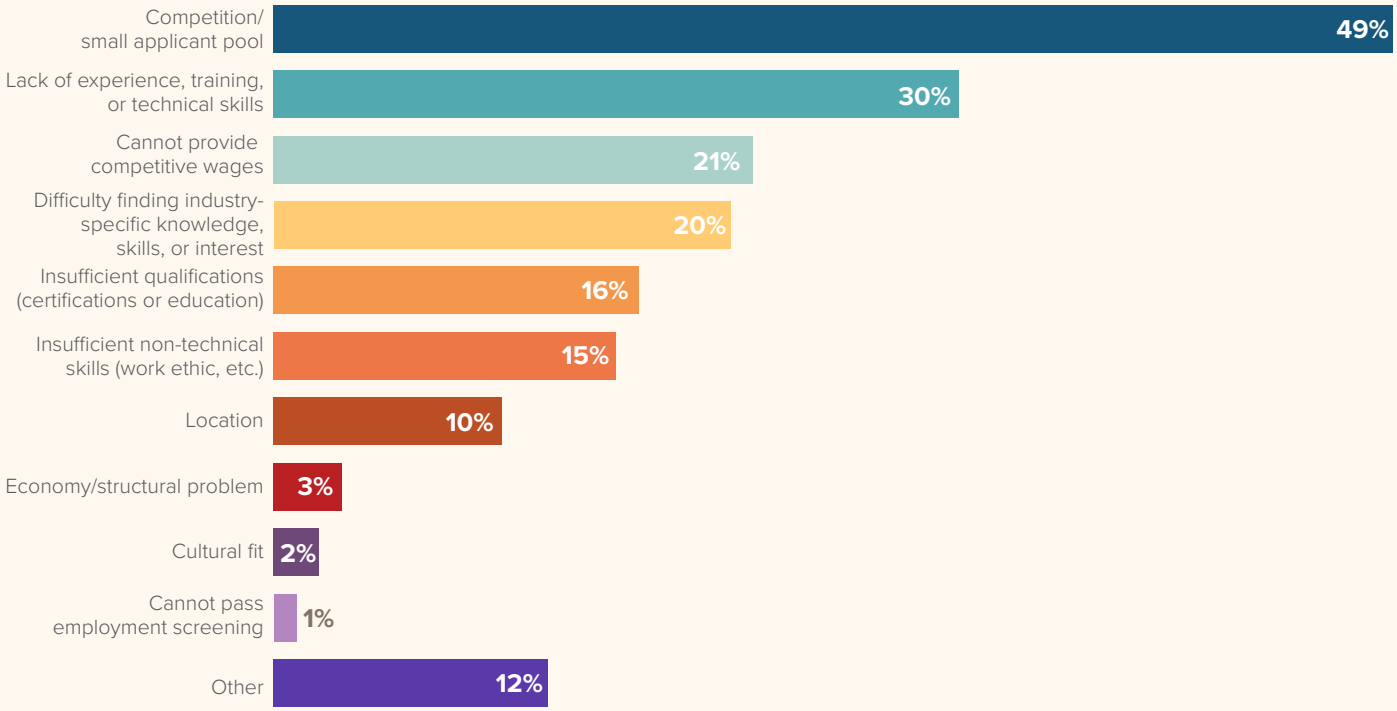
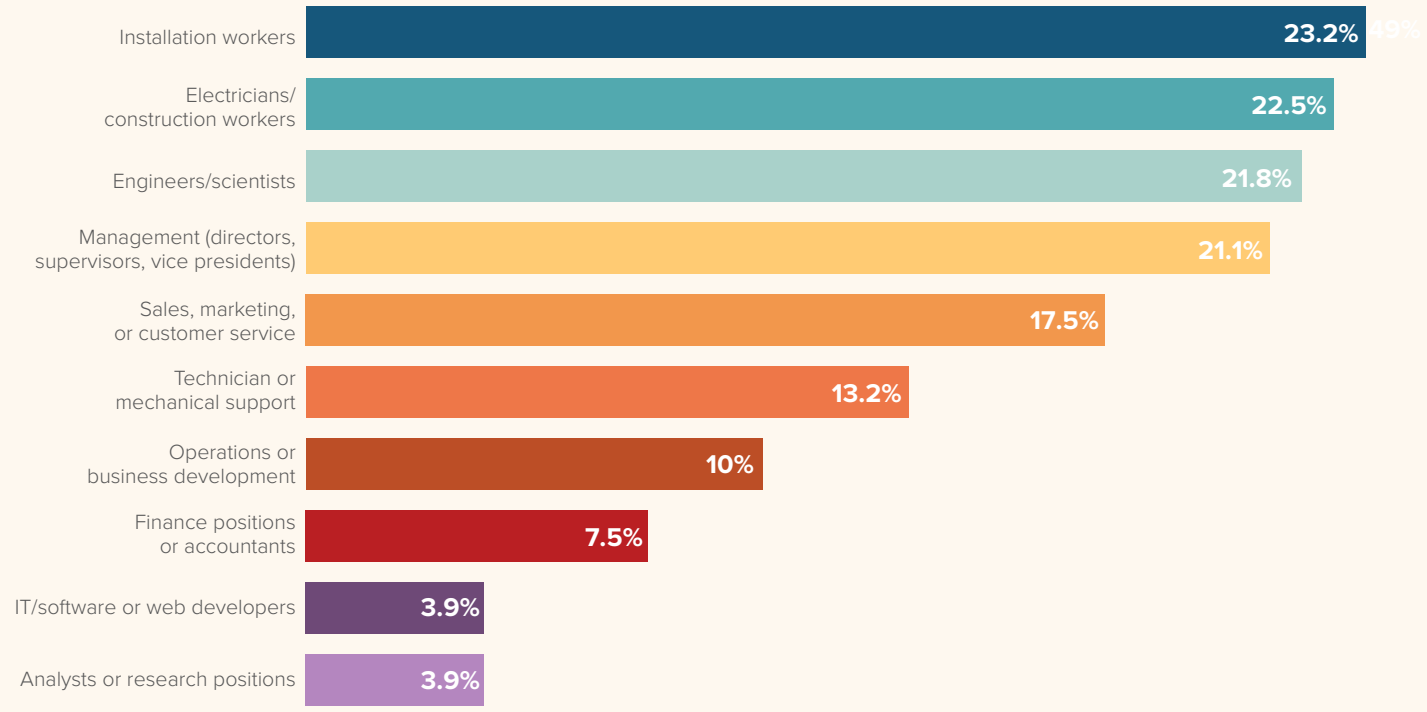


Figure 17

MOST DIFFICULT POSITIONS TO FILL AT SOLAR COMPANIES



Clean Energy Industry Unites to Meet Workforce Challenges

Building the clean energy workforce of the future is a monumental challenge that will require coordinated action to succeed. To address this need, IREC launched the National Clean Energy Workforce Alliance, a cross-sector effort convened in partnership with the National Council for Workforce Education.[xiv] Now over 450 organizations strong, the group unites employers, education and training providers, community-based and energy justice organizations, and federal, state, and local government.[61]

The top workforce challenges Alliance members have cited include the recruitment of students and workers, and the lack of awareness of clean energy career pathways. In response, the Alliance leads ongoing Solution Summits to detail successful strategies for removing barriers to entry, increasing workforce diversity, and other topics including curricular gaps, integrating clean energy into existing training and education pathways, and job placement.

Alliance members have identified several recruitment strategies that can help develop a qualified workforce and increase the diversity of the workforce pool. These include:

- Apprenticeships
- Building authentic relationships in communities
- Elevating the quality of the job (salary, benefits, etc.)
- Considering the formerly incarcerated
- Holding seminars in underserved areas
- Third-party-supported paid internships
- Partnering with the Department of Labor workforce system
- Working with community colleges, community-based organizations, unions, and other stakeholders.

Solutions identified at the summits will be shared with the broader clean energy community with the goal of spurring collaborative efforts to reach bold clean energy goals. To learn more about the Workforce Alliance or join future convenings, sign up for updates on the program website.

xiv Bank of America provides funding for this effort.

Strategies to Attract Qualified Workers

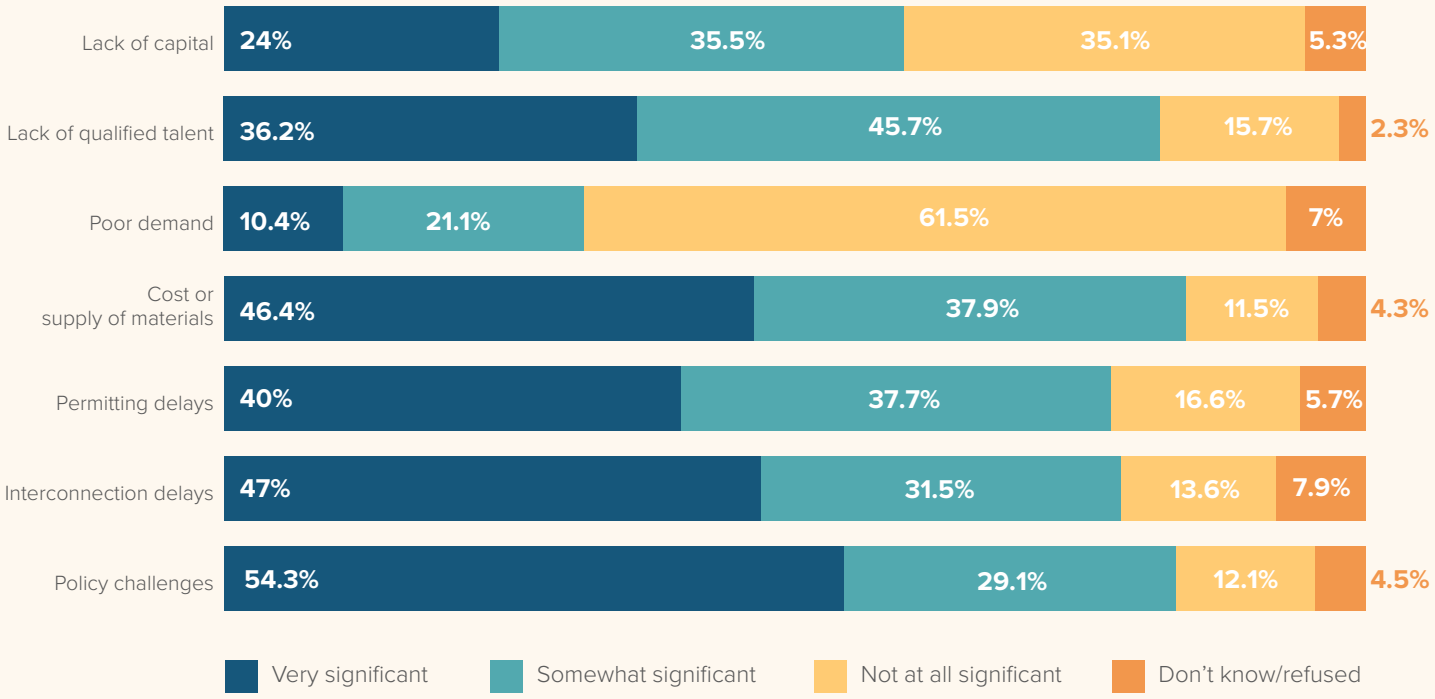
Fortunately, solar firms have many strategies at their disposal to expand the pool of qualified candidates. Employers often find success by investing their time in the communities where they do business or developing partnerships with local programs or institutions that provide training and job placement services. These can include community colleges, vocational schools, nonprofit organizations, energy justice organizations, local governments, and unions. Firms can also engage with nearly 2,400 American Job Centers located throughout the U.S., which provide no-cost assistance to job seekers for career and employment needs.[62]

The National Clean Energy Workforce Alliance, a cross-sector workforce development group led by IREC, has identified a number of recruitment strategies for solar and other clean energy firms (see box, p. 38). Employers can also take advantage of state and local workforce development programs. For example, the New York State Energy Research and Development Authority (NYSERDA) funds internships for students and recent graduates at clean energy companies and maintains a directory of approved employers.[63]

Solar Firms Identify Wide-Ranging Challenges to Business Growth

The *Solar Jobs Census* survey asked firms to identify the factors that contribute to the difficulty of growing a profitable business. More than half (54%) listed policy challenges as a very significant factor. Other factors often cited as significant included lack of capital, lack of qualified talent, cost or supply of materials, permitting delays, and interconnection delays. Notably, the one survey option that most firms did not consider a significant factor was poor demand—which likely reflects a robust and growing interest in solar energy among residential, commercial, and government consumers (Figure 18).

Figure 18
FACTORS THAT CONTRIBUTE TO THE DIFFICULTY OF GROWING A PROFITABLE SOLAR BUSINESS



Appendix A

Solar Jobs by State

State	2021 Solar Jobs	2020 Solar Jobs	Year/Year % Change	Year/Year Change in Jobs	Solar Jobs Rank	Solar Jobs Per Capita Rank
AK	63	59	6.7%	4	52	52
AL	689	481	43.3%	208	42	50
AR	354	338	4.8%	16	48	51
AZ	8,278	7,346	12.7%	932	6	9
CA	75,712	68,677	10.2%	7,035	1	3
CO	7,426	6,771	9.7%	655	7	8
CT	2,275	2,126	7.0%	149	29	21
DC	1,055	1,069	-1.4%	-14	37	6
DE	526	456	15.4%	70	45	30
FL	11,761	11,219	4.8%	542	2	27
GA	5,314	4,466	19.0%	848	14	34
HI	2,421	2,365	2.4%	56	28	5
IA	892	773	15.4%	119	39	46
ID	586	486	20.6%	100	44	43
IL	5,520	5,259	5.0%	261	13	36
IN	3,858	3,364	14.7%	494	23	25
KS	971	862	12.6%	109	38	40
KY	1,485	1,249	18.9%	236	33	41
LA	3,210	3,175	1.1%	35	25	17
MA	10,548	9,495	11.1%	1,053	3	7
MD	4,872	4,565	6.7%	307	15	15
ME	684	595	14.9%	89	43	33
MI	3,941	3,379	16.6%	562	22	37
MN	4,570	3,993	14.4%	577	17	13
MO	2,778	2,522	10.1%	256	27	35
MS	886	817	8.4%	69	40	45
MT	340	288	18.0%	52	49	44

State	2021 Solar Jobs	2020 Solar Jobs	Year/Year % Change	Year/Year Change in Jobs	Solar Jobs Rank	Solar Jobs Per Capita Rank
NC	6,978	6,107	14.3%	871	10	19
ND	262	211	24.1%	51	50	39
NE	1,548	1,246	24.2%	302	32	16
NH	1,101	985	11.8%	116	35	14
NJ	6,237	5,384	15.8%	853	12	18
NM	2,013	1,880	7.1%	133	30	11
NV	7,193	6,174	16.5%	1,019	9	1
NY	10,524	10,214	3.0%	310	4	29
OH	7,411	6,532	13.5%	879	8	22
OK	868	927	-6.3%	-59	41	48
OR	3,968	3,502	13.3%	466	20	12
PA	4,188	4,310	-2.8%	-122	18	42
PR	1,985	-	-	-	31	23
RI	1,067	1,010	5.6%	57	36	10
SC	3,377	3,086	9.4%	291	24	20
SD	479	452	6.1%	27	46	28
TN	4,109	3,948	4.1%	161	19	24
TX	10,346	10,088	2.6%	258	5	38
UT	6,971	6,926	0.6%	45	11	2
VA	4,791	4,312	11.1%	479	16	26
VT	1,193	1,046	14.0%	147	34	4
WA	3,950	3,565	10.8%	385	21	31
WI	2,942	2,910	1.1%	32	26	32
WV	372	311	19.6%	61	47	49
WY	152	152	0.0%	0	51	47

Note: Puerto Rico solar jobs numbers were not available for 2020.
Sources: National Solar Jobs Census, U.S. Census Bureau (annual population estimates)

Appendix B

Methodology

The *National Solar Jobs Census 2021* is based on the survey conducted for the *United States Energy and Employment Report 2022 (USEER)*, published by the U.S. Department of Energy. An introduction to this methodology, as referenced directly in the USEER, is below. A complete discussion of the USEER methodology can be found here: https://www.energy.gov/sites/default/files/2022-06/USEER%202022%20Appendices_1.pdf.

From the USEER: Methodology Introduction and Overview

The 2022 USEER methodology relies on the most recently available data from the BLS QCEW (QCEW, third quarter 2021), the BLS Unemployment Situation Table B-1 monthly reports, together with a detailed supplemental survey of business establishments across the United States designed and conducted by BW Research Partnership in partnership with the Department of Energy (DOE). During a time of rapid change in energy technology and business employment structure, supplemental surveys are an important tool to capture developing trends. Taken together, the BLS and survey data provide the most comprehensive calculation of energy-related employment available. The methodology has been used for local, state, and federal energy related data collection and analysis for a decade, including IREC's National Solar Jobs Census series, traditional and clean energy reports for state agencies in the Commonwealth of Massachusetts, New York State, the State of Vermont, the Commonwealth of Pennsylvania, the State of California, the State of Connecticut, the State of New Hampshire, and State of Rhode Island, the State of Maryland, the State of Minnesota, and numerous nonprofit agencies across the United States.

The 2022 USEER survey uses a stratified sampling plan that is representative by industry code (North American Industry Classification System [NAICS] or ANAICS), establishment size, and geography to determine the proportion of establishments that work with specific energy-related technologies, as well as the proportion of workers in such establishments that work with the same. These data are then analyzed and applied to existing public data published by the BLS, effectively constraining the potential universe of energy establishments and employment. For more detail, see the "USEER Sampling Plan" section, in the USEER report.

The 2022 USEER survey was administered by telephone (more than 247,500 outbound calls) and by web, with more than 104,000 emails sent to participants throughout the United States. An additional 33,000 business locations were mailed an invite letter instructing respondents to complete the survey via phone or web (included a link). The phone survey was conducted by ReconMR. The web instrument was programmed internally, and each respondent was required to use a unique ID in order to prevent duplication.

The sample was split into two categories, referred to as the known and unknown universes. The known universe includes establishments that have previously been identified as energy-related, either in prior research or in some other manner, such as membership in an industry association or participation in government programs. These establishments were surveyed census-style, and their associated establishment and employment totals were removed from the unknown universe for both sampling and for resulting employment calculations and estimates.

The unknown universe included tens of thousands of businesses in potentially energy-related NAICS codes, across agriculture, mining and extraction, utilities, construction, manufacturing, wholesale trade, distribution (including pipeline distribution), professional services, and repair and maintenance. Each of these segments and their total reported establishments (within the BLS QCEW) were carefully analyzed by size (employment) and state to develop representative clusters for sampling. In

total, approximately 33,000 business establishments participated in the survey effort, with approximately 7,500 providing full responses to the survey. These responses were used to develop incidence rates among industries (by state) as well as to apportion employment across various industry categories in ways currently not provided by state and federal labor market information agencies. The margin of error for incidence in the USEER is +/-0.54% at a 95% confidence interval.

For several industries, particularly transportation of goods, the USEER uses the methodology developed by the DOE and the National Renewable Energy Laboratory for the first installment of the QER. Proportion of employment was calculated by dividing commodity shipments by value (in millions of dollars) for coal, fuel oil, gas, motor vehicles, petroleum, and other coal and petroleum products out of total commodity value at the state level by truck, rail, air, and water transport. This proportion was applied to NAICS employment for truck transportation (NAICS 484), water transportation (NAICS 483), air transportation (NAICS 481), and Railroad Retirement Board employment for rail transportation at the state level. With this analysis, truck transportation represents the majority of energy-related transportation employment (70%), followed by rail (22%), water (7%), and air (1%).

Of important note, the USEER expressly excludes any employment in retail trade NAICS codes. This excludes motor vehicle dealerships, gas stations, appliance and hardware stores, and other retail establishments.

All data in the USEER rely on the BLS QCEW data for the end of the third quarter of 2021, and the BLS Employment Situation Table B1 monthly reports through December 2021. Employment extrapolations are based on BLS QCEW and survey data, resulting in totals that carry precise decimal values. As a result, some employment totals for tables in the report will sum differently due to rounding. The USEER survey was administered between January 13, 2022, and April 18, 2022, and averaged 16 minutes in length.

Additional details on the USEER methodology are available at https://www.energy.gov/sites/default/files/2022-06/USEER%202022%20Appendices_1.pdf.

SUPPLEMENTAL FOLLOW-UP SURVEY

A supplemental follow-up survey of solar employers that participated in the 2022 United States Energy and Employment Report (USEER) survey was administered in order to collect additional information not collected by USEER. The survey instrument was programmed internally by BW Research and each respondent was assigned a unique ID to prevent duplication. A total of 393 emails were sent to respondents that completed the USEER survey from SEIA's National Solar Database, and SEIA and IREC anonymous links, and provided contact information. Potential respondents were emailed a survey invite and sent up to eight reminders. In total, 199 respondents participated (answered at least one question) in the supplemental survey effort. The surveys were administered between March 1, 2022 and April 15, 2022 and the median survey duration was 5.2 minutes.

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