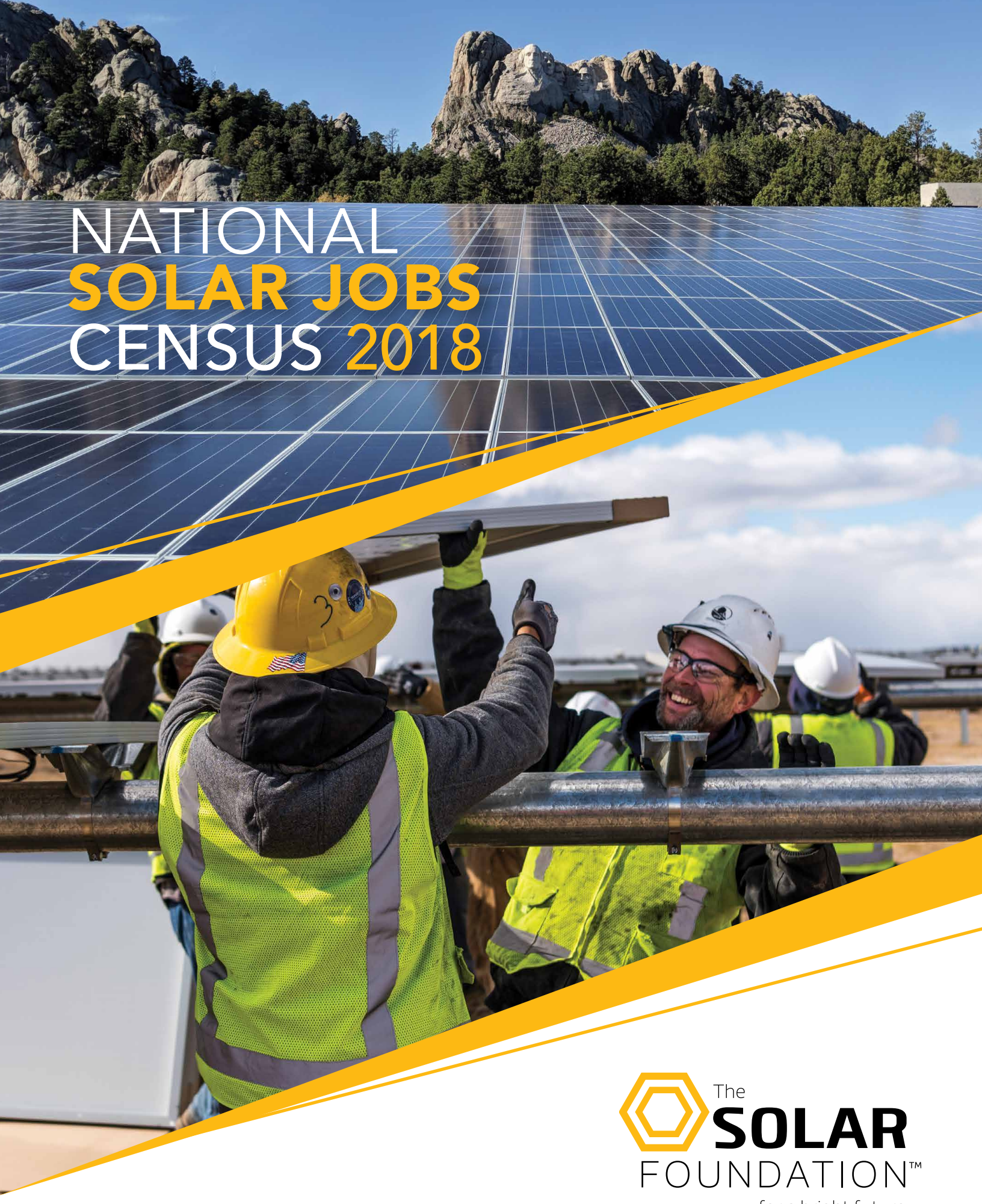

NATIONAL SOLAR JOBS CENSUS 2018

The SOLAR FOUNDATION™
for a bright future

ABOUT

The Solar Foundation

The Solar Foundation® is a national 501(c)(3) nonprofit organization whose mission is to accelerate adoption of the world's most abundant energy source. Through its leadership, research, and capacity building, The Solar Foundation creates transformative solutions to achieve a prosperous future in which solar and solar-compatible technologies are integrated into all aspects of our lives.

In 2010, The Solar Foundation conducted its inaugural *National Solar Jobs Census*, establishing the first comprehensive solar jobs baseline and verifying that the solar industry is having a positive impact on the U.S. economy. Using the same rigorous, peer-reviewed methodology, The Solar Foundation has conducted an annual *Census* in each of the last nine years to analyze trends and track changes over time.

BW Research Partnership

BW Research Partnership is a full-service, economic and workforce research consulting firm with offices in Carlsbad, California, and Wrentham, Massachusetts. It is the nation's leading provider of accurate, comprehensive clean energy research studies, including the *National Solar Jobs Census*, wind industry analyses for the National Renewable Energy Laboratory and the Natural Resources Defense Council, and state level clean energy reports for Massachusetts, New York, Illinois, Vermont, Iowa, and Florida, among others.

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ACKNOWLEDGEMENTS

The Solar Foundation would like to extend its gratitude to the numerous sponsors of this report. Without their financial contributions, this report would not have been made possible.

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The Solar Foundation and BW Research Partnership would also like to thank all the solar employers who participated in survey. Your responses were critical in providing us with accurate and timely data.

The Solar Foundation thanks Sam Boykin and Susan DeVico for assistance with communications and outreach, Travis Moore for assistance with research and data analysis, and report reviewers Justin Baca, Rachel Goldstein, and David Keyser. Thanks to the Energy Futures Initiative and the National Association of State Energy Officials for their assistance in providing solar + storage employment data. Report layout is by Top Shelf Design.

Unless otherwise indicated, all solar jobs data for 2010–2017 derive from The Solar Foundation's *Census* report series, available at SolarJobsCensus.org.

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Please cite this publication when referencing this material as:

"*National Solar Jobs Census 2018*, The Solar Foundation, available at: SolarJobsCensus.org"

The Minnesota content covered by this report is based upon work supported by the Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), under Award Number DE- EE0007479.

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EXECUTIVE SUMMARY

The Solar Foundation's *National Solar Jobs Census 2018* is the ninth annual report on employment and workforce trends in the U.S. solar industry, nationwide and state by state. Based on a rigorous survey of U.S. companies, this report represents the most comprehensive analysis of solar labor market trends in the United States.

This year's *National Solar Jobs Census* found that solar employment experienced its second decline since The Solar Foundation first began tracking jobs in 2010. As of November 2018, the solar industry employs over 242,000 solar workers, representing a decline of 3.2%, or 8,000 fewer jobs, since 2017. Since 2010, solar employment has grown 159%, from just over 93,000 to more than 242,000 jobs in all 50 states.

*The solar industry employs over **242,000** solar workers, representing a decline of **3.2%**, or **8,000** fewer jobs, since 2017.*

Key factors behind the decline in solar jobs from 2017 to 2018 include:

- Uncertainty over the outcome of the Section 201 trade case before the new solar tariffs were announced in January 2018. This uncertainty led to project delays, especially for the larger, utility-scale installations.
- State policy and economic challenges led to job declines in some states with well-established solar markets.

SOLAR JOB TRENDS IN 2018

This report includes up-to-date information on solar jobs state by state, by industry sector, and within demographic groups, as well as employer predictions on future job growth. Other major findings on the U.S. solar workforce, as of November 2018, are as follows:

- Despite losses in states with well-established solar markets, 29 states saw solar job growth in 2018, including many states with emerging solar markets. States that experienced significant gains in employment included Florida (+1,769 jobs), Illinois (+1,308), Texas (+739), New York (+718), Ohio (+644), and Washington (+612).
- The states that experienced the largest job reductions between 2017 and 2018 included California (-9,576 jobs), Massachusetts (-1,320), North Carolina (-903), Arizona (-857), Maryland (-808), New Jersey (-696), Georgia (-614), and Hawaii (-595). California, home to about 40% of U.S. solar capacity, still has by far the most jobs nationwide. In 2018, Florida overtook Massachusetts as the state ranking second to California in total solar jobs.

Solar employment ***increased 70% overall*** *from 2013-2018, adding* ***100,000 jobs.***

- In 2018, the *Solar Jobs Census* for the first time included jobs data for Puerto Rico, which has approximately 2,000 solar workers. These jobs are not included in the total job count for the 2018 *Census* for the purposes of comparison to previous years.
- For the first time, this year's *Census* also tallied jobs in solar + storage. Within firms that focus primarily on battery storage, there were 3,900 jobs directly linked to solar in 2018.*
- Long-term solar jobs growth remains positive. In the five-year period between 2013 and 2018, solar employment increased 70% overall, adding 100,000 jobs. By comparison, overall U.S. employment grew only 9.13% during that same period.
- Solar represents about 2.4% of overall U.S. electricity generation, yet it employs twice as many workers as the coal industry and almost five times as many workers as the nuclear industry.[1] In the energy sector, only the oil/petroleum and natural gas industries have more employment than solar.† Solar employs more workers per unit of generation due to the industry's high growth rate, creating thousands of jobs associated with construction.
- Demand-side sectors (comprised of the installation and project development sector, and the wholesale trade and distribution sector) make up 76% of overall solar industry employment (184,400 jobs), while manufacturing represents 14% (33,700 jobs) and operations and maintenance comprises just under 5% (11,000 jobs). The "other" sector, which includes engineering, legal, and financing firms, represents just over 5% (13,000 jobs).
- About 155,000 solar jobs, or two-thirds of the total, are in the installation and project development sector. Of these, about 87,000 jobs (56%) are focused on the residential market segment. Just under 30%, or 46,000 jobs, focus on non-residential (including about 12,500 jobs in community solar). The utility-scale market comprises the remaining 22,000 jobs in this sector (14%).
- Respondents to the *Census* survey predicted that total U.S. solar industry employment would reach about 259,400 jobs by the end of 2019, a 7% increase year-over-year.

** This category does not include jobs that are related to storage but part of another sector, such as installation. Furthermore, the solar + storage jobs are not included in the total job count for the 2018 Census for the purposes of comparison to previous years. Source for solar + storage figures is the U.S. Energy and Employment Report series, published by the Energy Futures Initiative and the National Association of State Energy Officials.*

† Includes all components of the respective industries: electric power generation (including construction) and fuels. Based on comparison with 2017, the latest year of complete data available from the 2018 U.S. Energy and Employment Report. Unlike the Solar Jobs Census, which defines solar workers as those who spend 50% or more of their time on solar-related work, this report counts those who spend any portion of their time on solar-related work.

THE U.S. SOLAR WORKFORCE

In addition to this overall employment data, the *National Solar Jobs Census* includes detailed information on other aspects of the solar workforce and industry trends, including; sector and segment analyses; demographics and diversity; hiring challenges; industry wages; and educational requirements. It also includes in-depth case studies of select solar companies to provide further insight into the U.S. solar workforce.

The solar industry is more diverse than comparable industries, but still not representative of the greater U.S. population. In 2018, women represented 26.3% of the solar workforce, Latino or Hispanic workers represented 16.9%, Asian workers comprised 8.5%, and black or African American workers comprised 7.6%. The percentage of solar workers who are veterans declined from 8.6% in 2017 to 7.8% in 2018.

Twenty-six percent of solar establishments reported that it was "very difficult" to find qualified candidates to fill open positions, an increase of 44% from the 18% reporting such challenges in 2017. This increase is not surprising given the tight labor market. Installation and project development experienced the most difficulty, with 33% of establishments reporting that it was "very difficult" to find qualified employees, almost double the 18% reported in 2017 for this sector.

Experience remains the most important hiring requirement for all sectors, with solar establishments requiring experience for 60% of their new hires. That number increased from 55% of new hires in 2017. The proportion of Bachelor's degrees required, 21%, was similar to that of 2017.

Solar industry wages remain competitive with similar industries and above the national median wage ($18.12) for all occupations.[2] The median reported wage for non-electrician photovoltaic (PV) installers is $18.92 for entry-level workers and $28.11 for mid-level workers. The median reported wage for electrician PV installers is $24.32 for entry-level workers and $32.43 for mid-level workers.

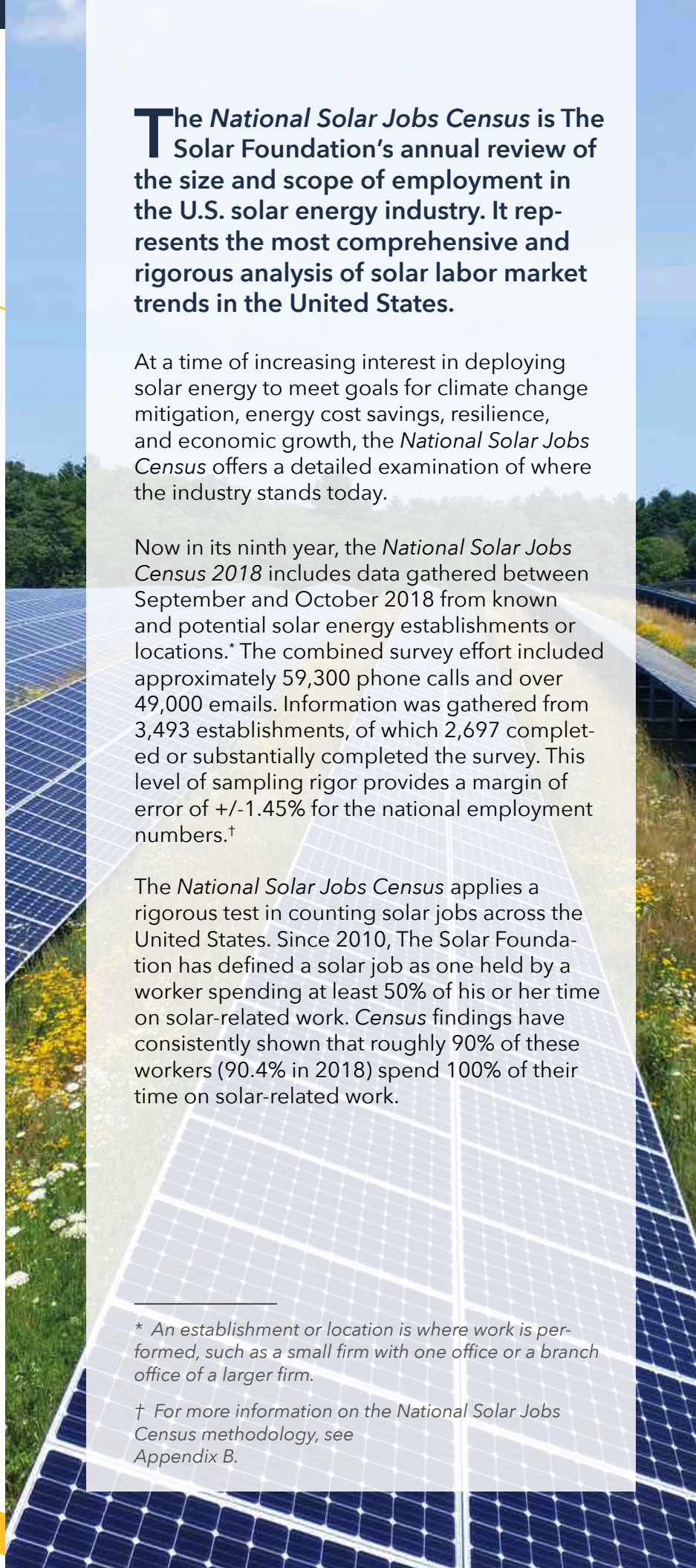
TOWARD A BRIGHT SOLAR FUTURE

Despite two years of decline in solar employment, solar installations are expected to ramp up over the coming years and new job opportunities will likely follow. The rapidly declining cost of hardware is making solar cost-competitive with fossil fuels. Policy support from many state governments will also aid the solar industry's growth.

While these are reasons for optimism, the urgent challenge of climate change means the progress we have seen to date is not nearly enough. Solar energy will need to develop and expand even faster in order to reduce carbon emissions to sustainable levels. If this can be achieved, a host of additional benefits will follow, including new solar job growth.

KEY FINDINGS

*The solar industry has **grown dramatically** in both jobs and added capacity over the past decade as installation **costs have plummeted.***



The *National Solar Jobs Census* is The Solar Foundation's annual review of the size and scope of employment in the U.S. solar energy industry. It represents the most comprehensive and rigorous analysis of solar labor market trends in the United States.

At a time of increasing interest in deploying solar energy to meet goals for climate change mitigation, energy cost savings, resilience, and economic growth, the *National Solar Jobs Census* offers a detailed examination of where the industry stands today.

Now in its ninth year, the *National Solar Jobs Census 2018* includes data gathered between September and October 2018 from known and potential solar energy establishments or locations.* The combined survey effort included approximately 59,300 phone calls and over 49,000 emails. Information was gathered from 3,493 establishments, of which 2,697 completed or substantially completed the survey. This level of sampling rigor provides a margin of error of +/-1.45% for the national employment numbers.†

The *National Solar Jobs Census* applies a rigorous test in counting solar jobs across the United States. Since 2010, The Solar Foundation has defined a solar job as one held by a worker spending at least 50% of his or her time on solar-related work. *Census* findings have consistently shown that roughly 90% of these workers (90.4% in 2018) spend 100% of their time on solar-related work.

** An establishment or location is where work is performed, such as a small firm with one office or a branch office of a larger firm.*

† For more information on the National Solar Jobs Census methodology, see Appendix B.

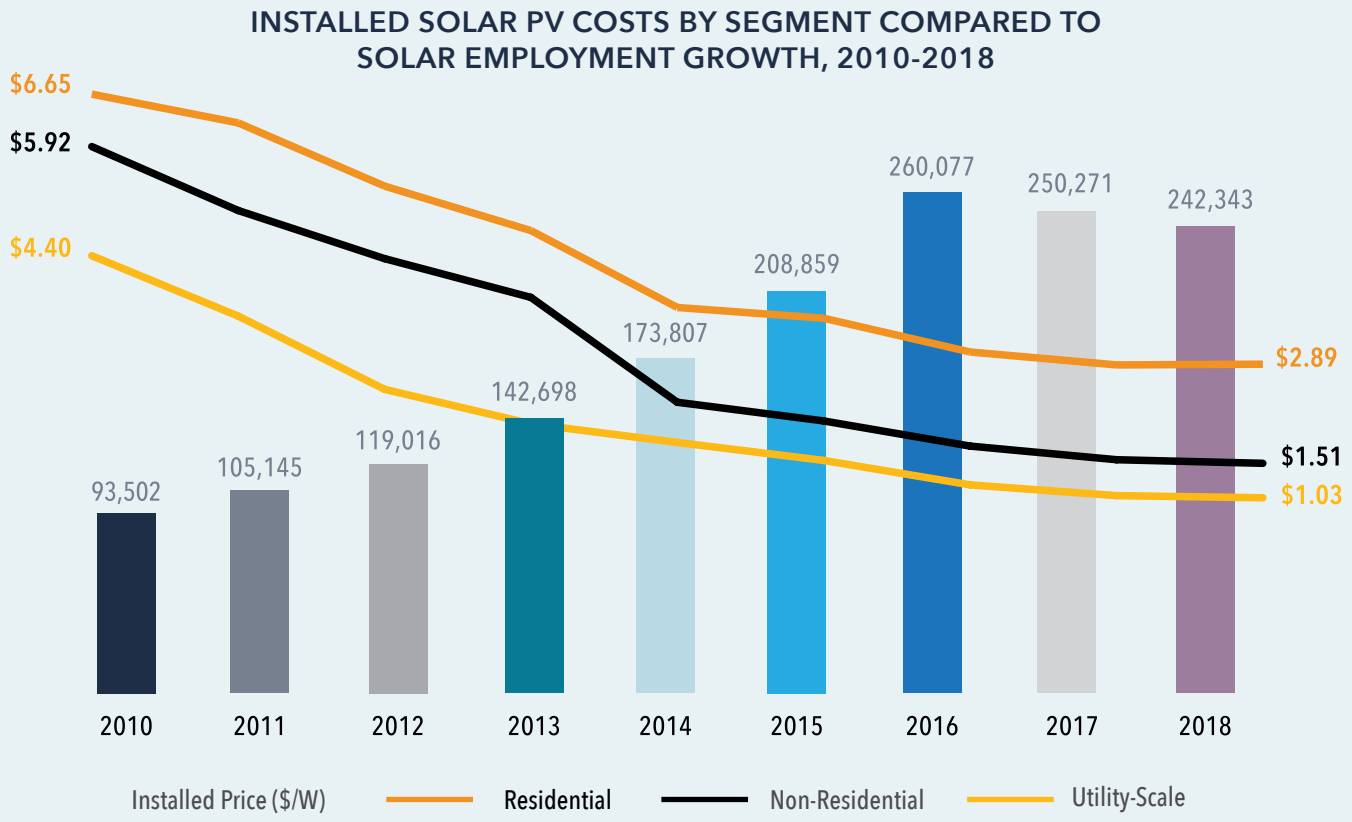


Figure 1

Sources: The Solar Foundation, Wood Mackenzie Power & Renewables

As of November 2018, the solar industry supports 242,343 jobs at 27,586 locations, a decrease of 3.2%, or 7,928 fewer jobs, since the 2017 *Census*.* This decline represents the second year in a row that solar employment has dropped after seven years of steady job growth. Taking the longer-term view, however, the solar industry has grown dramatically in both jobs and added capacity over the past decade as installation costs have plummeted (Figure 1). Solar employment grew by 159% from 2010 to 2018, and the 11 gigawatts (GW) in installations expected in 2018 is almost 12 times the 929 MW installed in 2010.[3]

The reduction in solar jobs during 2018 reflects lower-than-expected installed capacity that year. The most recent *U.S. Solar Market Insight®* report found the United States added about 6.4 GW of new installed solar capacity through Q3 2018, 5% below that of the same period in 2017. Much of the decline is attributable to uncertainty over the outcome of the Section 201 trade case on solar modules and cells. State policy challenges in well-established solar states such as California and Massachusetts also stymied growth.

THE IMPACT OF THE TRADE CASE

In April 2017, two U.S. solar manufacturers petitioned the U.S. International Trade Commission to impose tariffs on all imported crystalline silicon solar modules and cells (the dominant technology). Throughout the course of 2017 and into January 2018, uncertainty around the outcome of this petition made it more difficult for U.S. solar project developers to price, bid, and contract for future projects.

This uncertainty resulted in the postponement of many solar projects, leading to scaled-back installations in the first three quarters of 2018. The delays were especially prevalent for utility-scale solar, which has longer project development times and is more sensitive to increases in hardware costs. In Q3 2018, the utility-scale segment only comprised 39% of new solar deployment, its lowest such proportion since Q1 2012.[4] Utility-scale typically represents about 60% of new installations.

** When including all establishments that are involved in solar work, including those that employ solar workers that spend less than half their time on solar-related activities, the total number of jobs is 334,992.*

SOLAR JOBS BY STATE

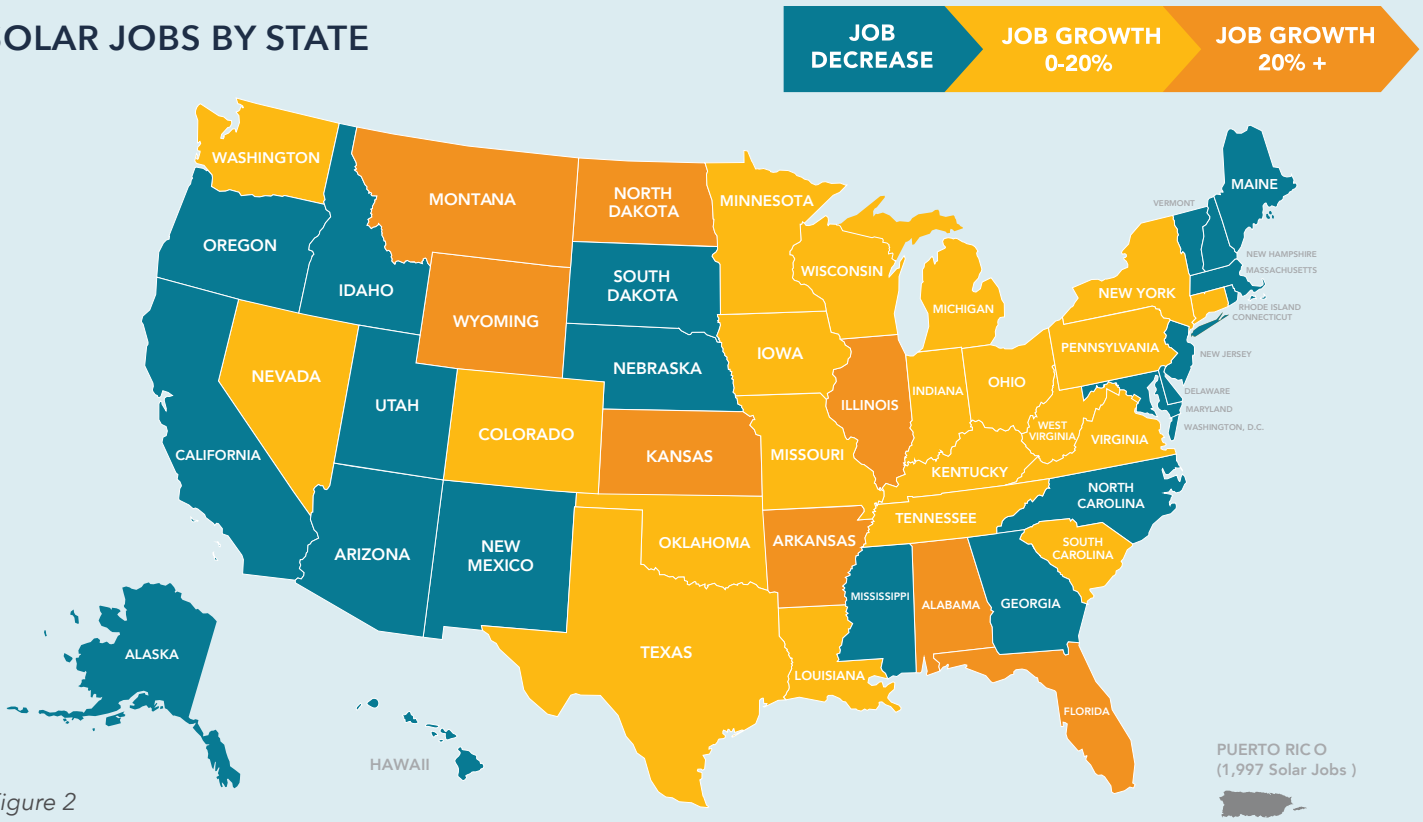


Figure 2

On January 22, 2018, the Trump administration set tariffs for crystalline silicon modules and cells at 30%, with a 5-percentage point reduction each year through 2022. While not as severe as they could have been, the tariffs (coupled with other newly-imposed tariffs on steel and aluminum) still increased hardware costs above baseline expectations and restrained industry growth.

In May, China cut its solar incentives, which reduced module demand and consequently lowered module prices. This policy shift, while harmful to solar manufacturers, gave developers concerned about rising hardware costs a green light to move forward with projects. The average price of solar panels in the U.S declined to 38 cents per Watt in Q3 2018, compared to 45 cents per Watt in Q3 2017.[5]

SOLAR JOBS BY STATE

Just as in 2017, the past year brought major job losses in states with well-established solar markets, as well as certain Southeastern and Western states that have seen recent surges in solar industry growth (Figure 2). California saw the greatest job loss in 2018, declining by 9,576 jobs to a total of 76,838 solar workers. Other states with notable declines include:

- Massachusetts lost 1,320 jobs, down to 10,210 solar workers.
- North Carolina lost 903 jobs, down to 6,719.
- Arizona lost 857 jobs, down to 7,524.
- Maryland lost 808 jobs, down to 4,515.
- New Jersey lost 696 jobs, down to 6,410.
- Georgia lost 614 jobs, down to 3,696.
- Hawaii lost 595 jobs, down to 2,120.

Other states saw solar jobs significantly increase, including in many regions where the solar industry is only beginning to gain a foothold. Overall, solar employment grew in 29 states in 2018. Florida surpassed Massachusetts to become the state with the second-highest solar jobs total, gaining 1,769 jobs for a total of 10,358 solar workers. Other notable states that experienced gains in employment included:

- Illinois gained 1,308 jobs, up to 4,879.
- Texas gained 739 jobs, up to 9,612.
- New York gained 718 jobs, up to 9,729.
- Ohio gained 644 jobs, up to 7,162.
- Washington State gained 612 jobs, up to 4,045.

In 2018, both California and Massachusetts lost jobs for the second year in a row. California, which is home to about 40% of cumulative U.S. solar capacity, has traditionally been the largest solar job generator.* However, California experienced the same uncertainty that was seen nationwide over the outcome of the trade case, leading to a delay in utility-scale projects. Meanwhile, California also passed ambitious new policies in 2018, including a rooftop solar mandate for new homes and an expansion of the renewable portfolio standard (RPS) (see box below).

These policies are likely to stimulate employment growth, but the impact will play out over the coming years and decades. California utilities were under less pressure to meet RPS goals in the near term since they had made significant progress in recent years. In addition, renewable energy electricity procurement was in flux as California localities struggled to ramp up their community choice aggregation (CCA) operations. Finally, California non-residential installers continued to face policy uncertainties over rate structures. Due to these factors, California experienced its second lowest level of added solar capacity in Q3 2018 since Q3 2012.[6]

Massachusetts also faced policy uncertainty on the delayed release of the Solar Massachusetts Renewable Target (SMART) program, weakening its non-residential market. The SMART program, a successor to the previous SREC (Solar Renewable Energy Certificate) incentive program, compensates PV system owners for the energy produced. The program finally launched in September 2018 and prompted a flurry of initial applications, demonstrating a high interest in the program.

In other states, a favorable policy environment helped drive solar job gains in 2018. Notably, Illinois is implementing the Future Energy Jobs Act, which includes an Adjustable Block Program to support distributed energy systems and community solar projects. In other states, such as Texas, the declining cost of installations helped encourage growth even in the absence of new policies.

** Although California lost jobs in 2017 and 2018, it grew by a staggering 24,500 jobs in 2016, representing almost half of the 51,000 new solar jobs added nationwide in 2016.*

STATE POLICIES: A KEY DRIVER FOR LOCAL GROWTH

Statewide policies are critical to driving local solar industry growth. One such example is California, which has historically implemented solar-friendly policies, helping the state become the largest solar market in the U.S. In 2018, California lawmakers passed a rooftop solar mandate for new homes, which is estimated to lead to a 14% increase in total U.S. solar sales over the next four years, supporting thousands of jobs.[7] Additionally, in September 2018, SB 100 was passed, committing the state to 100% carbon-free energy by 2045.[8]

Illinois has also adopted new policies as a follow up to the 2016 passage of the Future Energy Jobs Act. These include a 25% renewable portfolio standard (RPS) and an Adjustable Block Program (ABP).[9] The ABP, which mandates that 25% of installed capacity come from community solar projects, will fuel the growth of the non-residential market, which is already expected to reach 129 MW by the end of 2020.[10]

After a long wait, Nevada reinstated its net metering program in the summer of 2017 to boost the rooftop solar market. Nevada midterm voters also passed a ballot initiative to increase the state's RPS to 50% by 2030, which will further boost the state's solar market. In Florida, state regulators finally allowed solar leasing for residential customers; the state has seen a 62% increase in residential capacity since 2017.[11]

This edition of the *Census* for the first time includes jobs data for Puerto Rico, which had 1,997 solar jobs in 2018. For the purposes of comparison to previous years, the total U.S. jobs number of 242,343 does not include the Puerto Rico job numbers. (See box, p. 14).

A table listing solar jobs in all 50 states, the District of Columbia, and Puerto Rico, along with the gains or losses from 2017, can be found in Appendix A. In March 2019, The Solar Foundation will release more detailed state jobs data, as well as local data for counties, metropolitan areas, and federal and state congressional districts, on the interactive Solar Jobs Map at SolarStates.org.

SOLAR JOBS BY SECTOR

In addition to national job numbers, the *National Solar Jobs Census* reports on jobs by industry sectors: installation (including project development), wholesale trade and distribution, manufacturing, operations and maintenance (O&M), and the "other" category (Figure 3). The jobs per industry sector are calculated based on the type of solar establishment rather than individual employees. For example, a sales representative at a solar installation establishment would be classified within the installation sector.

SOLAR EMPLOYMENT BY SECTOR

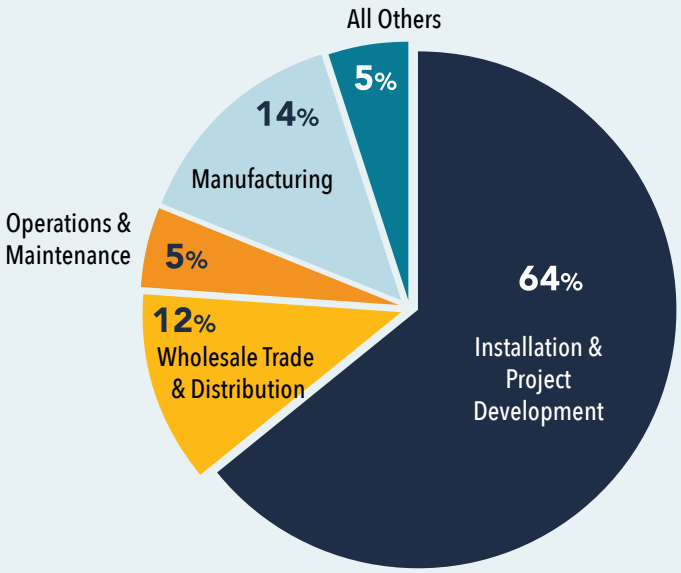


Figure 3

For the 2018 *Census*, The Solar Foundation adjusted the way the jobs sectors are categorized in order to better reflect the current state of the industry. Previous editions of the *Census* included a project development category, which is now incorporated into the installation sector. The sales and distribution category from previous years has been renamed wholesale trade and distribution, while O&M is a new category in 2018.

The 2018 *Census* found that demand-side sectors (installation and project development combined with wholesale trade and distribution) make up almost 76% of overall solar industry employment, with installation and project development firms accounting for 64% of the total solar workforce. In contrast, the manufacturing sector comprises only 14% of U.S. solar jobs, and O&M comprises just under 5%. The "other" sector represents about 5% of all solar jobs.

The 2018 *Census* is the first to break down the installation and project development sector into market segments: residential, non-residential, and utility-scale. About 87,000, or 56% of the installation and project development jobs, are focused on the residential segment, and just under 30%, or 46,000 jobs, are in non-residential. Utility-scale comprises the remaining 22,000 of this sector's jobs (14%). Although utility-scale represents the largest segment for installed capacity, it has considerably fewer jobs than the distributed generation segments. The economies of scale for this sector allow for relatively low transaction costs per unit of capacity deployed. (For more information on labor productivity in the solar industry, see p. 30.)

SOLAR EMPLOYMENT BY SECTOR, 2018

SECTOR	2018 Employment	% Total Employment	% Growth 2017 - 2018	% Growth 2010 - 2018
Installation and Project Development	155,157	64.0%	-6.1%	138.1%
Wholesale Trade and Distribution	29,243	12.1%	-5.4%	149.0%
Operations and Maintenance	11,164	4.6%	N/A	N/A
Manufacturing	33,726	13.9%	-8.6%	35.4%
All Others	13,053	5.4%	-24.6%	1.1%
Overall	**242,343**		**-3.2%**	**159.2%**

Table 1

Also, for the first time, the 2018 *Census* includes jobs data from firms that primarily work on battery storage (p. 43). These establishments report that 3,901 of their storage jobs focus on solar. However, this sector excludes jobs that are related to storage but part of another sector, such as installation. The solar + storage sector is not included in the total job count for the 2018 *Census* for the purposes of comparison to previous years.

Installation companies were responsible for most of the jobs lost between 2017 and 2018. The installation sector shed about 10,000 jobs, or 6.1% of its workforce (Table 1). The wholesale trade and distribution sector lost just over 1,650 jobs, the manufacturing sector saw a decline of 3,160 jobs, and the "other" category lost just over 4,000 jobs.*

In past years, jobs in the new O&M category were likely counted as part of the installation and "other" sectors. Therefore, the total job losses in these latter two categories are likely overstated.

LONG-TERM TRENDS FOR SOLAR JOBS

As solar energy has taken hold in the United States, the job market has expanded rapidly. While the job losses in 2017 and 2018 are important developments, overall trends have been positive. In the five-year period between 2013 and 2018, solar employment grew by 70% overall or 11% annually, adding a net of 99,646 jobs. By comparison, U.S. employment grew by 1.76% annually during that time period.† Therefore, solar employment grew six times faster than employment in the overall U.S. economy.[12] Solar growth accounted for 0.81% of the 12 million jobs added by all U.S. businesses, equal to one in every 124 new U.S. jobs.‡

From 2010 to 2018, the most significant growth has taken place in the installation and project development sector. Employment in this sector grew by 253%. Wholesale trade and distribution, the second fastest growing sector, grew by 149%, and manufacturing jobs grew by 35% (Table 2, Figure 4).§

---

* *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.*

† *Based on the compound annual growth rate.*

‡ *Based on 99,646 growth in solar jobs divided by 12,329,469 growth in total U.S. jobs.*

§ *The "other" sector grew just 1%. As noted, however, this sector no longer includes O&M as of 2018, so the low growth doesn't accurately reflect the long-term trend for this sector. For comparison, the "other" sector grew by 34% between 2010 and 2017.*

SOLAR POWER IN PUERTO RICO: BARRIERS AND OPPORTUNITIES

There are nearly 2,000 solar jobs in Puerto Rico as of 2018, and the island has the potential to greatly expand its solar workforce. As of August 2018, Puerto Rico had approximately 262 MW of total installed solar PV generation capacity, with about one-third of this (74 MW) attributed to the residential market segment.[13] Despite an abundant solar resource (similar to that available in Los Angeles) and residential and commercial electricity prices 60% and 100% higher than the U.S. average, respectively, only about 1% of the electricity generated in Puerto Rico comes from solar.[14]

As Puerto Rico rebuilds from the devastating impacts of Hurricane Maria, solar energy deployed with battery storage has received newfound attention as a way to improve resilience. To date, however, Puerto Rico's renewable portfolio standard (RPS) has been hampered by the lack of effective enforcement.[15] In addition, interconnection and permitting issues represent significant challenges to market growth. Of the Puerto Rico-based solar employers completing the *Census* survey, nearly 90% indicated that interconnection delays were a factor that made growing a profitable business more difficult. Over three-quarters of respondents also pointed to permitting delays, and over half noted broad policy challenges.

Though the market lags behind its potential, two-thirds of Puerto Rico companies indicated some level of difficulty in finding qualified applicants for open positions. The most common reason for this difficulty was employer competition or a small applicant pool (60% of respondents), followed by a lack of experience, training, or technical skills (40%).

These workforce challenges will likely be exacerbated by the rapid growth in both solar and storage capacity in Puerto Rico. In its recently-released five-year fiscal plan, the Puerto Rico Electric Power Authority (PREPA, currently the sole electric power provider in the territory) outlined an "aspirational" generation plan to increase installed solar capacity five-fold through 2023 – which would have solar comprising over 25% of total generation capacity – and to install over 300 MW of storage capacity.[16] This plan is in line with a proposal to meet 100% of Puerto Rico's electricity demand through renewables by 2050, which was making its way through the legislature at the time of publication.[17]

SOLAR EMPLOYMENT BY SECTOR, 2010-2019

SECTOR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019 (Projected)
Installation and Project Development	43,934	52,503	65,165	81,827	112,143	142,383	171,533	165,174	155,157	169,202
Wholesale Trade and Distribution	11,744	17,722	16,005	19,771	20,185	24,377	32,147	30,912	29,243	29,905
Operations and Maintenance	-	-	-	-	-	-	-	-	11,164	11,273
Manufacturing	24,916	24,064	29,742	29,851	32,490	30,282	38,121	36,885	33,726	34,949
All Others	12,908	5,948	8,105	11,248	8,989	11,816	18,274	17,300	13,053	14,024

Table 2. Note: The Census separated the installation and project development sectors from 2012-2017. For this chart, jobs in the two categories were combined into one sector.

SOLAR EMPLOYMENT GROWTH BY SECTOR, 2010-2019

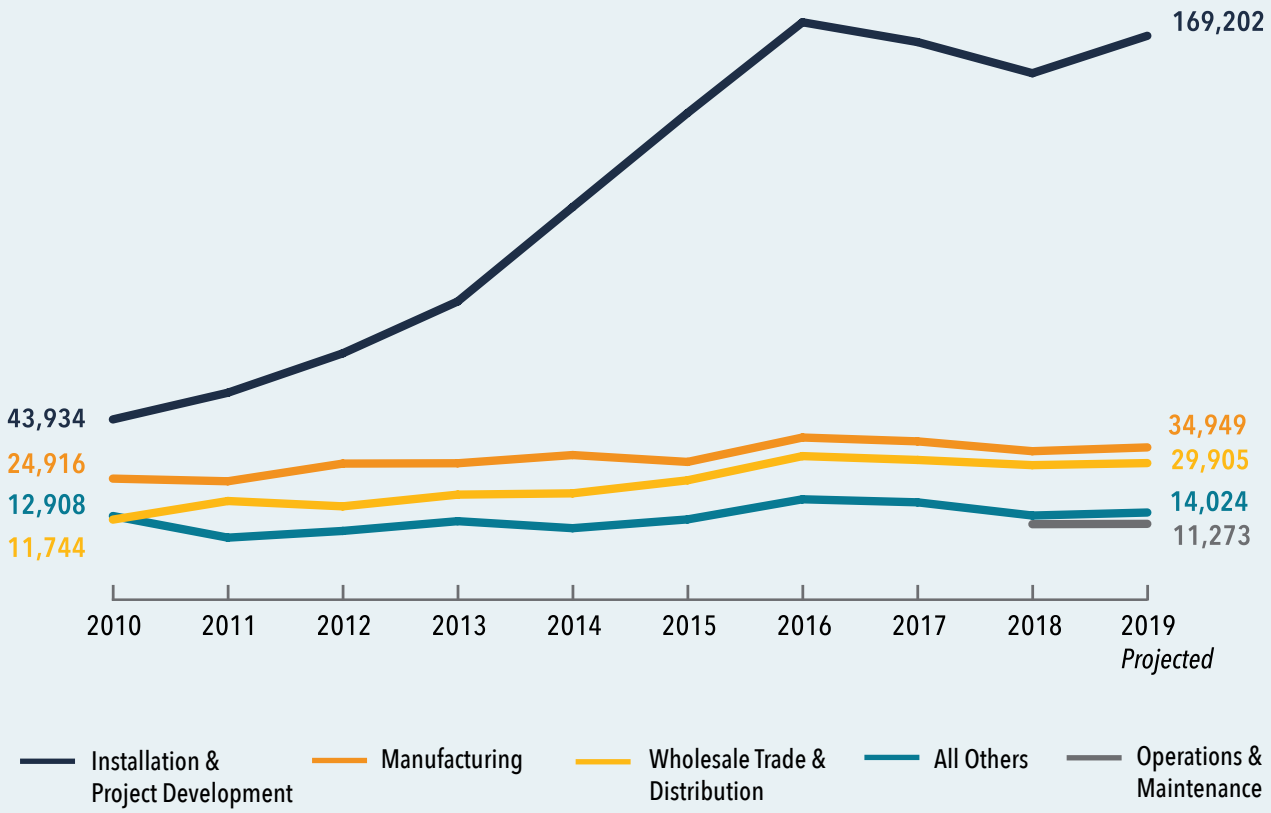


Figure 4

*Solar employment grew about **six times faster** than the **overall U.S. economy** from 2013-2018.*

This long-term job growth has been primarily driven by the falling costs of solar energy, especially the equipment and materials, or "hard costs." From Q3 2010 to Q3 2018, price estimates for PV installations have declined by nearly 57% for residential systems, 74% for non-residential or commercial systems, and 76% for utility-scale projects, as previously shown in Figure 1 (p. 9).* Today, utility-scale solar is cost competitive with new fossil fuel generators in many locations and even competitive with many existing fossil fuel power plants.[18] Federal and state policies, such as the federal investment tax credit, accelerated depreciation, state RPS policies, the Public Utility Regulatory Policies Act (PURPA), and net energy metering (NEM) also support the vibrant U.S. solar power market. Solar energy enjoys widespread and bipartisan support among elected leaders and the general public as a way to control energy costs, fight climate change, boost local economies, enhance national security, and make communities more resilient.

SOLAR JOBS COMPARED TO OTHER ENERGY INDUSTRIES

The solar industry ranks third in total employment among energy industries, behind only petroleum and natural gas. The solar workforce is over twice as large as the coal industry and almost five times as large as the nuclear energy industry workforce.[19] The rapid expansion of solar energy means that more workers are required to install new systems as well as maintain existing installations.†

LOOKING AHEAD TO 2019

With about 60 GW of total capacity nationwide, solar energy comprised 2.4% of U.S. electricity generation through October 2018.[20] New installations in 2018 likely exceeded all other sources of new electric generating capacity except natural gas.[21] In 2019, Wood Mackenzie Power and Renewables expects 11.5 GW of new solar capacity to come online, a 3.5% to 4% increase over the pace of new deployment in 2018. Over 60% of new capacity will come from utility-scale development. Residential solar development is also expected to see modest growth, but non-residential solar is projected to decline in 2019.[22]

Solar is expected to retain the number-two position in new energy generation in 2019, but wind is anticipated to retake the lead over natural gas as the leading source of new power. For 2019, wind is projected to provide 39% of new generating capacity, solar 30%, and natural gas 27%. Most of the added wind capacity is anticipated to be in the central United States. While rooftop solar generation will be widespread, utility-scale solar will be concentrated in California, Texas, Florida, and other South Atlantic coastal states. Coal and nuclear plants will continue to be decommissioned as renewable energy, along with natural gas, assumes greater importance as part of the country's energy mix.[23]

** Using the U.S. Solar Market Insight report series, 2010-2018, this analysis compares Q3 2010 to Q3 2018. The reporting switched from capacity-weighted average installed costs to modeled national PV installed price estimates with component costs in 2014. The prices are based on a 6 kW residential system, a 100 kW rooftop for non-residential, and a 10 MW utility-scale system.*

† Based on comparison with 2017, the latest year of complete data available from the 2018 U.S. Energy and Employment Report. Unlike the Solar Jobs Census, which defines solar workers as those who spend 50% or more of their time on solar-related work, this report counts those who spend any portion of their time on solar-related work.

NEW CLIMATE CHANGE WARNINGS POINT TO CENTRAL ROLE FOR SOLAR

Late 2018 may be remembered for its increasingly dire forecasts on the impacts of human-induced global warming. A special report from the Intergovernmental Panel on Climate Change, released in October, found it would take a global effort of unprecedented scale and speed to hold the average global temperature increase at 1.5 degrees Celsius (2.7 degrees Fahrenheit), the threshold required to avoid the most dangerous impacts of climate change. To meet this target, renewable energy would have to make up 70-85% of the world's electricity by 2050, a far higher level than many recent forecasts expect.[24] The U.S. Global Change Research Program followed up in November with its Fourth National Climate Assessment, a dramatic inventory of the devastating climate impacts already occurring in the United States. In the future, under a high-emissions scenario, the annual cost of climate change could reach $500 billion, nearly double the cost of the Great Recession.[25]

Despite these warnings, the latest benchmarks show the world is not on track to meet the challenge of climate change. Global carbon emissions were projected to rise 2.7% in 2018, the second year in a row that emissions increased. This includes an emissions increase of 2.5% in the United States and nearly 5% in China, where solar and wind installations are on the rise but coal still accounts for about 60% of the country's electricity consumption.[26]

If the world is to reverse this trend and meet the aggressive targets that scientists say are needed, it will take an accelerated rampup in renewable energy production, with solar energy necessarily playing a central role. One possible roadmap is identified in *Designing Climate Solutions: A Policy Guide for Low-Carbon Energy*, a new book by Hal Harvey, CEO of Energy Innovation. The book identifies a dozen "highly effective policies" that could achieve significant emissions reductions worldwide, including performance standards (such as renewable portfolio standards), a price on carbon, and support for public and private R&D.[27]

The Census In-Depth: Company Case Studies

This year's *National Solar Jobs Census* includes case studies on select solar companies, providing more detail on the wide range of careers available in the industry and how companies are meeting workforce development challenges. The full text of these case studies can be found at **SolarJobsCensus.org.**

This anticipated increase in solar installations should lead to new solar job growth in 2019. *The National Solar Jobs Census* survey respondents project employment growth of 7% in 2019, bringing the total to about 259,000 jobs (Figure 5). Firms focused on installation expect to grow by 9%, adding just over 14,000 jobs – by far the most of any sector. Wholesale trade and distribution is expected to grow at a slower, 2% rate, and O&M will likely grow at an even slower, 1% rate.* Manufacturing is expected to experience just under 4% growth, adding about 1,200 jobs over the coming year. Jobs in the "other" category are expected to grow by 7%. Of course, industry predictions are not guaranteed to become reality. The 2019 employment trends will be influenced by many unpredictable factors, including economic conditions, access to capital, and major policy shifts at the federal and state levels.

EXPECTED SOLAR EMPLOYMENT GROWTH FROM 2018-2019

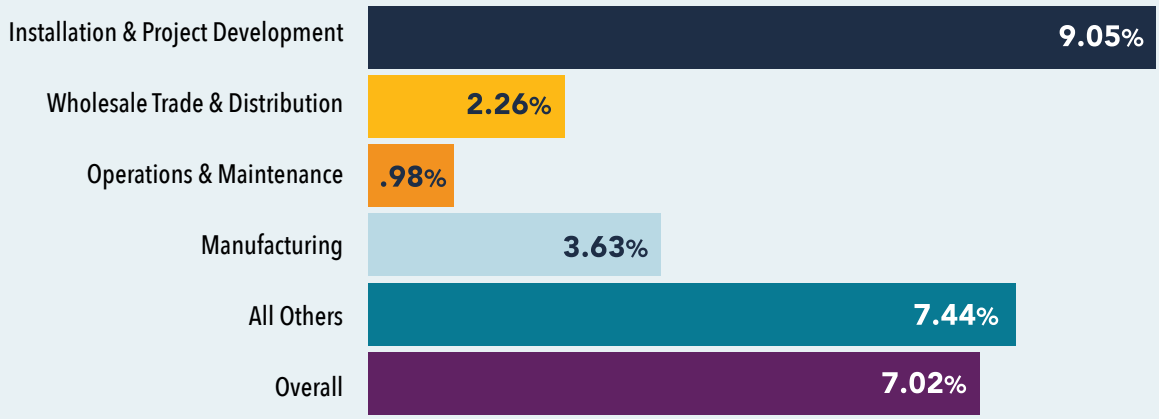


Figure 5

* *Unlike most of the jobs in the other sectors, O&M jobs are a function of cumulative installation rather than annual installation volume.*

SOLAR INDUSTRY CHARACTERISTICS

The 2018 *Census* found that the clear majority of U.S. solar establishments (about 83.1%) are focused on solar PV electric generation. About 10.1% of firms focus on renewable heating and cooling, such as solar water heaters, and 6.8% work on projects related to concentrating solar power (CSP). Unlike in past years, establishments could not select multiple responses, so it is likely that some of these establishments provide other services. For example, in 2017, 95% of all establishments reported working in solar PV and 15% in renewable heating and cooling.

The *Census* sector employment numbers are based on what an establishment reports as its primary focus. However, many establishments focus on multiple sectors of the value chain. For example, 22% of manufacturing establishments also work in wholesale trade and distribution, and 20% of the wholesale trade and distribution establishments also work in manufacturing. Over half (60%) of all establishments primarily focus on installation. However, 8% of these installers also work in wholesale trade and distribution and 41% of them also work in O&M. 26% of O&M establishments report that they work on installation (Table 3).

FOCUS OF SOLAR ESTABLISHMENTS BY VALUE CHAIN

	PRIMARY SECTOR FOCUS				
	Installation and Project Development	Wholesale Trade and Distribution	Operations & Maintenance	Manufacturing	All Others
Installation and Project Development	100.0%	35.0%	25.8%	26.3%	19.1%
Wholesale Trade and Distribution	7.8%	100.0%	24.7%	22.2%	7.1%
Operations and Maintenance	40.5%	20.5%	100.0%	21.1%	14.4%
Manufacturing	6.2%	19.7%	11.2%	100.0%	4.3%
Research & Development	5.0%	9.4%	11.2%	24.7%	24.5%
Utility	2.2%	7.7%	62.9%	1.5%	1.7%
Consulting, Engineering, Finance, Legal, or Other Services	32.7%	29.1%	20.2%	23.7%	100.0%

Table 3

McCarthy Building Companies

ENGINEERING, PROCUREMENT, AND CONSTRUCTION (EPC) FIRM

McCarthy will perform around ***one million labor hours annually*** *for solar projects, over* ***60%*** *of which are from direct hires from local communities.*

McCarthy Building Companies started its construction business over a century and a half ago, and this expertise facilitated a smooth entrance into solar installations in 2009. The company's employee-centric roots still impact the business today, with a strong emphasis on local workforce development. Based in Phoenix, Arizona with solar projects across the country, McCarthy values solar energy as an economic engine that can spark business investments and job creation.

Ten years ago, McCarthy established its national renewable energy business to apply its long-held expertise in construction to solar installations. The renewable energy program now accounts for 15% of the business at McCarthy, totaling over 1.7 GW of solar capacity either completed or under construction. McCarthy is an employee-owned company, which empowers employees at all levels to be included in the day-to-day decision-making process. The company credits its success in the solar industry to its dedication in hiring and training local labor to perform project construction, which in turn catalyzes local economic growth.

McCarthy's solar business offers Engineering, Procurement, and Construction (EPC) contracting services to large third-party developers, utilities, and cooperatives for utility-scale projects. "McCarthy is unique in our ability to hire, train, and execute local work, as well as our highly skilled engineering team," says Mike Corso, VP of Operations. Their business model emphasizes the hiring and training of local workforce crews to complete projects. In any given year, McCarthy will perform around one million labor hours for solar projects, over 60% of which are from direct hires from local communities. To achieve this, they partner with local workforce development organizations to help coordinate job fairs around the community.

McCarthy's dedication to hiring and training local workers helps create a robust workforce pipeline for solar and construction workers across the country. Since most of its projects are in rural areas, typically with a small labor pool, the job market can be particularly competitive in these areas since many industries are looking to hire similar workers. This means that McCarthy's workforce development partnerships are an essential part of the hiring process.

Every new hire goes through a three-month on-the-job installation training program inclusive with an elevated focus on safety unlike any other in the construction industry. New hires for an installation position learn from McCarthy foremen the specific building and safety skills critical to earning a solar installation certification for each specific craft including mechanical, electrical, and civil. All craft employees participate in the Training Within Industries (TWI) program, a McCarthy specific training program, specially designed to strengthen the solar workforce by teaching workers the skills necessary to complete complex solar projects. Together, these training programs allow workers with no previous work experience to start a new career in the solar industry.

Furthermore, the program equips workers with a skill-set that is transferable to construction careers with McCarthy, or elsewhere in solar construction.
Not only does the TWI program benefit workers, it has led to significant business advantages for McCarthy. "We have identified three key areas where TWI training has shown success for our business, including a better-quality product, improved labor efficiency, and improved safety," said Scott Canada, Senior VP of Renewable Energy for McCarthy.

LOCAL WORKFORCE DEVELOPMENT

To McCarthy, local workforce development is especially important to support underemployed or unemployed workers in rural America, which faces higher rates of unemployment compared to urban areas.[28] By training and developing the workforce in rural locations, where utility-scale solar projects are typically located, McCarthy sees widespread benefits for the community. A typical 100 MW project will employ 300 craft workers, including 150-180 hired from the local community and approximately 25 McCarthy staff, providing them with full-time employment and training for 3-12 months, Canada says.

Combined with McCarthy's local workforce development efforts, the utility-scale projects they build can help spark economic development in rural communities beyond solar jobs. As more and more businesses expand their clean energy goals, rural communities with solar infrastructure can be an attractive location to establish commerce. Attracting businesses that support clean energy goals leads to the creation of permanent jobs and infrastructure. McCarthy brings the expertise, innovative design, and best operational practices to help communities achieve their economic goals.

In addition to their direct-hire craft employees for temporary projects, McCarthy employs about 150 permanent employees working on solar energy. Each solar project undergoes a pursuit phase, design phase, and field operations and commissioning phase. Key employees during the pursuit and design phases include estimators, who determine project pricing and budgets; mechanical, electrical, and civil engineers who produce system designs; and operations and project personnel who oversee the management of projects.

During the field operations and commissioning phase, project managers, superintendents, and foremen oversee the installation crews and all aspects of the field work for a project. For a typical 100 MW project, there may be 25 permanent McCarthy employees on-site to supervise and execute the installation. In the hiring process, it can be challenging to find permanent field employees who are willing to travel extensively from project to project. To account for the strain that traveling may place on its employees, McCarthy provides special travel incentives such as increased salary, subsistence packages, and extra time off.

As innovation continues, McCarthy expects a bright renewable future which presents a multitude of opportunities. One future workforce need will be for experts who test models for system performance. "As more and more systems age, the market is expanding to understand the tools necessary for ongoing system performance to sustain systems at their full capacity," Canada notes. As storage starts to penetrate the market more, McCarthy will also seek to hire functional engineers with knowledge of solar+storage technology. These new roles, along with their focus on local workforce development, will ensure McCarthy continues to thrive in the solar industry and help spur economic development in local communities.

Learn more at McCarthy.com.

TYPES OF OCCUPATIONS

When comparing employment by occupational category rather than by industry sector, about 32% of all solar employment is reported to be in administrative, management, and professional positions. Another 38% of jobs were found to be in installation and repair positions, 7% were in manufacturing positions, and 15% were in sales positions (Table 4).

Unlike in the sector survey results, occupational categories match each specific job to a category. For example, the manufacturing sector comprises 14% of solar jobs, but those in manufacturing occupations make up only 7% of jobs across all sectors.

The *Census* survey also found that most establishments (77%) have fewer than 50 employees. About 30% of establishments have five or fewer employees, while another 14% have six to ten employees (Figure 6). Only 2.9% of establishments have over 500 employees.

SOLAR WORKERS BY OCCUPATIONAL CATEGORY

	Production/ Manufacturing	Installation or Repair	Administrative	Management/ Professional	Sales	Other
Installation and Project Development	3.4%	37.2%	16.1%	16.5%	20.9%	6.0%
Wholesale Trade and Distribution	5.5%	8.8%	24.5%	17.2%	14.0%	30.1%
Operations and Maintenance	8.6%	55.1%	13.3%	16.9%	2.6%	3.6%
Manufacturing	19.1%	43.2%	12.9%	10.0%	7.8%	7.1%
All Others	9.2%	5.8%	16.6%	32.3%	8.1%	28.1%
Overall	**7.1%**	**38.4%**	**15.9%**	**16.0%**	**14.8%**	**7.8%**

Table 4

LOCATION SIZE BY NUMBER OF PERMANENT EMPLOYEES

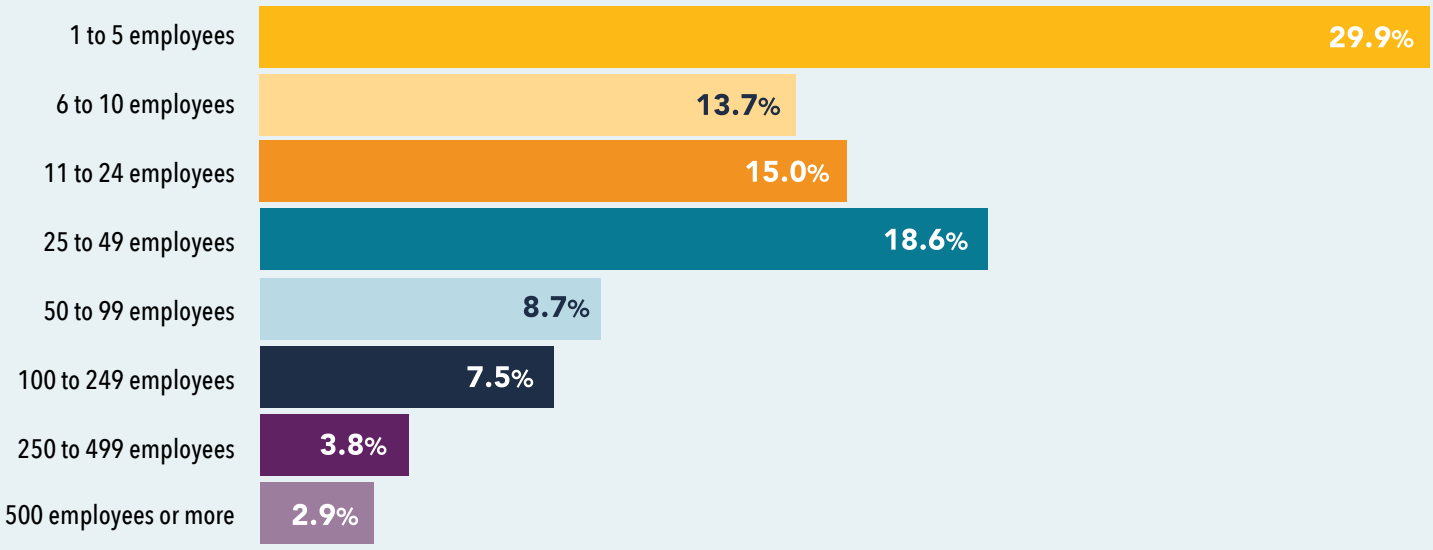


Figure 6

SUPPLY CHAIN ANALYSIS

Most installation and project development establishments (80%) report their primary customer is located within their state (Table 5). In contrast, the primary wholesale trade & distribution establishment customer is most often out-of-state (55%). The primary manufacturing customer is also most often located outside the facility's state (55%), while just under 11% of manufacturing establishments report that their primary customer is international. Half of O&M primary customers are within the state.

Most products and services in the solar value chain originate domestically. Solar establishments report that, on average, 70% of their suppliers and vendors are located in the United States (Table 6). Installation establishments report the highest percentage of vendors in the U.S. (78%) while O&M reports a slightly lower percentage of vendors in the U.S (74%). Manufacturing reports the highest percentage of vendors located outside the U.S, at 42%.

CHALLENGES TO SUCCESS

Respondents were asked to identify which key factors contribute to the difficulty of growing a profitable business. About half of the establishments selected federal or state policy challenges as "very significant." Roughly 30% identified the cost or supply of materials, interconnection delays, and permitting delays as very significant. About a quarter specified lack of capital and lack of qualified talent as very significant (Figure 7).

PRIMARY CUSTOMER LOCATION BY VALUE CHAIN

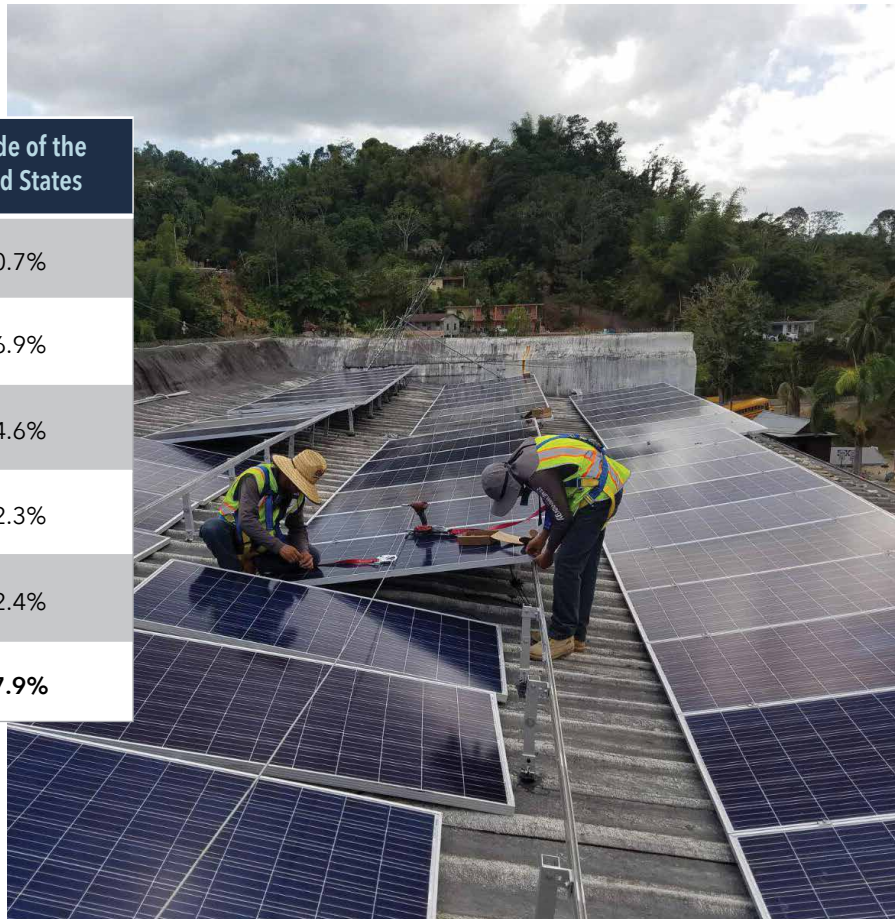
	In-state	In a bordering state but out of state	In the United States, but outside of a bordering state	Outside of the United States
Installation and Project Development	79.5%	6.1%	14.0%	0.4%
Wholesale Trade and Distribution	37.3%	4.5%	50.7%	7.5%
Operations and Maintenance	50.0%	14.0%	30.0%	6.0%
Manufacturing	34.5%	3.5%	51.3%	10.6%
All Others	46.0%	6.4%	43.6%	4.0%
Overall	**60.8%**	**29.4%**	**5.9%**	**3.9%**

Table 5

PERCENT OF SOLAR ESTABLISHMENT SUPPLIERS AND VENDORS BY LOCATION

	In the United States	Outside of the United States
Installation and Project Development	78.1%	20.7%
Wholesale Trade and Distribution	59.0%	36.9%
Operations and Maintenance	73.5%	24.6%
Manufacturing	56.8%	42.3%
All Others	69.8%	22.4%
Overall	**69.9%**	**27.9%**

Table 6



FACTORS THAT CONTRIBUTE TO THE DIFFICULTY OF GROWING A PROFITABLE BUSINESS

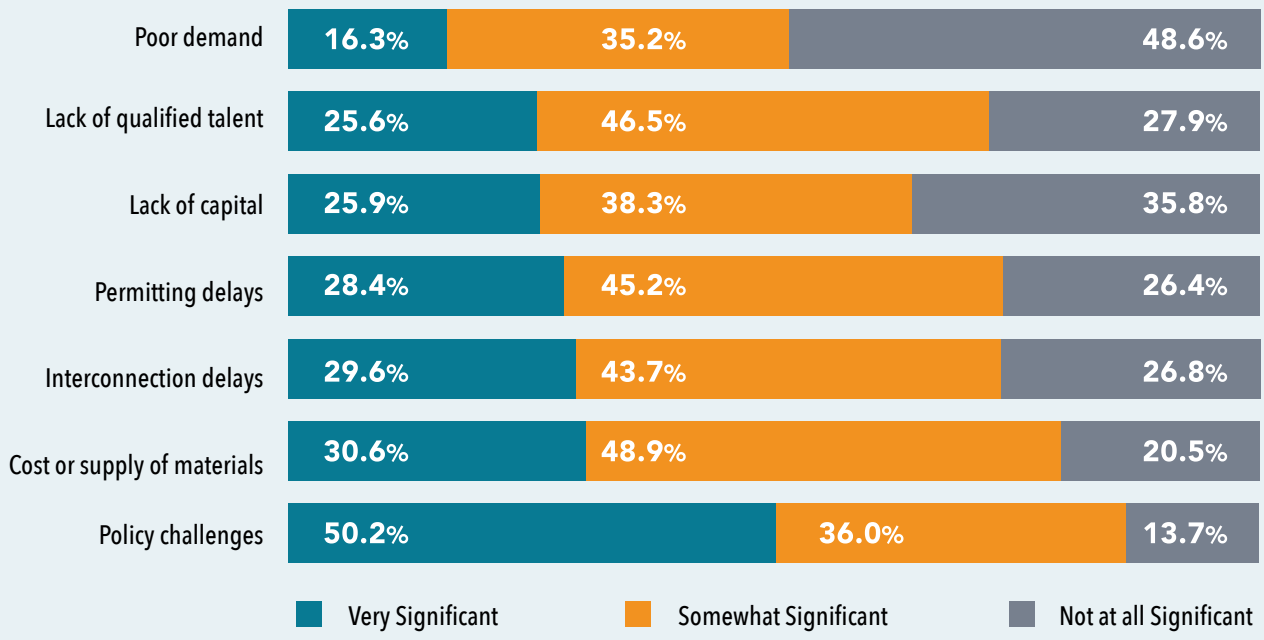


Figure 7

SECTOR ANALYSIS

Demand-side sectors, *comprised of the installation and project development sector and wholesale trade and distribution, make up* ***76% of overall solar industry employment, with 184,400 jobs.***

Installation and Project Development

This year's *National Solar Jobs Census* combines installation and project development into one installation sector. This allows for the correction of any survey biases among companies that had difficulty determining which of the two sectors they should be identified with. The redefined installation sector is then subdivided into residential, non-residential, and utility-scale market segments to better reflect the way that solar companies view the industry.

The installation sector, which represents the end of the solar value chain, makes up 64% of all solar jobs. Comprised of companies that primarily develop and install PV and other solar energy technologies like solar space heating and cooling, solar installation firms employ a wide range of specialized workers. The majority of these workers are connected to the building trades, particularly electricians and construction laborers. The *Census* not only counts those who spend at least 50% of their time performing the installation work, but also those who spend at least 50% of their time as project support staff, including permitting, engineering, design, sales, marketing, administration, accounting, and management staff.

The installation and project development sector makes up ***64% of the workforce, with 155,157 jobs.***

JOBS IN INSTALLATION AND PROJECT DEVELOPMENT

In 2018, the solar installation and project development sector reported a total of 155,157 jobs, a decline of 6.1% (Figure 8). Over the long term, the sector has experienced robust growth, and the number of jobs more than tripled between 2010 and 2018. Prior to 2018 and 2017, the sector was growing 20% or more annually. It is projected to grow by 14,000 jobs, or 9%, in 2019.

For the first time, the 2018 *Census* divides installation jobs among three market segments: residential, non-residential (also known as commercial and industrial, or C&I), and utility-scale. Utility-scale is the largest energy-producing segment, with about 60% of cumulative installed solar capacity. The remaining 40% is split about evenly between residential and non-residential solar installations. The non-residential segment includes community solar installations.

SOLAR INSTALLATION AND PROJECT DEVELOPMENT EMPLOYMENT GROWTH, 2010-2019

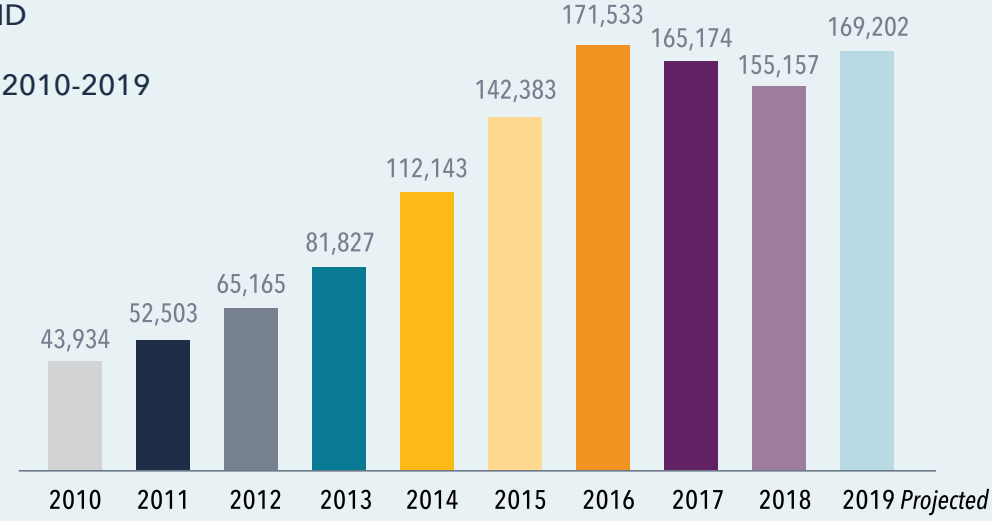


Figure 8

Among all jobs in this sector, the majority (56%) work in the residential segment. Another 30% work in non-residential and 14% in the utility-scale segment (Table 7). Distributed generation (residential and non-residential) represents 86% of all installation and project development jobs. Many of these jobs do not focus exclusively on a single sector. For example, the same contractor may work on a residential installation one day and a commercial system the next. Likewise, there is significant crossover in employment between commercial installation and utility construction crews. Furthermore, some installation jobs, especially for utility-scale development, may be retained on a contract over a few months while a project is under construction. These jobs would not be counted if they did not work enough time over the year to meet the 50% time threshold that defines a solar job. If the 50% constraint were removed, the number of installation jobs would increase from 155,157 to 225,462 jobs.

On average, a MW of solar can power 191 U.S. homes.[29] Residential solar systems average about 7.5 kW in size, which is enough to power 1.4 homes. Depending on state policies, residences that produce more solar than the household consumes may be able to sell the remainder back to the grid. Utility-scale solar deployment averages 19.5 MW, enough to power 3,719 homes (Table 8).

INSTALLATION AND PROJECT DEVELOPMENT JOBS BY SEGMENT

	Employment	Percentage
Residential	87,323	56.3%
Non-residential	46,058	29.7%
Community Solar	*12,674*	*8.2%*
Other Non-residential	*33,385*	*21.5%*
Utility-scale	21,775	14.0%
Total	**155,157**	

Table 7

NUMBER OF HOMES POWERED PER INSTALLED SYSTEM

	Average Size of Installation	Number of Homes Powered Equivalent
Residential	7.5 kW	1.4
Non-residential	221 kW	42.1
Utility-Scale	19.5 MW	3718.6

Table 8

INSTALLATION AND PROJECT DEVELOPMENT
JOBS PER MW INSTALLED

	Jobs Per MW
Industry Total	14.0
Residential	38.7
Non-residential	21.9
Utility-scale	3.3

Table 9

LABOR PRODUCTIVITY

Productivity varies widely between the residential, non-residential, and utility-scale segments. Residential installations require that more time be dedicated to setting up and removing equipment, driving to and from sites, and other tasks that must be repeated for each project. Consequently, residential installations require more jobs per MW than larger non-residential or utility-scale systems.

Utility-scale development benefits from economies of scale. While the permitting and approval process is longer than for a residential project, it is relatively short given the project size or on a time-per-MW basis. The utility-scale workforce is also more specialized. Since the arrays are typically ground mounted, in one location, and fairly uniform, the installation process is generally more efficient than a portfolio of residential rooftop projects of comparable capacity.

Jobs per MW figures are calculated based on total jobs for each segment and projected 2018 installed capacity for those segments. These numbers include all workers in the sector that spend 50% or more of their time on solar, including workers external to the surveyed company's establishment, such as subcontractors. Overall, there were 14 jobs/MW in the solar industry (Table 9). Residential generated the most jobs at 38.7 jobs/MW, followed by non-residential at 21.9 jobs/MW, and with utility-scale at the lowest at 3.3 jobs/MW.* Should the rise in Q4 2018 utility-scale deployment not occur as projected, the overall utility-scale jobs/MW would be higher.

** In the 2017 National Solar Jobs Census, the calculation to determine jobs per MW was based on interviews with select employers and used only their field-based jobs over their reported installed capacity.*

WHERE EMPLOYEES WORK RELATIVE TO THE OFFICE

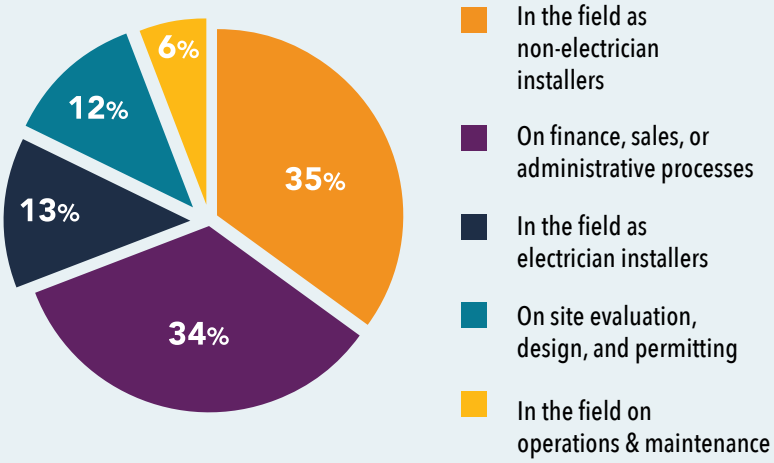


Figure 9

JOB LOCATIONS

In considering where installation employees work relative to their office location, establishments report that about 35% of their staff work in the field as non-electrician installers and roughly 14% work as electrician installers (Figure 9). About 12% work on-site evaluation, design, and permitting, and 34% work on finance, sales, or administrative processes. About 6% work in the field on operations and maintenance.

Of the field staff, about two-thirds of establishment employees work within the region or metropolitan area of the establishment (Table 10). Another 13% work out of the region but in the state, while 22% work out-of-state. Utility-scale installers (engineering, procurement, and construction firms) often employ out-of-state labor for their larger projects. A typical field crew may be made up of an experienced management team permanently employed by the firm and some permanent field workers, along with temporary employees from the local workforce. However, in rural areas where the local labor pool is small, most of the workforce will travel to the site, often staying and working onsite for three to nine months.

LOCATION OF FIELD CREW RELATIVE TO THE OFFICE

In-state within region/ metropolitan area	65.6%
In-state outside region/ metropolitan area	12.9%
Out-of-state	21.5%

Table 10

IN-DEPTH:

SUNBUG SOLAR

Residential and Commercial Solar Installation

SunBug Solar provides full-service installations to residential and commercial customers in Massachusetts. The company has about 65 employees and maintains six installation crews. Now that the state SMART program is in place, SunBug foresees job growth in the near future. The commercial team is growing at a faster pace as they continue to develop more projects. Additionally, as solar + storage becomes more prominent in the industry, SunBug foresees the potential need for storage system design experts and a sales team dedicated to storage.

Read the full profile of SunBug Solar at SolarJobsCensus.org.

IN-DEPTH:

STRAIGHTUP SOLAR

Turn-key Solar Energy Design and Installation Firm

StraightUp Solar designs, installs, and monitors residential and commercial-scale solar systems in Missouri and Illinois. Since 2015, they have more than doubled their workforce and expect to triple it by mid-2019. The fastest growing jobs at StraightUp Solar are electricians and array specialists, though all teams are growing to support the increased project load. The company foresees the need to create additional Field Project Coordinator positions that act as a direct line of communication between directors and field crews, presenting an opportunity to promote and train field employees.

Read the full profile of StraightUp Solar at SolarJobsCensus.org

Swinerton Renewable Energy

UTILITY-SCALE INSTALLATION FIRM AND OPERATIONS AND MAINTENANCE FIRM

*Craft employees constitute the bulk of the full-time staff, **totaling just under 500 employees** who work on-site constructing the solar systems.*

Swinerton Renewable Energy is an installation contracting firm focused on building utility-scale ground mounts and commercial solar projects, with an additional service specializing in operations and maintenance. Whenever possible, Swinerton contracts with local workers to complete its solar projects across the U.S.

Swinerton Renewable Energy offers two main service categories: engineering, procurement and construction (EPC), and SOLV, their operations and maintenance services. The EPC team is typically contracted by developers seeking to build utility-scale or commercial solar systems. The SOLV team offers continuous monitoring of all Swinerton systems, which includes a 24-hour operations and control center and expert staff who respond to any maintenance needs.

Swinerton's EPC group has offices in San Diego, California; San Francisco, California; and Raleigh, North Carolina. Their scope of work includes procurement, engineering, and construction of solar systems. The workforce includes project managers and assistants specializing in procurement, engineering, and construction; marketing and administrative teams; field superintendents; and craft employees. Craft employees constitute the bulk of the full-time staff, totaling just under 500 employees who work on-site constructing the solar systems. They travel extensively from job to job, typically out-of-state.

For typical projects, Swinerton hires local workers who make up the vast majority of the on-site workforce. Depending on the state and local regulations, the workforce is either hired through temp agencies or directly from local union halls. Permanent Swinerton craft employees oversee the training of the subcontractors to ensure quality and safety throughout project construction. Michael Stevenson, Assistant Project

Manager, estimates that 90% of the workforce on an 80 MW project is hired from the local community, totaling about 300 people who are provided with full-time work for about six months.

The SOLV side of Swinerton has offices in San Diego and Bend, Oregon, along with dozens of satellite offices across the country to provide on-site maintenance services. Their workforce includes employees operating the control center and others providing maintenance services on-site. The SOLV group oversees 315 projects across 20 states, with 100 solar technicians to perform maintenance work. Swinerton is constantly hiring SOLV technicians to support the growing business. "For the last 15 years, the industry has been building and expanding," Stevenson notes. "The industry is now taking a new step toward operating and maintaining these systems to ensure optimal performance."

One challenge Swinerton faces is finding labor and equipment for projects. "Typically, when we build a large utility-size solar farm, it is located in an area with a low population, making it difficult to find qualified workers," says Brandi Pearson, Swinerton's HR Manager. Especially in heavy coal and oil-producing states, Stevenson adds it is hard to find skilled solar workers compared to states with more established solar industries, such as California and Nevada.

To overcome this obstacle, Swinerton is devoted to establishing and fostering local ties in project locations. Throughout the year, Swinerton sponsors events that support active community engagement and give back to the communities they work in.

To support its core staff, Swinerton is dedicated to employee development, growth, and leadership. Swinerton offers extensive learning opportunities to help employees build a skill set and develop their career, including: online classes covering topics from subcontractor management to time management; in-house LEED certification; the "Better Builders" program to provide on-the-job field experience training; a leadership development program; and other professional development programs such as peer mentoring. This dedication to employee development and satisfaction is particularly important, Pearson says, due to the extensive travel that is required for craft laborers. Pearson understands the difficulty their craft employees face with extensive travel but says, "we take care of our people and invest heavily in their personal and professional growth." In fact, Swinerton has been named among Fortune's "Best Places to Work for Millennials" and "Best Workplaces to Retire From."

Learn more at swinertonrenewable.com.

THE RESIDENTIAL SEGMENT

Within the installation and project development sector, about 87,000 workers focus on residential development. Since this is the first year the *Census* has separated jobs by market segment, data is not available on residential jobs for previous years. However, trends in installed residential capacity provide some indication on how this market segment has progressed, nationwide and state by state.

Based on Q3 2018 data, annual installed capacity in the residential market was expected to be flat in 2018, following a 15% year-over-year decline in 2017.[30] This trend varies considerably by state, with some states experiencing rapid residential growth and others experiencing significant losses. Buoyed by policy reforms, residential installed capacity grew significantly in Florida and Nevada. A second tier of emerging residential markets, including Idaho, Illinois, Louisiana, North Carolina, Virginia, and Washington, experienced solid growth. Even states with very little solar development, such as Arkansas, Michigan, Ohio, Wisconsin, and Wyoming, experienced residential growth.

Residential capacity slowed in states with more established solar markets, such as Arizona, Hawaii, Maryland, New Jersey, New York, and Utah, due to economic and policy challenges. States with relatively new residential markets, such as Delaware, Iowa, New Hampshire, and Pennsylvania, also experienced declines in installed capacity.[31] Almost all significant residential market changes can be attributed to state policies. For example, Nevada, which reinstated its net metering policies in mid-2017, is expected to have more than tripled its installed residential capacity in 2018. Florida bolstered its residential market by accepting leases, which allows for third-party ownership (see box, p. 11).

THE NON-RESIDENTIAL SEGMENT

The non-residential segment includes commercial, industrial, nonprofit, and government installations (including schools). There are approximately 46,100 non-residential jobs, which are comprised of 12,700 jobs that focus on community solar, and another 33,400 jobs focused on other non-residential development.

Non-residential installations were expected to decline by 5% nationwide in 2018, following a dramatic 32% bounce upward in 2017. Traditional solar markets such as California, Hawaii, Massachusetts, and New Jersey saw declines in non-residential deployment. Some emerging states experienced considerable growth: Alabama grew from less than 1 MW in 2017 to an expected 15 MW in 2018. Other strong growth took place in Arkansas, Georgia, North Carolina, Maryland, and Oklahoma.

As with the residential segment, state policies played key roles in driving capacity growth and decline. California's decline in non-residential deployment was spurred by firms that rushed to complete projects in 2017 before favorable policies and incentives expired (but have since been extended). Massachusetts firms, for the second year in a row, faced policy uncertainty concerning the new SMART incentive program, but developers rushed to queue up their projects once the program was rolled out in November. One positive development is that community solar growth continues to accelerate in a few key states. Over 400 MW of community solar was deployed through Q3 2018, of which over half was deployed in Minnesota.[32]

THE UTILITY-SCALE SEGMENT

About 14% of installation and project development jobs (22,000 jobs) focus on utility-scale development. While providing only a small fraction of all solar jobs, this segment accounts for more solar capacity than the other two segments combined.

Because of its cost structure, utility-scale development suffered the most from the uncertainty surrounding the tariffs on solar modules and cells. Hardware costs represent a greater proportion of total costs in utility-scale development compared to residential or non-residential solar. Therefore, the anticipated tariffs delayed the start of many utility-scale projects, which in turn delayed their completion until Q4 2018 or later. States such as California, Nevada, and Texas saw significant declines in utility-scale development by Q3 2018.

However, the utility-scale segment is expected to recover in Q4 2018, ending the year with 5% annual growth nationwide. States anticipating significant utility-scale capacity growth by the end of 2018 include California, Colorado, Indiana, Massachusetts, Missouri, New York, and Vermont. Other states, such as Georgia, Idaho, Minnesota, Mississippi, and Virginia, expect a marked decline in growth. Typically, solar expansion in these states is driven by the construction of major projects. One or two large utility-scale projects, or the absence thereof, can dramatically impact a state's annual capacity additions. Off-site corporate activity has and will continue to support additional utility-scale growth, as corporations set aggressive sustainability goals and invest in solar projects to meet them.[33]

In summary, with more states setting aggressive RPS goals, growing corporate interest, and declining costs, utility-scale development should remain strong for the foreseeable future.

Figure 10 displays the overall additions in solar capacity by year, based on data in the *U.S. Solar Market Insight* report.[34]

IN-DEPTH: PIVOT ENERGY

Solar Project Development Firm

Pivot Energy is a solar project developer headquartered in Denver, focusing on community solar and medium-to-large commercial and industrial projects. While it contracts out the construction work, it is a full-service development firm involved in every stage of PV system installation. Pivot Energy expects to hire more engineers, project managers, policy advocates, and developers in the near future. Additionally, the company foresees the need for solar+storage professionals as the technology improves and customers begin seeking storage options.

Read the full profile of Pivot Energy at SolarJobsCensus.org.

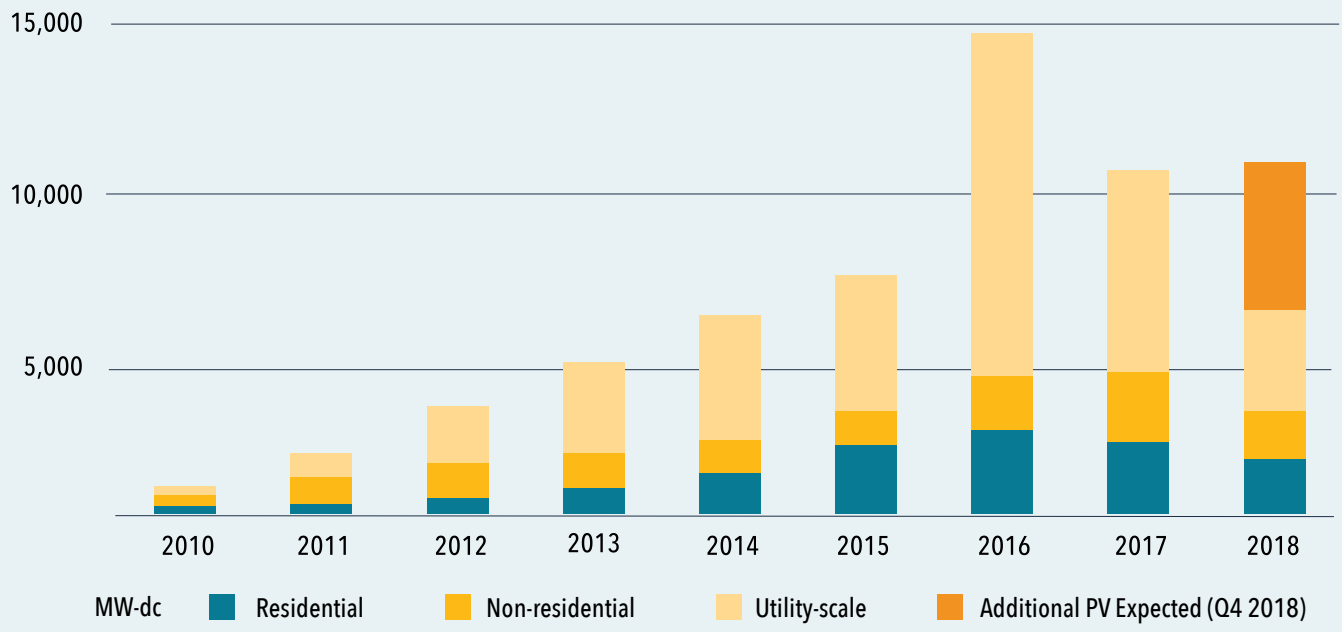


Figure 10

Source: Wood Mackenzie Power & Renewables

INSTALLATION AND LEVELIZED ENERGY COSTS

With China's pullback on solar incentives, the costs of Chinese modules and equipment continued to decline in 2018. This, in turn, had an effect on the U.S. solar market. Residential costs decreased 2-3% from Q3 2017 to $2.85/W in Q3 2018. Non-residential solar prices dropped 7-8% to $1.47/W, while utility-scale costs dropped 9-10% to just below or above $1/W, depending on the technology.[35] Non-hardware costs, or "soft costs," such as customer acquisition, labor, permitting, and interconnection, remained unchanged from 2017 to 2018. Nonetheless, the decline in hard costs meant that soft costs made up a greater proportion of total costs. Soft costs represented 69% of residential system costs, and 56% and 37% of non-residential and utility-scale costs, respectively.[36]

Another way to evaluate costs is through the levelized cost of electricity.* Unsubsidized utility-scale solar costs are now competitive with fossil fuels in many states. The levelized cost of energy for thin film utility-scale solar ranges from $36/MWh to $44/MWh. By comparison, combined cycle natural gas, the lowest fossil fuel cost, ranges from $41/MWh to $74/MWh.[37] Moreover, with no fuel costs, solar power costs are more predictable over the long term than fossil fuel costs, and therefore, solar is sought out by utilities and other firms to round out energy portfolios with volatile prices.

** The levelized cost of electricity (LCOE) is the net present value of the unit-cost of electricity over the lifetime of a generating asset. It is often taken as a proxy for the average price that the generating asset must receive in a market to break even over its lifetime. (Wikipedia)*

GLOBAL SOLAR OUTLOOK:
CAPACITY UP, INVESTMENT DOWN

An estimated 109 GW of solar was installed globally in 2018 compared to 99 GW in 2017, according to figures from Bloomberg New Energy Finance (BNEF). In contrast, global solar investment declined 24% to $131 billion, partly because of declining installation costs.[38]

In May 2018, China announced it was reducing its solar incentives. Consequently, Chinese solar deployment declined by 18%, from 53 GW in 2017 to 44 GW in 2018.[39] As a result, solar module prices dropped, helping to propel additional solar capacity in other markets.

Meanwhile, in Germany, renewable energy overtook coal to become the largest source of electric power in 2018. Renewables, including solar, wind, hydro, and biomass, provided 40% of the country's electricity, compared to 39% from coal. A jump of nearly 20% in solar power generation and a series of coal plant closures propelled the renewable team into first place.[40]

For 2019, BNEF is forecasting new global solar PV capacity of 125 GW to 141 GW.[41]

Manufacturing Sector

Setting aside the controversy over tariffs on imported solar cells and modules, U.S. solar manufacturing remains critical to the overall solar value chain.

Solar energy systems are comprised of hundreds of components, such as cells, wafers, modules, racking, and inverters, as well as the components required to manufacture these items. Some solar manufacturers are vertically integrated, meaning they manufacture all aspects of the solar supply chain, while others specialize in one or two aspects of the supply chain.

Manufacturers currently employ 14% of the solar workforce, or 33,726 solar workers, a decrease of 3,159 jobs (8.6%) since November 2017. By comparison, U.S. manufacturing overall grew by 2.3% in 2018.[42] The solar industry expects to add 1,223 manufacturing jobs in 2019, equating to 3.6% growth (Figure 11).

Manufacturers currently employ ***14%*** *of the solar workforce, or* ***33,726 solar workers.***

Manufacturing activities often occur at facilities that build some solar components, but where most employees do not spend 50% of their time on solar-related work. Employees must meet this 50% threshold to be counted as a solar job in the *Census*. If these additional part-time solar manufacturing jobs were tallied, there would be 45,315 total solar manufacturing jobs.

Some manufactured goods, such as modules, are largely imported. Of the 7.4 GW of modules shipped to or within the U.S. over the 12 months ending October 31, 2018, about 90% were imported.[43] For 2017, about a third of the imported modules were from Malaysia, followed by South Korea (19%), Vietnam (10%), China (7%), and 31% from other countries.[44]

SOLAR MANUFACTURING EMPLOYMENT GROWTH, 2010-2019

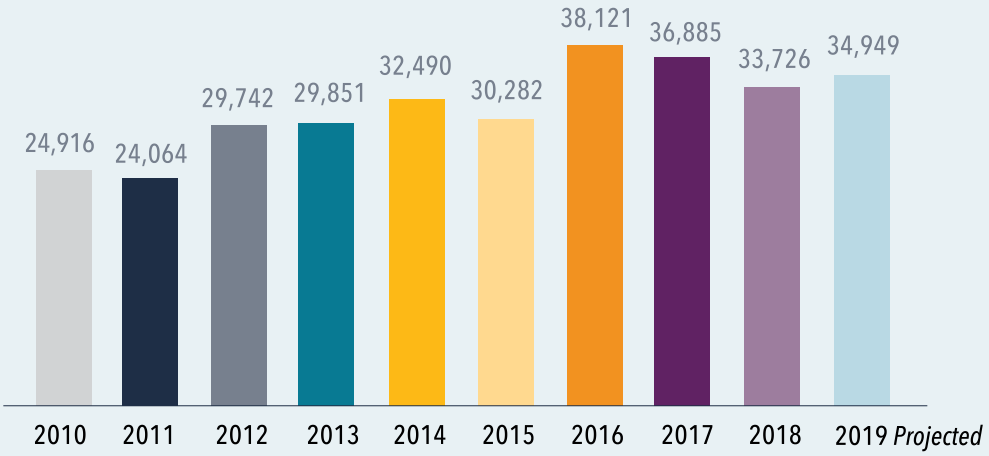


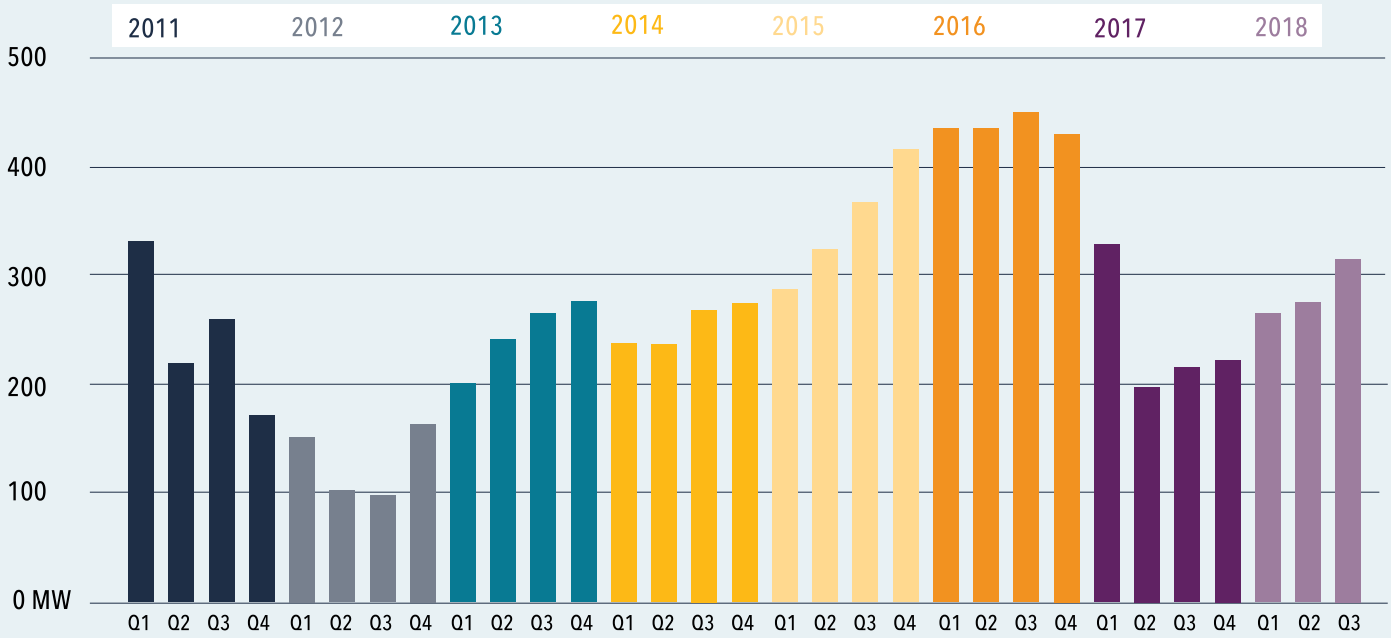
Figure 11

Domestic module production increased 16% for the first three quarters of 2018 compared to the same period in 2017 (Figure 12). Historically, module production has fluctuated based on shifts in supply and demand. Due to a surplus in U.S. PV module supply at the beginning of this decade, module production fell in 2012. As the market shifted toward a more balanced supply and demand, production recovered through 2016. Production then dropped off in 2017 as a result of several bankruptcies, then began rebounding in late 2017 as suppliers built potential tariffs into their prices, while also dealing with a tight supply in global wafers which drove up material prices.[45] Production continued to rise in 2018 as added capacity at domestic production facilities (e.g. Panasonic, First Solar) came online.[46]

There are about 20 solar module manufacturing facilities in the U.S., of which six appear to be expanding operations. California has the most facilities, although the largest is the Tesla/Panasonic facility in Buffalo, New York.[47] About 4 GW of new U.S. module manufacturing capacity is under construction and expected to commence operations in late 2018 or 2019. The new facilities are located in Georgia, Ohio, Alabama, Florida, and Texas. In Oregon, SunPower is retooling the former SolarWorld factory that it acquired in 2018. Although the tariffs helped encourage the companies to open U.S. facilities, they will still likely face difficulty competing with lower-cost overseas production.[48]

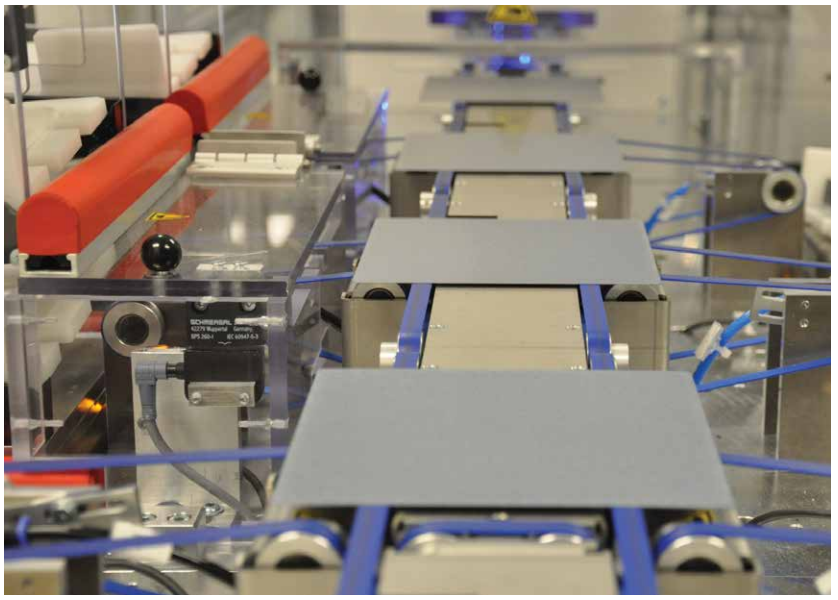
Figure 12

U.S. DOMESTIC SOLAR MODULE PRODUCTION, 2011-2018



Source: Wood Mackenzie Power & Renewables

Manufacturing activity goes well beyond the production of modules. When asked what solar energy components they manufacture, only 31% of *Census* respondents said they manufacture modules. Another 28% produce mounting structure hardware, 24% produce monitoring systems, 15% produce inverters, 12% produce trackers, and 21% manufacture other items (Table 11).[49] Other manufactured products include charge controllers, rectifiers and distribution systems, optimizers, wire management clips, software, and test equipment for manufacturing. Others reported manufacturing solar thermal components such as solar thermal collectors.



U.S. solar component manufacturing is facing an uncertain future. Polysilicon (not counted in the *Census*) is produced in three U.S. plants. Production of polysilicon is declining given that the chief export market, China, has pushed prices down to cost. Wafer production was largely discontinued in the United States when SunEdison closed its Oregon plant. Although the bankruptcies of Suniva and SolarWorld reduced domestic cell production in 2017, Panasonic started domestic cell production in 2018, increasing U.S. cell production 5% from 2017.[50]

There are eight reported companies with inverter production facilities in the U.S.[51] Most *Census* respondents report that they acquire their inverters from domestic sources. Domestic quarterly shipments are down from 2017 but have stabilized for the first three quarters of 2018.[52] The U.S. Section 301 tariffs on Chinese goods could disrupt the global inverter market, especially if the winter 2019 trade negotiations are unsuccessful and the tariffs increase from 10% to 25%.

A *Solar Power World* survey found that just over half of manufacturer representatives reported that their companies would be impacted, mostly because they have facilities in China. Nonetheless, many of the inverter manufacturers have shifted or intend to shift enough manufacturing out of China to cover their U.S. business, especially if the tariffs jump to 25%. Such measures could limit inverter price increases, although there would likely be increases from inverter components that remain in Chinese production. Respondents noted that they have shifted or would shift the manufacturing to India, Mexico, and the United States.[53]

MANUFACTURING SECTOR
BY SOLAR ENERGY COMPONENT FOCUS

Solar Component	Percent of Manufacturers
Modules	31.4%
Mounting Structures	27.9%
Monitoring Systems	24.4%
Inverters	15.1%
Trackers	11.6%
Cables/Conduits/Wires	10.5%
Battery Storage	9.3%
Cells	4.7%
Wafers	1.2%
Other	20.9%

Table 11. Note: Percentages do not add up to 100 as respondents could choose multiple responses

MANUFACTURERS BRING DOWN SOLAR STOCKS IN 2018

Following a strong year in 2017, major solar company stocks struggled in 2018. The Invesco Solar Exchange Traded Fund (ETF), which tracks the Mac Global Solar Energy Index, was down 19% after the third quarter compared to an 8% gain for the S&P 500. The ETF was off 28% for the year, eclipsing the more modest S&P loss of 7%. A closer look at the stocks shows that solar module manufacturers dragged the group down. In May, China announced it was reducing solar incentives, decreasing Chinese domestic demand for modules and depressing prices worldwide.

Stock prices for SunPower, a manufacturing company which also develops and installs solar, were down 45% for the year. First Solar, a solar manufacturer and developer, saw its stock prices down 40% for the year. Stock prices for JinkoSolar, a Chinese company that expanded into the United States following the tariff announcement, declined 60% in 2018.[54] Select solar component manufacturers fared better. The micro-inverter manufacturer Enphase posted a strong 82% gain for the year. Power optimizer SolarEdge mirrored the S&P 500, losing 8% in 2018.[55]

The declining module prices favored solar installers. Although installed capacity was flat for 2018, the lower component costs generated greater margins for large residential installers such as Sunrun and Vivint, but the impact on stock prices was mixed. Vivint, which experienced a 50% increase in its stock price in 2017, saw its shares rise another 24% after three quarters, then gave it all back for a 3.5% loss by year end. Sunrun's stock more than doubled after three quarters, ending the year with a still very healthy 84% gain.

As more solar systems are installed and begin to age, the importance of ***Operations & Maintenance*** *is growing.*

IN-DEPTH:

WORLD WIND AND SOLAR

Operations & Maintenance Firm

World Wind and Solar (WWS) is an independent service provider, based in Tehachapi, California, that offers operations and maintenance services for existing and newly commissioned solar and wind energy projects. Their work spans all types of services, from land management, such as lawn and fence care, to panel cleanings and scheduled inverter maintenance. To provide these services, WWS employs about 400 permanent field technicians with a wide range of skills. Since WWS provides services for systems across the country, it is working on a regionalization effort to set up branches in areas with large ongoing projects.

Read more about World Wind and Solar at SolarJobsCensus.org.

Additional Solar Jobs Sectors

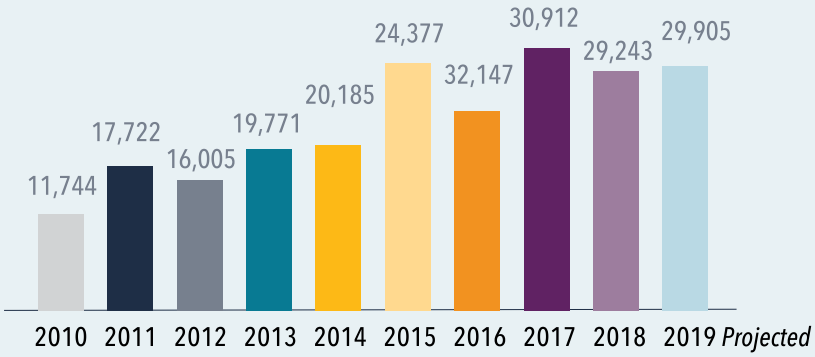
WHOLESALE TRADE AND DISTRIBUTION SECTOR

The wholesale trade and distribution sector is primarily made up of establishments engaged in the warehousing, sales, and distribution (but not installation) of solar and other ancillary products to installers and manufacturers. These establishments distribute both U.S. and foreign-made solar products to other companies along the supply chain. Since the *Solar Jobs Census* delineates companies by the activities at each business location, much of the data for this section includes information from distribution centers that are part of larger companies across other segments of the value chain.

Solar establishments primarily engaged in wholesale trade and distribution employ 12% of the solar workforce, or 29,243 solar workers (Figure 13). This represents a decrease of 5.4%, or 1,669 jobs, since 2017. By comparison, the nation's overall wholesale trade employment grew by 1.5% from 2017 to 2018.[56] Solar establishments expect to increase wholesale trade and distribution employment by 2.3% in 2019, adding 662 jobs.

SOLAR WHOLESALE TRADE AND DISTRIBUTION EMPLOYMENT GROWTH, 2010-2019

Figure 13



OPERATIONS AND MAINTENANCE

For the first time, the 2018 *Census* includes a separate sector for operations and maintenance. As more solar systems are installed and begin to age, O&M is becoming increasingly important. O&M includes panel cleaning, parts replacement, and system updates. While panels may last 25 years or more, other components, such as inverters and communications systems, may last only up to 10-15 years.[57] In 2018, 11,164 solar jobs, or 4.6% of the total, were reported to be in O&M. For 2019, *Census* respondents expect there to be a 1% growth in jobs for this sector.

SOLAR "OTHER" EMPLOYMENT GROWTH, 2010-2019

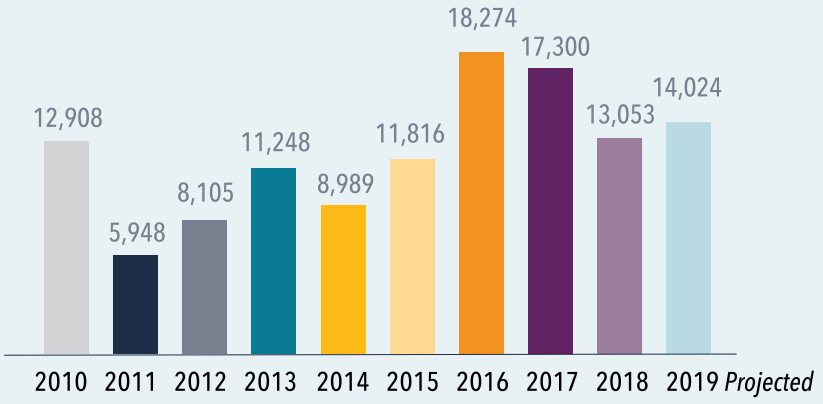


Figure 14

OTHER SOLAR EMPLOYMENT

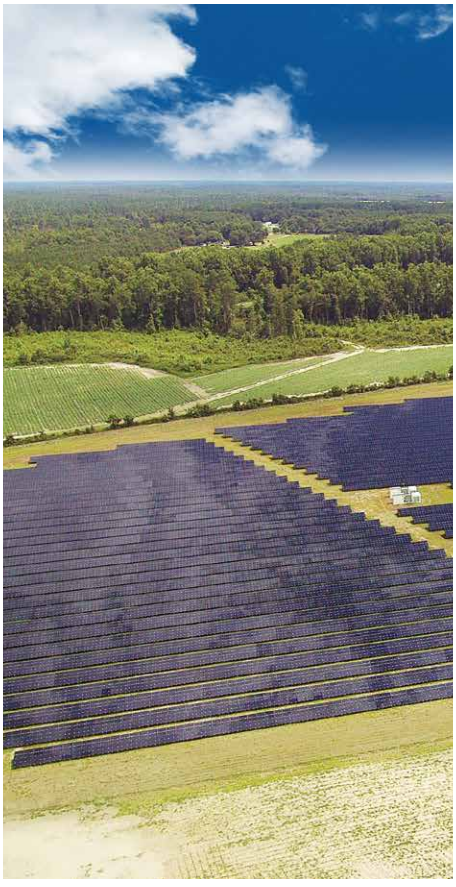
About 5.4% of the solar workforce, or 13,053 workers, are employed by firms that specialize in activities not covered by the other four sectors (Figure 14). Jobs in the "other" category include academic research, government oversight, research & development, training, nonprofits, finance, engineering, consulting, law, and communications. Employment in the "other" category declined by 24.6% in 2018, a loss of 4,247 jobs. This decline does not necessarily reflect job losses, but rather a shift in jobs to the newly created O&M sector. The "other" sector is expected to resume growth in 2019, increasing by 971 jobs (7.4%) by November 2019.

IN-DEPTH:

GREENPACE CAPITAL

GreenPACE Capital is a financial firm that offers power purchase agreements (PPAs) to residential and commercial customers by allowing them to access Property Assessed Clean Energy (PACE) loans to finance solar energy projects. The firm works with local contractors to install solar for customers who would otherwise be unable to pay the upfront costs of a solar installation, or for customers who cannot take advantage of the tax benefits that come along with solar ownership. Employees include financial engineers and modelers, data miners, and sales professionals, as well as solar concierge customer service personnel who work with both the customer and local contractors.

Read the full profile of GreenPACE Capital at SolarJobsCensus.org.

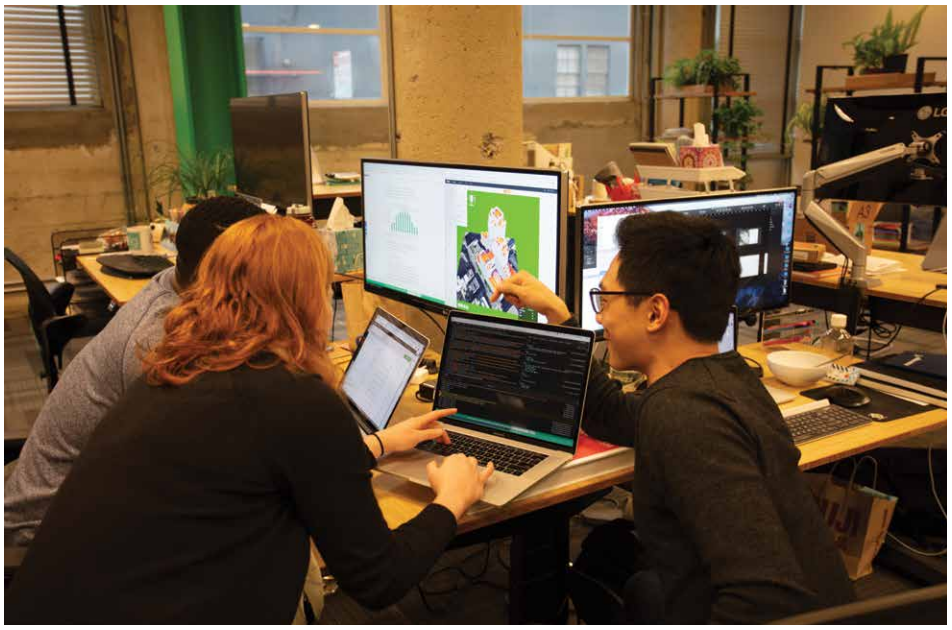


SOLAR AND BATTERY STORAGE

Storage can complement solar in many ways. While battery storage combined with solar provides many benefits, one or two advantages stand out within each market segment. The residential market benefits from improved resiliency, especially to keep the lights on when the power goes out. Resiliency is important to non-residential solar as well, but this sector can also benefit from reduced electricity costs, since these facilities are often hit with costly demand charges when they use an abnormally large amount of electricity for a few hours a month. Utility-scale solar + storage can help stabilize the flow of electricity on the grid.

The *Census* found about 3,900 jobs directly related to solar within establishments that primarily work in battery storage. However, this total excludes jobs related to storage that are part of another sector, such as installation. Storage jobs are not included in the total job count for 2018 for the purposes of comparison to previous years.

Storage deployment is experiencing rapid growth. About 61 MW was deployed in Q3 2018, of which 57% was for residential and non-residential customers. Most of the deployment in these market segments consisted of storage co-located with solar. These behind-the-meter customers installed three times the storage installed in Q3 2017.[58]



Aurora Solar

SOFTWARE APPLICATION FIRM

Aurora Solar's ***rapidly expanding workforce*** *spans software engineering, customer success, sales, and marketing.*

Aurora Solar is a software company that offers streamlined solar design and sales software for solar companies. Aurora is headquartered in San Francisco, California and has more than doubled its workforce over the past year as its software advances and its customer base continues to expand.

Aurora Solar specializes in software that enables residential and commercial solar installers to design and sell solar systems more accurately and efficiently. The Aurora application includes tools that allow installers to accurately calculate how many panels will fit on a given property, precisely forecast how much energy the system will produce, and evaluate how much money their clients will save. Aurora makes all this possible without leaving the office, helping solar installation companies save time and money. Aurora has been used in over 2 million residential and commercial solar proposals around the world. Samuel Adeyemo, co-founder of Aurora Solar, says that Aurora works with several of the largest solar companies in the U.S., but also has thousands of clients who are employed by small solar contractors.

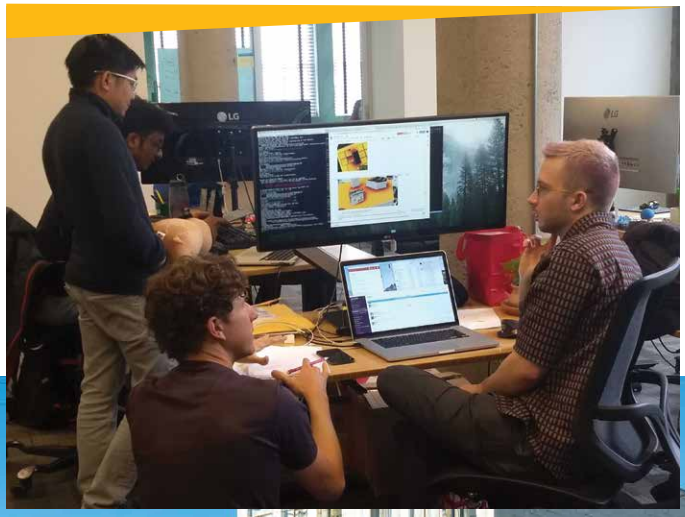
Aurora Solar's rapidly expanding workforce spans software engineering, customer success, sales, and marketing. Software engineering is Aurora's biggest department. The engineering team is broken into various domain expertise areas, including: general web development; scientific computation; CAD graphics; computer vision; and research and development teams. Additional staff in sales, marketing, and customer success allow Aurora to offer services for all installers, including content and workshops on solar design, sales, policy, and more.

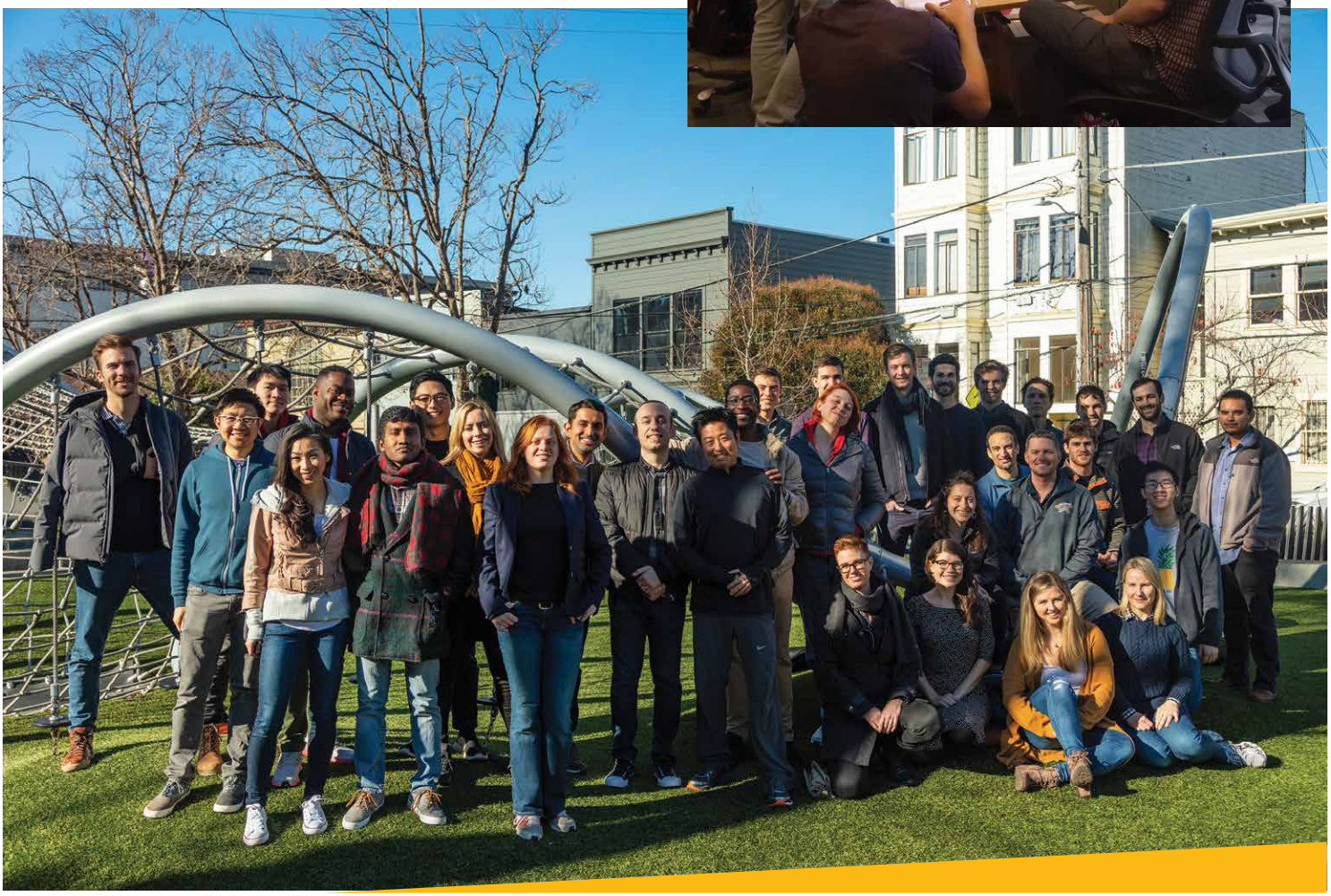
While engineers make up the majority of Aurora's workforce, the customer success team is its fastest-growing group. This team works to ensure customers understand the software and quickly get answers to any solar design questions that arise. Adeyemo notes that solar customers are becoming increasingly savvy and installation companies must provide accurate and insightful data—such as solar savings estimates under complex utility rates—to stay competitive. Aurora Solar succeeds when companies are armed with the data to win over potential solar customers, he says.

Adeyemo says the most challenging aspect of hiring is finding candidates who have a deep interest in solar energy as well as expertise in their field. "We need to find the right intersection of those extremely talented people that are passionate about our mission to create a solar energy future for all," Adeyemo says.

He added that when the business model relies on constant innovation, every week the bar for developing new features gets higher. "That's another challenge we face—how do we make sure we are solving hard problems, things that matter for customers?" To address this challenge, employees at Aurora communicate and collaborate across teams as well as with their customer base regarding new updates to their product.

Learn more at AuroraSolar.com.





IN-DEPTH:

SAME SUN OF VERMONT

Same Sun of Vermont provides full-service installations using high quality American-assembled modules. Same Sun employs three full-time installation crews consisting of about four installers per crew. A new sister company focused on operations & maintenance will be another opportunity for growth. This company, called Solar PROformance Services, will likely grow and seek to hire workers who can perform a variety of tasks including project management, office management, sales, and general crew work.

Read the full profile of Same Sun of Vermont at SolarJobsCensus.org.

SOLAR + STORAGE CHALLENGES NATURAL GAS

Utility-scale solar + storage is competing with natural gas. The levelized energy costs of solar co-located with battery storage range from $108/MWh to $140/MWh. By comparison, natural gas peaker plants range from $152/MWh to $206/MWh.[59] Some recent solar + storage projects have even bid below $100/MWh. Hawaiian Electric Company received six bids below $100/MWh for 262 MW of solar and 1,048 MWh of storage.[60] With storage, solar can to a large extent overcome its major drawback, intermittency (the absence or reduction of solar energy during the evening or during significant cloud cover). Therefore, solar + storage can provide power during the evening, when states with high solar penetration like Hawaii experience peak loads. With such low costs, solar + storage is an economical substitute for gas peaker plants.

DEMOGRAPHIC ANALYSIS

*Despite the industry's **increased attention to diversity** and inclusion, the solar industry's demographic profile saw **little change in 2018.***

Toward a More Diverse and Inclusive Solar Workforce

The solar industry has been one of America's leading job creators over the past decade, but like many high-growth sectors, it does not yet reflect the country's diversity in the demographic makeup of its employees. Fortunately, a growing number of industry leaders are making it a top priority to improve the representation of women, people of color, the LGBTQ community, and veterans among their staff and leadership teams.

Fostering a more diverse and inclusive solar workforce opens up pathways for underrepresented communities to enjoy the career opportunities the solar industry provides. Not only are diversity and inclusion worthy values, but substantial research shows they make any industry more profitable and competitive.[61] Moreover, solar companies are better positioned to attract new customers when their workforce better reflects the communities where they operate or hope to expand.

*There were **63,806** women working in solar, or **26% of the workforce** in 2018.*

While the industry's increased attention to diversity and inclusion is welcome and needed, the demographic profile saw little change in 2018 compared to the previous year. In 2018, there were 63,806 women working in solar, or 26.3% of the workforce (Table 12). This is a slight change from 67,204 women in 2017, representing 26.9% of the workforce.* In other words, the solar industry has a long way to go before it achieves equal representation based on gender. At the same time, solar companies fare better compared to some similar industries. For example, only 9.1% of workers in the construction industry and only 12.8% of oil and gas workers are women.

The percentage of women employees by industry sector was also similar to previous years (allowing for changes in how these sectors are defined) (Table 13). Among the sector categories, the largest percentages of women in 2018 were in wholesale trade and distribution, at 35.9%; and in the "other" category, at 33.6%. Women made up 24.5% of the workforce in the installation and project development sector, 25.5% in O&M, and 28.3% in manufacturing.

** The largest number of women in the solar workforce was seen in 2016, with 28% women working in solar that year. 2016 was also the biggest year for national job growth, with a 25% increase in employment nationwide.*

SOLAR WORKER DEMOGRAPHIC BREAKDOWN, 2014-2018

	2014 % of workforce	2015 % of workforce	2016 % of workforce	2017 % of workforce	2018 % of workforce	2018 Overall
Women	21.6%	23.9%	28.0%	26.9%	26.3%	63,806
Gender Non-Binary					1.4%	3,427
Latino or Hispanic	16.3%	11.3%	17.2%	16.8%	16.9%	40,977
American Indian or Alaska Native	-	-	1.1%	1.0%	1.1%	2,744
Asian	7.0%	8.7%	9.1%	8.4%	8.5%	20,620
Black or African American	6.0%	5.2%	6.6%	7.4%	7.6%	18,392
Native Hawaiian or other Pacific Islander	-	-	1.3%	1.2%	1.2%	2,918
White	-	-	73.6%	73.7%	73.3%	177,706
Two or more races	-	-	8.3%	8.3%	8.3%	20,124
Veterans	9.7%	8.1%	9.0%	8.6%	7.8%	19,019
55 and over	-	18.5%	11.2%	11.4%	10.5%	25,471

Table 12

The representation of people of color in the solar workforce also saw little change. For 2018, 73.3% of solar workers were white, 16.9% were Latino or Hispanic, 7.6% were black or African American, and 8.5% were Asian. The percentage of solar workers who are African American is substantially lower than the 12.1% in the overall workforce. However, the percentage of Latino/Hispanic workers in solar is about the same as in the U.S. workforce as a whole, and the solar industry also has a greater percentage of Asians compared to the broader workforce. This is likely attributable to the high level of solar development in California and other states with higher-than-average Latin American and Asian populations. Diversity in age is another area where the solar industry could see improvement: 10.5% of solar workers were 55 and over, compared to 21.1% across the U.S. workforce.

The number of veterans in solar in 2018 came to 19,019 employees, or 7.8% of the workforce, a decline from 8.6% of the workforce in 2017. In large part, this can be attributed to the steep solar jobs decline in California, a state with a higher-than-average veteran population. There is still a greater proportion of veterans in solar compared to the overall workforce (6.6%). The Solar Foundation has long supported the recruitment and training of job candidates with military experience, recognizing that veterans acquire technical knowledge and leadership experience that can transfer well to a solar career.* In 2019, The Solar Foundation will lead a new program funded by the U.S. Department of Energy to support solar industry apprenticeships for transitioning military personnel and help link veterans to solar training and jobs.

** In 2014, The Solar Foundation and Operation Free released a groundbreaking report, Veterans In Solar: Securing America's Future, to highlight the contributions of veterans in the solar workforce.*

The challenge of building a diverse solar industry goes beyond improving a company's hiring practices, and also extends to the populations a company serves. A recent study from researchers at Tufts University and the University of California, Berkeley found that African-American and Hispanic neighborhoods have fewer rooftop solar installations, even after controlling for economic factors.[62] Increasing diversity among solar employees could help the industry expand customer outreach and make the benefits of solar energy more widely accessible. Leadership matters, and the management and HR team should foster a culture of diversity and inclusion that extends across the company.

Overall, the latest data helps clarify that there is no "quick fix" solution. Rather, a sustained and long-term effort will be required to bring more people from underrepresented groups into the industry. This year, The Solar Foundation will release the second update to the *U.S. Solar Industry Diversity Study* (see box, p. 51) and work with the industry to take action. But it will take considerable attention over many years for the industry to meet the essential goal of creating a more diverse and inclusive workforce.

SOLAR WORKER DEMOGRAPHICS BY SECTOR AND IN COMPARISON TO OTHER INDUSTRIES

	Female	Gender Non-Binary	Latino or Hispanic	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 and Project Development	24.5%	1.0%	17.3%	1.0%	7.1%	7.7%	1.3%	73.7%	8.9%	7.5%	9.1%
U.S. Construction	9.1%	-	29.8%	-	1.9%	6.1%	-	88.8%	-	7.3%	21.8%
Solar Wholesale Trade and Distribution	35.9%	0.1%	21.4%	1.3%	9.2%	5.7%	2.8%	59.3%	11.6%	7.2%	9.9%
U.S. Wholesale Trade	29.9%	-	16.9%	-	5.8%	9.3%	-	82.4%	-	7.8%	26.4%
Solar Operations & Maintenance	25.5%	1.6%	15.2%	0.4%	8.5%	8.3%	0.5%	79.3%	3.7%	8.1%	9.2%
U.S. General Repair & Maintenance	11.9%	-	25.4%	-	3.9%	8.9%	-	83.0%	-	14.3%	22.9%
Solar Manufacturing	28.3%	4.3%	20.9%	1.0%	15.5%	8.8%	1.5%	56.8%	13.3%	10.2%	14.3%
U.S. Manufacturing	29.5%	-	16.6%	-	7.1%	10.1%	-	79.9%	-	7.9%	24.9%
Solar All Others	33.6%	1.2%	15.5%	1.1%	11.1%	4.6%	0.8%	79.1%	6.0%	5.3%	16.7%
Solar Overall	26.3%	1.4%	16.9%	1.1%	8.5%	7.6%	1.2%	73.3%	8.3%	7.8%	10.5%
U.S. Workforce Overall	46.9%	-	16.9%	-	6.2%	12.1%	-	78.4%	-	6.6%	21.1%

Table 13

COMING UP IN 2019:
THE SOLAR INDUSTRY DIVERSITY STUDY

As the data in the *Solar Jobs Census 2018* and earlier years makes clear, women and people of color remain underrepresented in today's solar workforce. The good news, however, is that many leading solar companies and executives are now making diversity and inclusion a top priority. They recognize that a commitment to diversity and inclusion stands to benefit the entire solar industry, helping companies create a fair and equitable work-place culture and positioning them to attract top talent. To help chart the path forward, The Solar Foundation worked with industry in 2017 to publish the *U.S. Solar Industry Diversity Study,* the first comprehensive report on women, people of color, and veterans in solar.[63]

The *U.S. Solar Industry Diversity Study* is based on statistical surveys of both solar employers and their employees, as well as qualitative information gleaned from interviews and focus groups. It provides baseline data on career paths, wages, and other indicators of where the industry stands today. The next edition of the study will be published in the spring of 2019.

WORKFORCE DEVELOPMENT

26% *of all solar employers said it was* ***"very difficult" to hire qualified employees****, a substantial increase from the previous year.*

The American solar industry offers rewarding careers for employees across a wide range of skill sets, educational levels, and levels of experience. In this new and growing industry, solar workers often have the opportunity for rapid career advancement. Solar job opportunities range from entry-level rooftop installers, to sales and distribution professionals, to project managers, software engineers, financiers, and much more.

The *Solar Jobs Census 2018* provides detailed insight into the makeup of the American solar workforce, showing how solar companies contribute to job creation and economic growth. At the same time, the industry is facing an ongoing challenge: the difficulty of hiring qualified workers. The solar industry has an opportunity to engage with local workforce development resources, develop new training opportunities, and pursue other strategies to strengthen the workforce and build a steady pipeline of talent.

NEW HIRES IN 2018

Despite the overall loss in solar jobs in 2018, many solar companies hired staff to fill new positions and replace existing employees (Figure 15). In 2018, 48.4% of new hires were for newly created positions. Most of the remainder (38.7%) were for replacement workers due to turnover or retirement. Another 13.0% represent existing employees with new responsibilities related to solar energy. Each of these categories are similar to the percentages found in 2017.

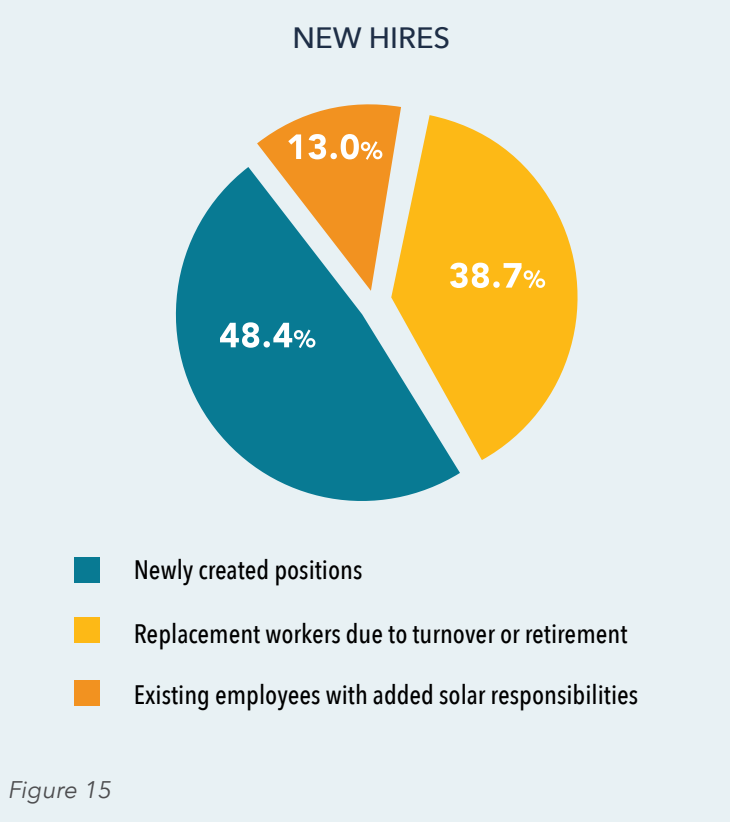


Figure 15

WAGES

The solar industry provides competitive wages for both entry-level and mid-career employees (Table 14). For full-time installers, the *Census* found that median entry-level wages were $24.32/hour for solar PV electricians, and $18.92 for non-electricians. These wages are above the national median wage ($18.12) for all occupations.[64]

Moving beyond the entry level, median wages for mid-level employees were $32.43 for electricians and $28.11 for non-electricians. Part-time and non-permanent employee wages were considerably lower. For entry-level electricians, median wages were $21.75 for part-time installers and $20 for non-permanent employees. For non-electricians, the median entry-level wage was $15 for both part-time and non-permanent installers.

For full-time manufacturing workers such as assemblers and fabricators, the *Census* found that median entry-level wages were $24.46/hour (Table 15). The median overall wages for mid-level employees were $29.89. As with installers, part-time and non-permanent median manufacturing wages were lower than full-time wages, at $20 and $15, respectively, for entry-level positions.

*The solar industry provides **competitive wages** for both entry-level and mid-career employees.*

MEDIAN FULL-TIME INSTALLER WAGES

	Solar PV Installer (Electrician)	Solar PV Installer (Non-electrician)	Solar Thermal Installer
Entry-level wage	$24.32	$18.92	$21.62
Mid-level wage	$32.43	$28.11	$28.11
Highest paid employee	$41.62	$35.14	$43.24

Table 14

MEDIAN FULL-TIME MANUFACTURING WORKER WAGES

	Manufacturing
Entry-level wage	$24.46
Mid-level wage	$29.89
Highest paid employee	$32.61

Table 15

A MINNESOTA CASE STUDY: STATE LICENSING REQUIREMENTS CAN SLOW HIRING

State licensing requirements can create challenges for the solar workforce, especially in states experiencing considerable growth in solar deployment and jobs. Often, states without solar-specific licensing require that the electrical aspect of a solar installation be performed by a journey level electrician.[65] Just over 30 states require at least one electrician to be on site to perform the electrical work on a PV system. Electricians can be difficult to hire, as they are often in high demand from multiple construction trades. In fact, the third most difficult position to fill at solar companies is electricians, as reported by just over 22% of solar companies (p. 57). Further, state requirements often set ratios for the number of unlicensed installers allowed on an installation site for each licensed electrician, potentially leading to the need for dozens of licensed electricians, especially on large installations.

For example, Minnesota, which is experiencing rapid growth in solar installations, has stringent licensing requirements. Minnesota considers solar installations electrical work and therefore requires a journey level or master level electrician to perform all electrical aspects of the PV installation. Further, all electrical sites in Minnesota require at least one licensed electrician for every two unlicensed electricians.[66] Therefore, a large installation in Minnesota may require 20 electricians if the labor demands of the installation require 40 total workers. As a result, the licensing ratio requirement has created a bottleneck in hiring for the solar industry in Minnesota.

Often, solar companies in Minnesota will have to hire electricians from states with reciprocity in Minnesota because there are simply not enough local electricians to meet industry demand. The *Census* found that a staggering 43% of Minnesota solar companies reported the most difficult position to fill is an electrician, illustrating the challenges posed by the licensing requirements. Additionally, the *Census* found that, on average, 10% of the electrical work for solar installations in Minnesota was done by non-resident electricians, and some companies hired all their electricians from outside of Minnesota.

As the solar industry continues to grow, it is important for states to consider the impact of local licensing requirements. Rather than accepting only a journey level electrical license, seven states have their own solar-specific license, six states accept the North American Board of Certified Energy Practitioners (NABCEP) certification, and ten states have no licensing requirements to perform solar installation work. While not always needed, solar-specific licensing, including NABCEP, can be advantageous, as the training specifically addresses the relevant skills to perform solar installations.

EXPERIENCE AND EDUCATION REQUIREMENTS

In 2018, solar establishments said they required experience for 60% of all new hires, an increase from the 55% required in 2017 (Table 16). However, experience requirements vary considerably across industry sectors. Within the installation and project development sector, establishments said they require experience for 61% of new hires. Among other sectors, experience was required for 80% of wholesale trade and distribution new hires; 43% of new hires in manufacturing; and 90% of new hires at O&M establishments.

Educational requirements also vary widely depending on the industry sector. Overall, establishments said they require a Bachelor's degree for 21% of new hires; a vocational or technical certificate for 14% of new hires; and an Associate's degree for 9%. Establishments in the installation and project development sector required a Bachelor's degree for only 15% of new hires. Establishments in wholesale trade and distribution, as well as in the "other" category, required a Bachelor's degree more often than other sectors.

Within each sector, the experience and education requirements will naturally vary based on the type of position. Entry-level installer positions, for example, will likely have fewer barriers to entry than project managers. Generally speaking, however, the solar industry provides ample opportunities for candidates with little or no prior experience to learn and advance on the job.

The Solar Foundation's previous research has found that most solar installation companies prefer some experience, but do not necessarily require formal or semester-long training. A 2017 report, *Solar Training Hiring and Insights,* found that 58% of installers required less than a year of experience for entry-level candidates. The same study found that employers were almost evenly split on whether it was important for entry-level candidates to obtain a solar certification.[67]

HIRING DIFFICULTIES

In 2018, 26% of all solar employers said it was "very difficult" to hire qualified employees (Figure 16). This is a substantial, 44% increase from the previous year, when only 18% of employers reported hiring was very difficult. When combined with employers who said hiring qualified employees was "somewhat difficult," 82% of employers reported difficulty hiring in 2018.

The industry sector reporting the greatest difficulty in hiring was installation and project development, with 33% reporting "very difficult," almost double the 18% reported in 2017 for this sector. This figure dropped to 26% for O&M and 17% for manufacturing. The wholesale trade and distribution sector reported the lowest difficulty hiring, at 8%.

NEW HIRE EXPERIENCE AND EDUCATION REQUIREMENTS

	WITH EXPERIENCE				EDUCATION (2018)		
	2015	2016	2017	2018	% with Bachelor's Degree or Higher	% with Vocational or Technical Certificate or Credential	% with Associate's Degree or Certificate from Accredited College
Installation and Project Development	71.3%	61.4%	48.9%	60.9%	15.1%	17.8%	10.3%
Wholesale Trade and Distribution	65.1%	66.2%	62.4%	79.5%	66.9%	3.7%	3.7%
Operations and Maintenance	N/A	N/A	N/A	89.7%	48.0%	9.0%	10.3%
Manufacturing	65.0%	62.5%	45.5%	43.4%	14.3%	4.9%	4.4%
All Others	79.1%	76.3%	64.3%	32.3%	85.5%	2.2%	29.6%
Overall	**67.0%**	**64.5%**	**54.8%**	**60.4%**	**20.8%**	**14.4%**	**9.2%**

Table 16

HIRING DIFFICULTY BY SECTOR, 2018

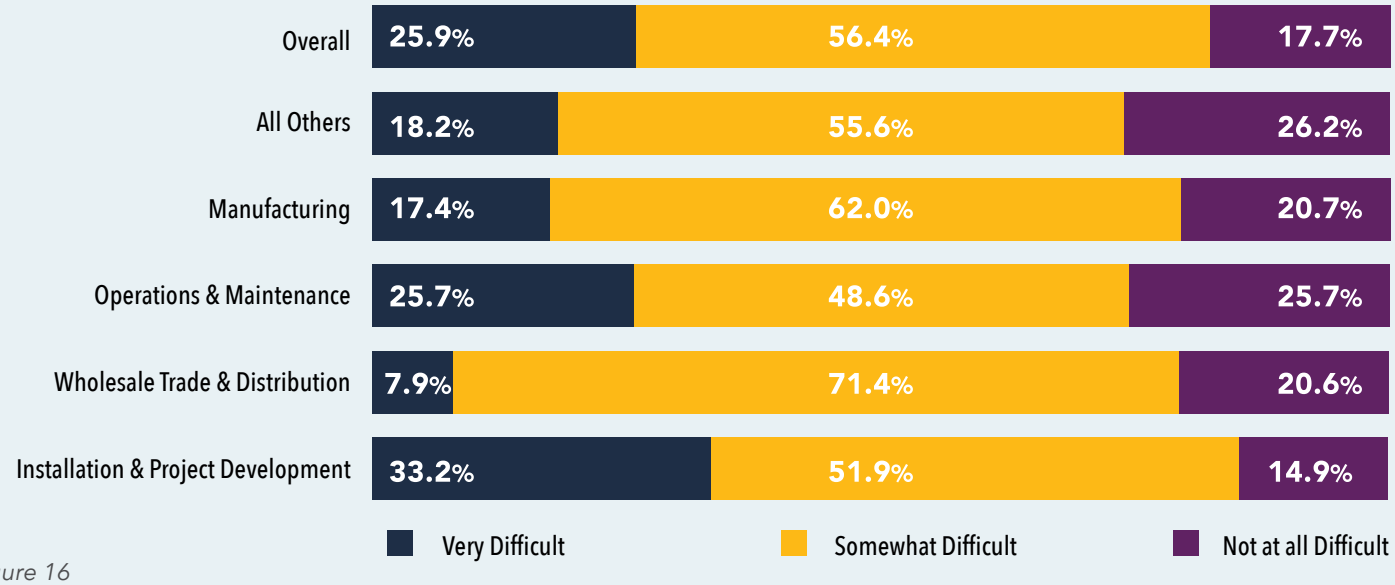


Figure 16

The installation sector faced a very competitive job market in 2018. The November 2018 unemployment rate hit a 49-year low of 3.7%. Construction jobs, a competitive alternative to solar installation, are growing faster than jobs in the overall economy. Based on preliminary December figures, in 2018, U.S. employment for the construction sector grew by a healthy 280,000 jobs, or 4%, over twice the rate of the rate of 1.8% job growth for total employment (nonfarm, seasonally adjusted).[68] With such robust growth in construction jobs, it is not surprising that installers reported such difficulty in hiring.

Solar companies are using a number of strategies to meet this hiring challenge, including salary incentives and opportunities for training and professional development. For Southern Current LLC, headquartered in Charleston, South Carolina, finding employees with significant solar experience in the region can be challenging. As a result, the company is open to employees with less experience who can be trained on the job (see *Census In-Depth,* p. 62). Utilizing local workforce resources is also beneficial. McCarthy Building Companies partners with local workforce development organizations to organize job fairs in its solar project locations (see *Census In-Depth,* p. 20).

The most common reason for the difficulty hiring in 2018 was a lack of experience, training, or technical knowledge, which just over 50% of solar employers cited as a factor (Figure 17). The second most common reason was competition or a small applicant pool, at 20%. This was followed by costs such as business expenses and wages, at 19%.

When asked to list the most difficult positions to fill, the most common response was sales, marketing, or customer service; followed by management positions, and then electricians or construction workers. Installation workers were close behind, with 21% of employers reporting it as a difficult position to fill (Figure 18).

The difficulty finding qualified candidates is not new to the industry, but appears to be more pronounced in 2018. Hiring difficulties place a resource burden on employers and increase the soft costs associated with solar projects. According to the *Solar Training Hiring and Insights* study, two-thirds of solar employers reported that the difficulty finding qualified applicants led to increased costs and impacted their ability to grow.[69]

Hiring challenges were especially acute in certain regions of the country (Table 17, Figure 19). In the East South Central Region, which includes Alabama, Kentucky, Mississippi, and Tennessee, 43% of employers reported hiring was very difficult. With the exception of Mississippi, these states all saw significant solar job growth in 2018. Furthermore, the solar industry is less established in this region and experienced candidates may be more difficult to locate. Difficulty hiring was also high in the West North Central region, with 34% reporting "very difficult."

In general, however, hiring difficulties were widespread across the country. In nearly all states, at least 20% of employers reported that hiring was very difficult. In Florida, Pennsylvania, and Ohio, all states where the job market expanded in 2018, this figure was above 40%. But employers also reported hiring difficulty in major solar markets where solar jobs declined, such as in California (25% reporting "very difficult") and Massachusetts (23%).

BUILDING A STRONG AND DIVERSE WORKFORCE

To help the industry meet hiring needs and build a pipeline of highly qualified candidates, The Solar Foundation released *Strategies for Solar Workforce Development: A Toolkit for the Solar Industry.* This 2018 report was produced by the Solar Training Network, a program led by The Solar Foundation and funded by the U.S. Department of Energy. The toolkit shows how solar companies can engage with local workforce development resources to expand the pool of qualified candidates. Work-based learning can help employers reduce the cost of hiring and create a streamlined training process tailored to the company's needs.[70]

As explained in more detail in the Demographic Analysis section (p. 47), a commitment to diversity is essential for the solar industry to attract highly qualified candidates and better reflect the communities they serve. Stepping up the recruitment of women, people of color, veterans, and other diverse candidates can help solar companies meet their hiring requirements and position themselves for future growth.

MOST SIGNIFICANT REASONS FOR REPORTED DIFFICULTY HIRING

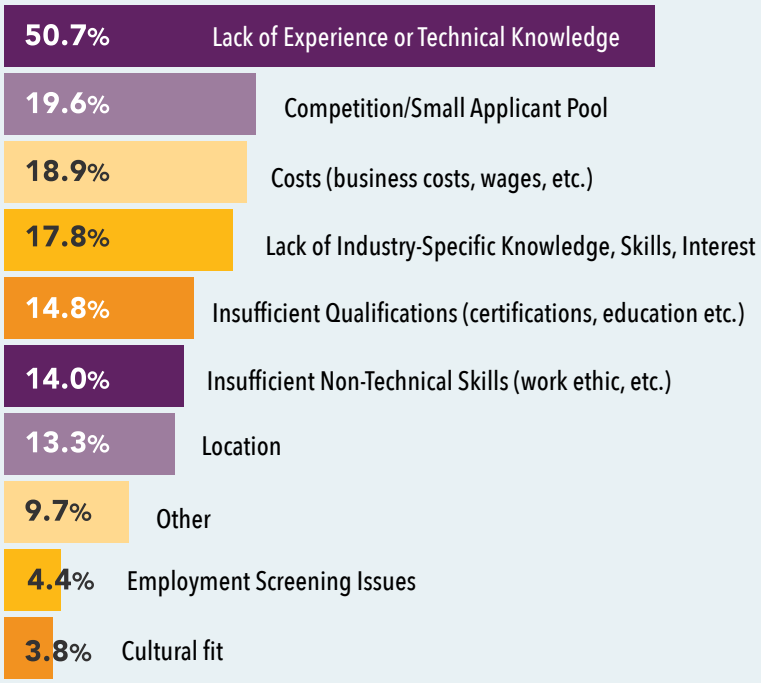


Figure 17

MOST DIFFICULT POSITIONS TO FILL

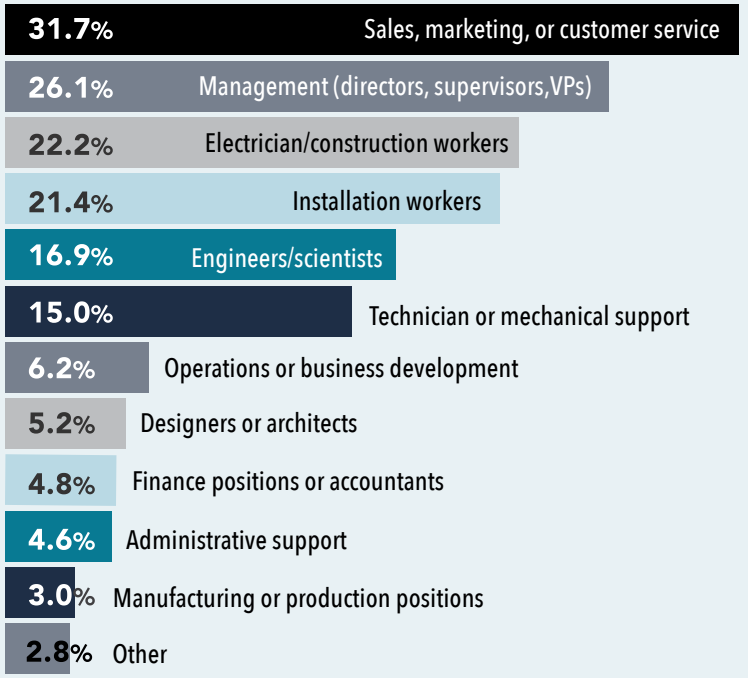


Figure 18

sPower

SOLAR PROJECT DEVELOPMENT FIRM

*sPower has over **200 permanent staff** and is growing fast, adding **80 employees** in the past year alone.*

sPower, an AES and AIMCo company, is the largest private owner of solar assets in the U.S., with a portfolio of over 150 operating projects nationwide. Its workforce has almost doubled over the past year, adding over 80 permanent employees covering a range of positions. sPower is excited by the prospect of an expanding workforce and ready to meet the challenge of hiring experienced employees.

sPower is a developer, owner, and operator of utility-scale wind and solar assets. The company develops utility-scale projects and sells the power to large off takers such as commercial businesses or utilities. sPower is headquartered in Salt Lake City, with branch offices in California and Virginia. They own and operate over 150 projects across the U.S., totaling 13 GW either in operation or under development.

sPower has over 200 permanent staff and is growing fast, adding 80 employees in the past year alone. This growth is attributable to their increased project load as sPower acquires more utility-scale projects. Although the fastest growing positions at sPower are in their solar development team, "we have job growth across our company, as every role is integral to determining the volume of assets we can develop in any given year," says Brian Callaway, VP Structured Finance. As the workforce expands, sPower has seen challenges in the hiring market. According to Suko Mdlawuzo, Human Resources Manager, it can be difficult to find candidates that have relevant renewable energy experience. "In spite of Salt Lake City being a great city with access to amazing outdoor lifestyle opportunities, it has been challenging, at times, to hire folks out here," says Mdlawuzo.

sPower requires a unique set of employees for each phase of a project's development. The strategic development phase includes experts in business, site assessments, and financial modeling to evaluate potential assets. The development phase includes a solar development team in charge of securing permits, land rights, and interconnection rights. The project execution phase includes a team of project managers working on-site to manage construction of the project. Throughout all development phases, sPower relies on a group of subject matter experts in engineering, land and real estate, permitting and interconnection, and data analysis.

Construction of sPower's solar facilities is contracted to large Engineering, Procurement, and Construction (EPC) firms, regularly selected from a list of preferred vendors. In the past, most of the equipment procurement was handled by the EPC contractor, but sPower has begun to perform some procurement tasks in-house. Generally, the EPC contractors are not hired in the project state and will travel to the site, though in states with union labor requirements, local labor is always hired. The EPC construction managers work closely with sPower's project managers on-site to ensure the efficient progression of each project.

Learn more at sPower.com.

HIRING DIFFICULTY BY CENSUS REGION

	New England	Middle Atlantic	East N. Central	West N. Central	South Atlantic	East S. Central	West S. Central	Mountain	Pacific
Very difficult	27.2%	29.2%	25.0%	34.4%	28.5%	42.9%	22.8%	22.7%	24.2%
Somewhat difficult	57.6%	50.8%	52.4%	46.9%	53.2%	39.3%	56.1%	55.3%	58.7%
Not at all difficult	15.2%	20.0%	22.6%	18.7%	18.4%	17.9%	21.1%	22.0%	17.1%

Table 17

U.S. CENSUS DIVISIONS

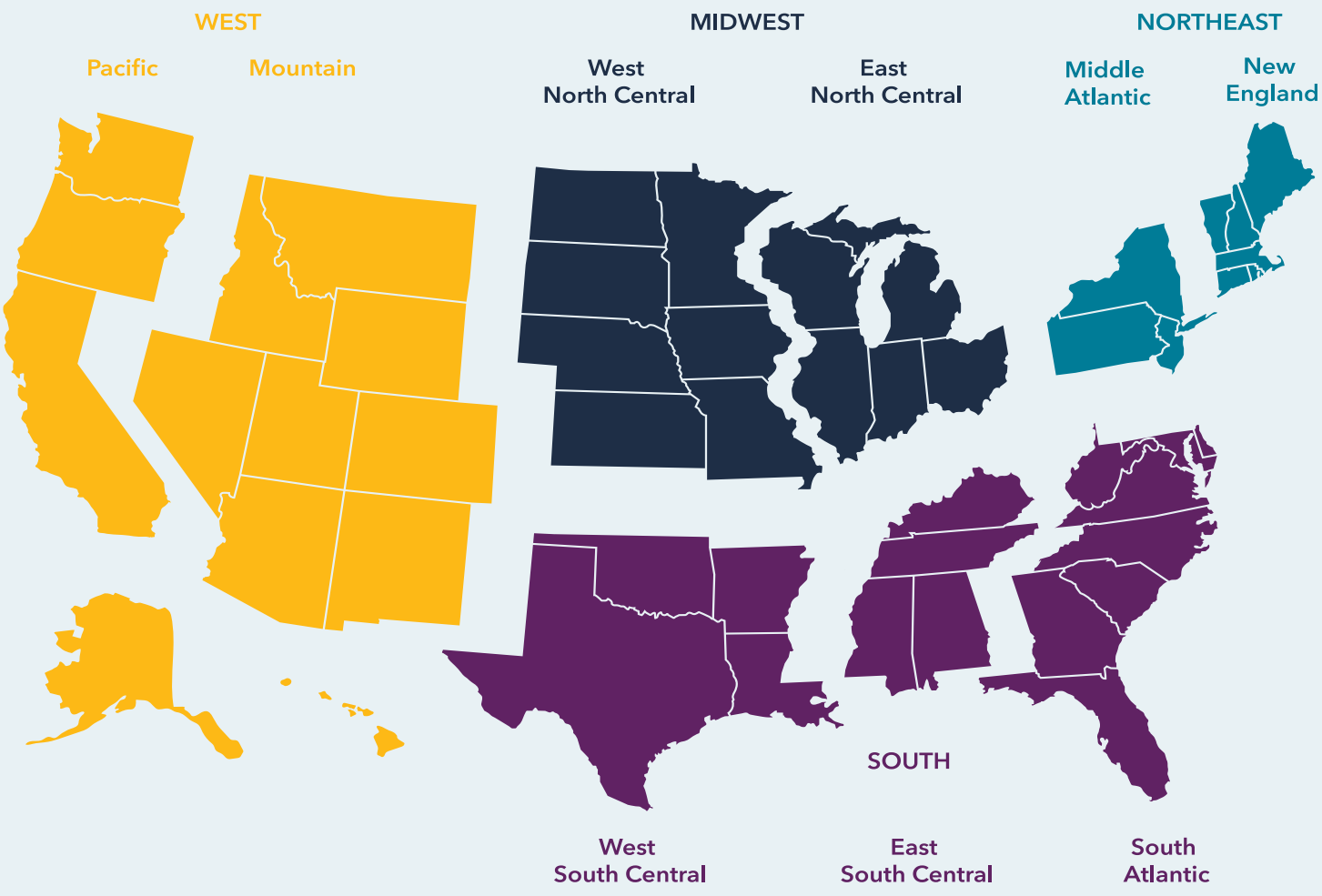


Figure 19

CITIES, COUNTIES COMMIT TO PARIS CLIMATE GOALS

In June 2017, the United States announced that it would withdraw from the 2015 Paris Agreement on climate change mitigation. In the immediate aftermath of the announcement, over 1,200 states, local governments, businesses, and educational institutions signed on to the "We Are Still In" Declaration in support of action to achieve the Paris Agreement's goals.[71] To date, there have been over 2,750 signatories to the Declaration, which include almost 300 cities and counties. Local officials also signed on to the Global Covenant of Mayors for Climate and Energy (formerly known as the Covenant of Mayors), an international alliance of local governments committed to action to address climate change.[72] And through efforts such as the Sierra Club's "Ready for 100" campaign, cities across the nation have pledged to transition their electricity sectors to 100% renewable or carbon-free energy.

In order to translate these goals into action, these communities will need roadmaps for increasing the use of solar energy and other renewables. The Solar Foundation helps communities achieve these goals through *SolSmart*, a community designation program funded by the U.S. Department of Energy Solar Energy Technologies Office. Through SolSmart, The Solar Foundation and its partners have helped over 225 municipalities and counties across the nation make it faster, easier, and more affordable for residents and business owners in their jurisdictions to invest in solar energy.[73]

Southern Current LLC

SOLAR PROJECT DEVELOPMENT FIRM AND EPC CONTRACTING FIRM

*Since **2016**, Southern Current has more than **tripled the size of the engineering department** and added dozens of field employees and project managers.*

Southern Current is a solar developer and engineering, procurement, and construction (EPC) contractor headquartered in Charleston, South Carolina. Since it can be challenging to find employees in the region with significant solar experience, Southern Current will often hire entry-level employees and provide training.

As a market leader that operates in 10 states with nearly $450 million in investment to reach 500 MW to date, Southern Current takes a "whole process" approach to solar. That means they are engaged from project development through construction and financing.

The development division specializes in developing utility-scale systems, while the EPC division installs residential, non-residential, and utility-scale projects. The EPC division is mostly used to execute the company's own utility-scale development projects along with its smaller installations, but also provides contracting services to national developers seeking expertise in the Carolinas.

Permitting is easily the most labor-intensive aspect of Southern Current's work and requires every department to get involved. As a result, the company relies on development professionals who become experts on the zoning and permitting procedures for relevant jurisdictions. A development professional's expertise is demanded in every stage of a project, from early strategic development to project interconnection. Additional roles on the EPC team include engineers, procurement experts, a sales and operations team, project managers, and installation crews.

Southern Current's workforce has grown immensely over the past few years, particularly the EPC division. Since 2016, it has more than tripled the size of the engineering department and added dozens of field employees and project managers to accommodate increased project volume. In addition to hiring new workers, "we have also added more complexity to our employees' roles to continue to be a dynamic, forward-thinking company," says John Wilson, Design Project Manager.

As Southern Current expands its workforce, hiring employees can be tough because solar is a nascent industry in the Southeast. Rather than looking for specific experience, "we look more to how we can develop new hires and are willing to take less experience so we can train and develop employees' skill sets from within," says Greg White, Chief EPC officer.

The biggest challenge Wilson faces as a project manager is when technologies change over the progression of a project. For example, solar components could be outdated between the time a project is initiated and when construction begins. "In order to ensure each system has the greatest economic feasibility and system performance, we must constantly reevaluate our system designs for any given project, as system component technology is always changing," Wilson says.

Learn more at southerncurrentllc.com.

Conclusion

The solar industry has undergone a challenging two years. A decade of rapid growth made the industry an American success story and one of the nation's leading job creators, with almost 150,000 jobs added since 2010.

As we have seen, however, 2018 marked the second year in a row that the solar industry saw job losses, with a small but significant decrease of 3.2% from 2017. The industry has lost more than 17,000 jobs since the boom year of 2016, when solar employment increased by 25% in one year alone. At the same time, the current job total of 242,343 remains well above the approximately 209,000 solar workers in 2015.

At the state level, policy challenges and a difficult business climate led to a job decline in several major solar markets in 2018, including California, Massachusetts, and North Carolina. In other states, jobs increased thanks to favorable policies and/or the declining costs of solar installations. Florida ramped up to the second-highest number of solar jobs nationwide, and Nevada, New York, Texas, Illinois, and Virginia were among the 29 states where job totals increased in 2018.

Nationwide, a significant factor contributing to the jobs decline was uncertainty about pending tariffs on solar modules and cells, which led the industry to delay new projects in late 2017 while awaiting the outcome of the trade case. These delays spilled over into the job market when the *Solar Jobs Census* survey was conducted in September and October of 2018.

*The solar industry expects a jobs turnaround with **7% growth in 2019.***

Today, solar companies can factor the cost of the tariffs into their business decisions and are moving forward with new utility-scale projects. Based on the *Census* survey, the solar industry expects a jobs turnaround with 7% growth in 2019. This would bring the workforce close to the 2016 jobs number, with 259,000 jobs nationwide. It is important to note that these predictions do not always come to fruition; in the previous *Census*, the industry expected jobs growth of 5.2% in 2018. Nonetheless, there is considerable evidence that the outlook for the solar industry is improving, and that solar employment will resume a growth path in 2019 and beyond.

THE FUTURE SOLAR WORKFORCE IN AN AUTOMATED WORLD

As 21st-century automation and software technology improve, what does this mean for the future of the solar workforce? In our followup interviews to the *Solar Jobs Census* survey, we asked select companies about the effects of automation technology on the labor demands of workers. Though improvements in technology have the potential to increase the efficiency of solar jobs, most leaders expect that in the near term, these efficiency gains will only lead to the hiring of more workers as costs continue to drop and companies take on more projects.

One such technology improvement that may reduce labor demands is the advancement in digital infrared cameras and drones. Aerial thermography is becoming increasingly popular as part of preventative maintenance services.[74] The technology already available allows a single drone to fly over a large utility-scale system and detect any service issues such as broken modules, panel hot spots, and erosion.

Automated cleaning and mowing technology have the potential to reduce the manual labor dedicated to land management services. For example, a Germany-based company recently designed a functional remote-controlled cleaning system that cleans panels five times faster than traditional manual labor.[75] Advancements in mowing technology will greatly reduce labor demands, as solar farms require hundreds of labor-hours to mow hundreds of acres of grass.

Other technology improvements include the development of new software tools to create more functional and reliable software not only for customer service, but for server and administrator service. In fact, in California, lawmakers are looking to mandate new smart inverter standards that would allow continuous monitoring of system performance, removing the need for on-site workers to monitor systems. Other new technology, such as the software developed by Aurora Solar, allows solar companies to model sites, design systems, simulate energy production, create sales proposals, and even assist in permitting requirements, all without visiting a system site (see *Census In-Depth*, p. 44).

INDUSTRY OUTLOOK FOR 2019

With the solar industry expected to reach 2 million U.S. installations early in 2019, development is proceeding at a rapid pace. Industry analysts expect to find that 3.5 GW of utility-scale solar were installed in Q4 2018, the largest amount since Q4 2016.[76] And with 11.2 GW in new projects announced in 2018, the industry also has a large and expanding procurement pipeline that bodes well for the future. As of Q3 2018, Wood-Mackenzie found the pipeline of utility-scale solar was at 26.5 GW, the highest level ever.[77] *PV Magazine* recently surveyed planned projects among select grid operators and predicted an "unprecedented solar boom."[78] While many of the planned projects will be built after 2019, considerable solar expansion across the United States appears likely in the near future. The industry forecasts that total installed capacity will double in the next five years.[79]

Factors driving solar development in 2019 will include the pending rampdown of the Investment Tax Credit. Solar developers need to begin projects no later than 2019 in order to "anchor" them to the full tax credit before it is reduced in future years. However, many of these projects will not actually be completed until 2021 or later. In addition, the industry may delay some projects to take advantage of reduced tariff rates, as the tariffs step down 5% each year from 30% in 2018 to 15% in 2021.[80]

LONG-TERM DRIVERS FOR GROWTH

Several long-term developments will likely encourage solar job growth in 2019 and future years. One overriding trend continues to be the rapid reduction in costs, making solar energy increasingly competitive with fossil fuels. The financial firm Lazard reported that the levelized cost of utility-scale solar is now competitive with the marginal cost of a coal-fired power plant.[81] This means electric utilities are now often deploying solar energy because it is the cheapest option available. According to Deloitte, voluntary procurement drove 73% of utility-scale solar projects in the first half of 2018.[82] More utilities are now accounting for solar in their long-term planning as the least-cost option for energy development.

The installation costs of residential solar declined to a historic low in 2018, driven by higher module efficiency, higher labor productivity, and lower permitting costs.[83] Nevertheless, the cost of rooftop solar is still artificially high, due to cumbersome permitting and interconnection requirements that contribute to the soft costs of installations. Residential installation costs in the United States are well above other developed countries, such as Germany and Australia.[84] The Solar Foundation is now co-leading an industry-wide effort, known as Solar Automated Permit Prcessing (SolarAPP), to streamline the permit process and reduce costs.[85]

Meanwhile, state governments are pursuing bold new policies that will drive future solar energy expansion. In 2018, California adopted a historic 100% clean energy target, as well as a ramp-up of the state RPS and a mandate for solar installation on new homes.[86] A growing number of other states are setting more aggressive renewable energy targets, or have plans to do so. And electric utilities are following suit. Xcel Energy has pledged to go zero-carbon by 2050, and the Indiana utility NIPSCO plans to eliminate coal from its portfolio within the next decade.[87]

This does not mean that all long-term developments will be positive. Recent reports have pointed to the possibility of an economic slowdown or even a recession, which could have major repercussions for the industry in 2019. Nevertheless, it is encouraging to see a growing number of leaders in government, utilities, and local communities show a commitment to a future powered by solar energy.

THE FUTURE OF THE SOLAR WORKFORCE

All the evidence suggests that solar will continue to be a source of stable, well-paying careers that offer rapid opportunities for advancement. Labor analysts bear out this prediction: The BLS expects that "solar photovoltaic installer" will be among the fastest growing occupations in the next decade, growing 105% through 2026.[88]

As the industry matures, however, the nature of the workforce will change along with the types of positions available. Advances in automation technology will increase labor productivity, though rather than eliminating jobs, industry leaders expect that in the near term this will improve efficiency and drive increased demand (see box, p. 65). The expanded use of robotics and other new technologies will require employees to learn new skills and take on different roles in the industry.[89] Technological change will amplify the importance of employees with general problem-solving, creativity, and leadership skills as well as specialized knowledge.[90]

*The BLS expects that **"solar photovoltaic installer"** will be among the fastest growing occupations in the next decade.*

General trends affecting the overall workforce will also have an impact on the solar industry. Solar companies already rely heavily on contractors for many projects, and they may evolve toward a more flexible workforce with the increased use of contingent or freelance workers. In addition, solar companies may see increasing advantage in partnering with educational providers, nonprofits, and government entities to provide ongoing training opportunities for employees, helping solar workers advance in their careers as the industry evolves.[91]

Hiring qualified workers will continue to be a major challenge for solar companies as the industry grows. The *Census* survey found that one-fourth of all solar employers and one-third of installers said it was "very difficult" to hire qualified employees (see Workforce Development, p. 55). Solar companies should engage with local workforce development boards, training providers, and other community resources to expand outreach to job candidates and make solar careers more broadly accessible.

To ensure the industry continues to thrive, solar companies will also need to make improved workforce diversity a priority. Representation of women, people of color, and veterans saw little change in 2018, but more industry leaders are devoting attention to diversity and inclusion. While the solar industry's demographics may be on par with or slightly better than comparable industries, solar companies have a responsibility to lead. The industry should adopt proven best practices and explore new strategies to ensure the workforce reflects America's diverse communities.

POLICIES MATTER: TOWARD A BRIGHT FUTURE FOR SOLAR

Economic and policy trends suggest the outlook is generally favorable to solar job growth in the coming years. However, in order to truly address the global challenges we now face, it will not be sufficient to sit back and let the trends play out over time. The world is facing a climate emergency with a closing window for action, demanding accelerated renewable energy development that is far above the current trajectory (see box, p. 17). Instead of slow or incremental progress, we should pursue the rapid investment and deployment of renewables at a level commensurate to the scale of the challenge.

Policy support at all levels of government will be essential for this vision to become reality. The federal government should turn away from policy disincentives such as the tariffs and support new deployment and job growth in solar and other renewables. National leaders should back aggressive goals to reduce carbon emissions and accelerate renewable energy growth. State governments should increase their renewable energy targets and support a modern electricity grid that is conducive to clean energy development. Local governments can also help facilitate the clean energy transition by reducing solar permitting costs and opening pathways to solar markets.

The good news is that accelerated renewable energy use confers a long list of benefits – from the environmental and climate impacts, to increased resilience, to economic development, and not the least, as a driver of job growth. There is enormous potential for solar energy expansion across all 50 states, and everywhere from major cities to rural areas. Setting policy goals to drive more solar energy growth should not be a partisan choice, but a smart economic, climate, and national security strategy that will benefit all Americans.

Appendix A: Solar Jobs by State

State	2018 Solar Jobs	2017 Solar Jobs	Year/Year Growth	Solar Jobs Rank	Solar Jobs Per Capita Rank	2018 Ratio of Solar Worker to Overall Workforce	2017 Ratio of Solar Worker to Overall Workforce
AK	66	72	-7%	52	52	1:4,909	1:4,721
AL	614	488	26%	43	50	1:3,362	1:3,987
AR	369	284	30%	47	51	1:3,408	1:4,250
AZ	7,524	8,381	-10%	6	9	1:384	1:322
CA	76,838	86,414	-11%	1	3	1:225	1:198
CO	6,847	6,789	1%	8	8	1:403	1:389
CT	2,193	2,168	1%	28	22	1:778	1:785
DC	1,092	1,294	-16%	35	5	1:729	1:593
DE	468	549	-15%	45	30	1:995	1:813
FL	10,358	8,589	21%	2	29	1:858	1:977
GA	3,696	4,310	-14%	21	37	1:1,245	1:1,011
HI	2,120	2,715	-22%	30	6	1:314	1:240
IA	844	815	4%	39	45	1:1,893	1:1,929
ID	557	654	-15%	44	41	1:1,333	1:1,107
IL	4,879	3,571	37%	13	36	1:1,261	1:1,682
IN	3,114	2,775	12%	23	32	1:1,015	1:1,096
KS	896	538	66%	37	43	1:1,598	1:2,560
KY	1,410	1,293	9%	32	42	1:1,379	1:1,462
LA	2,950	2,668	11%	26	20	1:675	1:715
MA	10,210	11,530	-11%	3	7	1:362	1:313
MD	4,515	5,324	-15%	16	14	1:613	1:506
ME	635	713	-11%	42	31	1:989	1:882
MI	4,169	4,134	1%	18	35	1:1,067	1:1,056
MN	4,602	4,256	8%	15	13	1:647	1:682
MO	2,819	2,609	8%	27	33	1:1,036	1:1,080
MS	770	923	-17%	41	46	1:1,523	1:1,223
MT	274	208	31%	49	47	1:1,759	1:2,272
NC	6,719	7,622	-12%	9	19	1:675	1:572
ND	233	145	60%	50	44	1:1,865	1:2,905
NE	1,328	1,375	-3%	33	17	1:778	1:716
NH	890	1,051	-15%	38	18	1:782	1:633
NJ	6,410	7,106	-10%	11	15	1:657	1:580
NM	2,168	2,522	-14%	29	10	1:395	1:323
NV	6,680	6,564	2%	10	1	1:211	1:203
NY	9,729	9,012	8%	4	28	1:996	1:1,045
OH	7,162	6,518	10%	7	23	1:789	1:832
OK	838	739	13%	40	48	1:2,032	1:2,142
OR	3,654	3,965	-8%	22	12	1:529	1:482
PA	4,219	3,848	10%	17	39	1:1,438	1:1,523
RI	1,007	1,064	-5%	36	11	1:501	1:458
SC	2,983	2,829	5%	25	24	1:721	1:726
SD	444	485	-9%	46	27	1:1,008	1:897
TN	4,690	4,411	6%	14	16	1:658	1:668
TX	9,612	8,873	8%	5	38	1:1,326	1:1,359
UT	6,045	6,170	-2%	12	4	1:254	1:233
VA	3,890	3,565	9%	20	34	1:1,036	1:1,090
VT	1,229	1,535	-20%	34	2	1:255	1:205
WA	4,045	3,433	18%	19	25	1:859	1:977
WI	3,007	2,921	3%	24	26	1:998	1:994
WV	341	311	9%	48	49	1:2,212	1:2,219
WY	190	144	32%	51	40	1:1,537	1:1,946
PR	1,997	-	-	31	21	1:427	-

Appendix B: Methodology

The *National Solar Jobs Census* methodology is closely aligned with the Bureau of Labor Statistics' methodology for its Quarterly *Census* of Employment and Wages (QCEW) and Current Employment Statistics (CES). Like the BLS, this study uses survey questionnaires and employer-reported data, though *Solar Jobs Census* surveys are are administered by phone and email, as opposed to mail. In 2018, this included approximately 59,300 phone calls and over 49,000 email invitations.

The *National Solar Jobs Census 2018* includes data gathered between September and October 2018 from known and potential solar energy establishments or locations. The survey was administered by BW Research Partnership to a known universe of solar employers that included 13,945 separate establishments and was derived from the Solar Energy Industry Association's National Solar Database. Of these establishments, 3,493 provided information about their solar activities (or lack of solar activities), and 2,697 completed full or substantially completed surveys.

It is important to note that surveys were completed for each employment location and not necessarily for each firm. If a solar employer was asked to participate in a survey, s/he would be asked about the employment profile of a given location and not of the entire firm.

The survey was also administered to a stratified, clustered, random sampling from various industries that are potentially solar-related and include a total of 173,948 establishments nationwide. After an extensive cleaning and de-duplication process, a sampling plan was developed that gathered information on the level of solar activity (including none) from 4,512 establishments. Of these, 200 establishments qualified for full surveys. This level of sampling rigor provides a margin of error of +/-1.45%.

These establishments stemmed from a sampling of employers in specific industries within wholesale trade, manufacturing, professional services, other services, and the construction (installation) industries. The survey was completed over the phone and the sample was stratified by industry, region, and firm size (4 or fewer employees, 5 to 49 employees, or 50 or more employees).

It is also important to note that known employment was allocated based on 2-digit and 6-digit NAICS code of responding establishments and removed from the unknown QCEW totals prior to generating employment estimates in the unknown. As a result, the potential for double counting establishments or employment is nonexistent.

Since responses to the survey are often not representative by industry, a weighting adjustment (by size of segment) is applied to the primary value chain of the responding location. This prohibits inaccuracy of responses by value chain (over-representation or under-representation) and ensures an accurate read of employment and other responses within the survey.

Since 2010, The Solar Foundation has defined a solar job as one held by a worker spending at least 50% of his or her time on solar-related work. *Census* findings have consistently shown that roughly 90% of these workers (90.4% in 2018) spend 100% of their time on solar-related work.

ENDNOTES

1 *The 2018 U.S. Energy and Employment Report*. National Association of State Energy Officials, and Energy Futures Initiative, May 2018. https://www.usenergyjobs.org/

2 May 2017 National Occupational Employment and Wage Estimates, U.S. Bureau of Labor Statistics Occupational Employment Statistics, https://www.bls.gov/oes/current/oes_nat.htm#51-0000

3 *U.S. Solar Market Insight Q4 2018*. Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), December 2018.

4 Ibid.

5 Ibid.

6 Ibid.

7 Pyper, Julia. "California Rooftop Solar Mandate to Boost Sales 14% Over 4 Years," *Greentech Media*, May 11, 2018. https://www.greentechmedia.com/articles/read/california-rooftop-solar-mandate-to-boost-sales-14-over-four-years#gs.FG1gbrM.

8 *SB-100: California Renewables Portfolio Standard Program: emissions of greenhouse gases.* California State Legislature, September 10, 2018. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB100

9 *Long Term Renewable Resources Procurement Plan*. Illinois Power Agency, August 2018. https://www2.illinois.gov/sites/ipa/Documents/2019ProcurementPlan/Long%20Term%20Renewable%20Resources%20Procurement%20Plan%20%288-6-18%29.pdf.

10 *U.S. Solar Market Insight Q4 2018*. Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), December 2018.

11 Ibid.

12 "Quarterly *Census* of Employment and Wages." *Bureau of Labor Statistics*, Q3 2018 BLS, https://data.bls.gov/cew/apps/table_maker/v4/table_maker.htm#type=1&year=2017&qtr=2&own=0&ind=10&supp=0..

13 *Exhibit 1 – Fiscal Plan (PREPA)*. Puerto Rico Electric Power Authority, August 1, 2018. https://aeepr.com/es-pr/Documents/Exhibit-1-FiscalPlan_(PREPA)-20180801.pdf; *U.S. Solar Market Insight Q4 2018*. Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), December 2018.

14 "Puerto Rico Territory Energy Profile." *U.S. Energy Information Agency,* July 19, 2018. https://www.eia.gov/state/print.php?sid=RQ. Note: Based on data from July 2016 to June 2017, the most recent period for which data is available. The most recent data available is for the year ending June 30, 2017.

15 *SB 1519: Public Policy on Energy Diversification by Means of Sustainable and Alternative Renewable Energy in Puerto Rico Act.* Legislative Assembly of Puerto Rico, December 17, 2010. http://www.oslpr.org/download/en/2010/A-0082-2010.pdf. Note: When originally passed in 2010, the RPS set a target for producing 12% of retail electricity sales from renewable sources by 2015, 15% by 2020, and 20% by 2035 and thereafter.

16 *Exhibit 1 – Fiscal Plan (PREPA).* Puerto Rico Electric Power Authority, August 1, 2018. https://aeepr.com/es-pr/Documents/Exhibit-1-FiscalPlan_(PREPA)-20180801.pdf.

17 "Puerto Rico Energy Public Policy Act." *McConnell Valdes LLC,* October 23, 2018. http://www.mcvpr.com/newsroom-publications-Puerto-Rico-Energy-Public-Policy-Act.

18 *Lazard Levelized Cost of Energy Analysis - Version 12.0.* Lazard, November 2018, https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf.

19 *The 2018 U.S. Energy and Employment Report.* National Association of State Energy Officials, and Energy Futures Initiative, May 2018. https://www.usenergyjobs.org/

20 "Electric Power Monthly with data from October 2018." U.S. Energy Information Administration, December 2018. https://www.eia.gov/electricity/monthly/current_month/epm.pdf.

21 *U.S. Solar Market Insight Q4 2018*. Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), December 2018.

22 Ibid.

23 Marcy, Cara. "New Electric Generating Capacity in 2019 Will Come from Renewables and Natural Gas," *U.S. Energy Information Administration*, January 10, 2019, https://www.eia.gov/todayinenergy/detail.php?id=37952. Note: EIA percentages recalculated to include distributed generation.

24 Intergovernmental Panel on Climate Change, October 2018. https://www.ipcc.ch/sr15/.

25 Irfan, Umair. "3 Big Takeaways from the Major New US Climate Report," *Vox*, November 24, 2018. https://www.vox.com/2018/11/24/18109883/climate-report-2018-national-assessment.

26 Dennis, Brad and Chris Mooney. "'We Are in Trouble.' Global Carbon Emissions Reached a Record High in 2018." *The Washington Post*, December 5, 2018. https://www.washingtonpost.com/energy-environment/2018/12/05/we-are-trouble-global-carbon-emissions-reached-new-record-high/?utm_term=.00cf06eb33c9.

27 Energy Innovation. "Policy Design to Win the Future." Accessed December 2018. https://www.energypolicy.solutions/guide/.

28 "Rural Employment and Unemployment" United States Department of Agriculture, 2017. *https://www.ers.usda.gov/topics/rural-economy-population/employment-education/rural-employment-and-unemployment/*

29 Solar Energy Industries Association

30 *U.S. Solar Market Insight Q4 2018*. Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), December 2018.

31 Ibid.

32 Ibid.

33 Ibid.

34 Ibid.

35 Ibid. Note: Utility-scale costs are an average of fixed-tilt and single-axis tracking.

36 Ibid.

37 *Lazard Levelized Cost of Energy Analysis - Version 12.0*. Lazard, November 2018, *https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf.*

38 "Clean Energy Investment Exceeded $300 Billion Once Again in 2018," *Bloomberg New Energy Finance*, January 16, 2019. *https://about.bnef.com/blog/clean-energy-investment-exceeded-300-billion-2018/.*

39 Shaw, Vincent. "China Installed 43.6 GW of Solar Last Year – Despite 5/31 New Policy," *PV Magazine*, January 17, 2019. *https://www.pv-magazine.com/2019/01/17/china-installed-42-6-gw-of-solar-last-year-despite-5-31-new-policy/.*

40 Wilkes, William and Brian Parkin. "Renewables Beat Coal in Germany Power Mix for First Time," *Bloomberg*, January 4, 2019. *https://www.bloomberg.com/news/articles/2019-01-04/renewables-beats-coal-in-germany-power-mix-for-first-time.*

41 Osborne, Mark. "BNEF Offers Wide-Range Forecast for Global Solar Demand in 2019," *PV Tech*, January 21, 2019. *https://www.pv-tech.org/news/bnef-offers-wide-range-forecast-for-global-solar-demand-in-2019.*

42 Establishment data, Table B-1a., Current Employment Statistics, Bureau of Labor Statistics, retrieved Jan. 25, 2019; https://www.bls.gov/web/empsit/ceseeb1a.htm

43 "Monthly Photovoltaic Shipments Report," U.S. Energy Information Administration, December 18, 2018. https://www.eia.gov/renewable/monthly/solar_photo/.

44 *Annual and Monthly Photovoltaic Module Shipments Report – Form EIA-63B.* U.S. Energy Information Administration, December 2018. https://www.eia.gov/renewable/monthly/solar_photo/pdf/renewable.pdf.

45 *U.S. Solar Market Insight Q4 2018*. Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), December 2018.

46 Ibid.

47 *Solar Power World*. "U.S. Solar Panel Manufacturers." Accessed January 2019. https://www.solarpowerworldonline.com/u-s-solar-panel-manufacturers/.

48 Roselund, Christian and John Weaver. "2018 Solar Power Year in Review (Part 1)," *PV Magazine*, December 20, 2018. https://pv-magazine-usa.com/2018/12/20/2018-solar-power-year-in-review-part-1/

49 Ibid. Note: Since some manufacturers produce more than one item, the total percentage adds up to more than 100%.

50 *U.S. Solar Market Insight Q4 2018*. Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), December 2018.

51 *Solar Power World*. "Global Inverter Manufacturing Locations." Accessed January 2019. https://www.solarpowerworldonline.com/global-inverter-manufacturing-locations/.

52 *U.S. Solar Market Insight Q4 2018*. Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), December 2018.

53 Misbrener, Kelsey. "Chinese Tariffs Cause Wave of Changes to Solar Inverter Manufacturing," *Solar Power World*, January 7, 2019. https://www.solarpowerworldonline.com/2019/01/chinese-tariffs-change-solar-inverter-manufacturing/.

54 "First Solar: Undervalued Prior To 2019 Financial Guidance?" *Seeking Alpha*, December 3, 2018. https://seekingalpha.com/article/4225854-first-solar-undervalued-prior-2019-financial-guidance-.

55 Hoium, Travis. "Solar Energy's Top Growth Stocks Today," *The Motley Fool*, August 8, 2018. https://www.fool.com/investing/2018/08/08/solar-energys-top-growth-stocks.aspx.

56 Establishment data, Table B-1a., Current Employment Statistics, Bureau of Labor Statistics, retrieved January 25, 2019. https://www.bls.gov/web/empsit/ceseeb1a.htm

57 Cinnamon, Barry. "10 Predictions for Rooftop Solar and Storage in 2019," *Greentech Media*, January 3, 2019. https://www.greentechmedia.com/articles/read/barry-cinnamons-2019-solar-predictions-piece.

58 Wood Mackenzie Power & Renewables/ESA ***Energy Storage Monitor Q4 2018*** *http://energystorage.org/energy-storage/us-energy-storage-monitor*

ENDNOTES

59 *Lazard Levelized Cost of Energy Analysis - Version 12.0.* Lazard, November 2018, *https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf.*

60 Ibid.

61 Hunt, Vivina, Lareina Yee, Sara Prince, and Sundiatu Dixon-Fyle. *Delivering Through Diversity.* McKinsey & Company, January 2018. https://www.mckinsey.com/business-functions/organization/our-insights/delivering-through-diversity. Note: This report found that companies in the top quartile for gender diversity on their executive teams were 21% more likely to have above-average profits. Companies with executive teams in the top quartile for ethnic and cultural diversity were 35% more likely to have above-average profits.

62 Lillian, Betsy. "Study: The Disparity Of Rooftop Solar Deployment By Race," *Solar Industry Magazine*, January 10, 2019, https://solarindustrymag.com/study-the-disparity-of-rooftop-solar-deployment-by-race/.

63 *2017 U.S. Solar Industry Diversity Study*. The Solar Foundation, September 2017. https://www.thesolarfoundation.org/diversity/.

64 May 2017 National Occupational Employment and Wage Estimates, U.S. Bureau of Labor Statistics Occupational Employment Statistics, *https://www.bls.gov/oes/current/oes_nat.htm#51-0000*

65 Interstate Renewable Energy Council. "IREC National Solar Licensing Map." Accessed January 2019. https://irecusa.org/workforce-education/training-resources/solar-licensing-database/. Note: Licensing requirements for each state are laid out in the Interstate Renewable Energy Council's National Solar Licensing map.

66 Minnesota Department of Labor and Industry, "Apprenticeship Ratios." Accessed January 2019. http://www.doli.state.mn.us/business/workforce/apprenticeship-ratios.

67 *Solar Hiring and Training Insights 2017*. The Solar Foundation, April 2017, https://www.americansolarworkforce.org/wp-content/uploads/2018/09/sthr.pdf.

68 Establishment data, Table B-1a., Current Employment Statistics, Bureau of Labor Statistics, retrieved January 25, 2019; https://www.bls.gov/web/empsit/ceseeb1a.htm

69 *Solar Hiring and Training Insights 2017*. The Solar Foundation, April 2017. https://www.americansolarworkforce.org/wp-content/uploads/2018/09/sthr.pdf.

70 Walker, Chris. "Vintage Hiring and Training Solutions for a Better Solar Workforce," *PV Magazine*, July 10, 2018, https://pv-magazine-usa.com/2018/07/10/vintage-hiring-and-training-solutions-for-a-better-solar-workforce/.

71 We Are Still In. "We Are Still in Declaration." Accessed January 2019. *https://www.wearestillin.com/we-are-still-declaration*

72 Global Covenant of Mayors for Climate & Energy. "Global Covenant Cities." Accessed January 2019.

73 Sierra Club. "Ready for 100." Accessed January 2019. https://www.sierraclub.org/ready-for-100

74 Brehaut, Cedric. "Low O&M Prices Drive 'Digitalization' and New Technologies." *Greentech Media*, January 25, 2018. https://www.greentechmedia.com/articles/read/low-om-prices-drive-digitalization#gs.ijCyHEKH.

75 Lang, Nicole. "New Solar Panel Cleaning Product Reduces Manual Labor, Improves Safety." *Solar Power World*, January 9, 2019. https://www.solarpowerworldonline.com/2019/01/new-solar-panel-cleaning-product-reduces-manual-labor-improves-safety/.

76 *U.S. Solar Market Insight Q4 2018.* Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), December 2018.

77 Ibid.

78 Roselund, Christian. "US on Cusp of Unprecedented Solar Boom," *PV Magazine*, January 2, 2019. https://www.pv-magazine.com/2019/01/02/us-on-cusp-of-unprecedented-solar-boom/.

79 *U.S. Solar Market Insight Q4 2018.* Wood Mackenzie, Limited, and the Solar Energy Industries Association (SEIA®), December 2018.

80 Ibid.

81 *Lazard Levelized Cost of Energy Analysis - Version 12.0.* Lazard, November 2018. https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf. Note: The levelized cost includes building, running, supplying, and maintaining a solar plant.

82 Maloney, Peter. "'Voluntary Demand' for Renewables Pushes Utilities to New Technology, Business Models: Deloitte," *Utility Dive*, December 12, 2018. https://www.utilitydive.com/news/voluntary-demand-for-renewables-pushes-utilities-to-new-technology-busin/544174/

83 Fu, Ran, David Feldman, and Robert Margolis. *U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018.* National Renewable Energy Laboratory, November 2018. https://www.nrel.gov/docs/fy19osti/72399.pdf. Note: Installation costs are now at $2.70 a Watt for residential solar and approaching $1/Watt for utility-scale solar.

84 Trabish, Herman. "Can the Price of Rooftop Solar Keep Falling?" *Utility Dive*, October 18, 2018. https://www.utilitydive.com/news/can-the-price-of-rooftop-solar-keep-falling/539612/.

85 The Solar Foundation. "Solar Automated Permit Processing (SolarAPP)." Accessed Jan. 27, 2019. *https://www.thesolarfoundation.org/solarapp/*

86 Roselund, Christian. "100% Clean Energy Passes California Assembly," *PV Magazine*, August 28, 2018. https://pv-magazine-usa.com/2018/08/28/100-clean-energy-passes-california-assembly/.

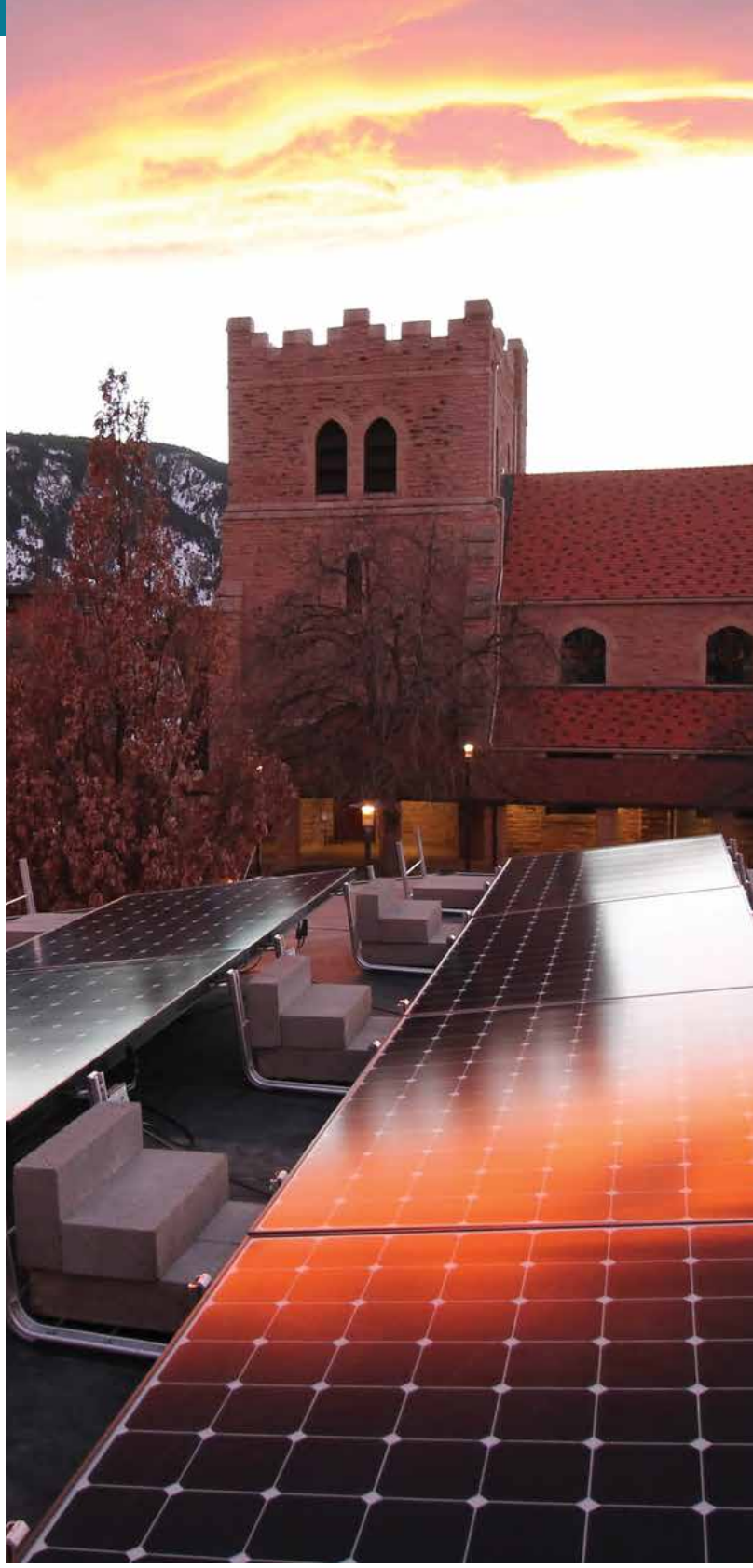
87 *Xcel Energy Aims for Zero-Carbon Electricity by 2050*, Xcel Energy, December 4, 2018. http://investors.xcelenergy.com/file/Index?KeyFile=395990778; Bade, Gavin. "Even in Indiana, New Renewables are Cheaper than Existing Coal Plants," Utility Dive, October 25, 2018. https://www.utilitydive.com/news/even-in-indiana-new-renewables-are-cheaper-than-existing-coal-plants/540242/.

88 Bureau of Labor Statistics, Occupational Outlook Handbook: "Fastest Growing Occupations," retrieved January 27, 2019. *https://www.bls.gov/ooh/fastest-growing.htm*

89 Schwartz, Jeff. *The Future of the Workforce*. Deloitte, July 2016. https://www2.deloitte.com/global/en/pages/human-capital/articles/future-of-the-workforce.html.

90 Brown, Justine, Tom Gosling, Bhushan Sethi, Blair Sheppard, Carol Stubbings, John Sviokla, Jon Williams, et al. *Workforce of the Future*. PricewaterhouseCoopers, May 2018. https://www.pwc.com/gx/en/services/people-organisation/publications/workforce-of-the-future.html.

91 Schwartz, Jeff. *The Future of the Workforce*. Deloitte, July 2016. https://www2.deloitte.com/global/en/pages/human-capital/articles/future-of-the-workforce.html.



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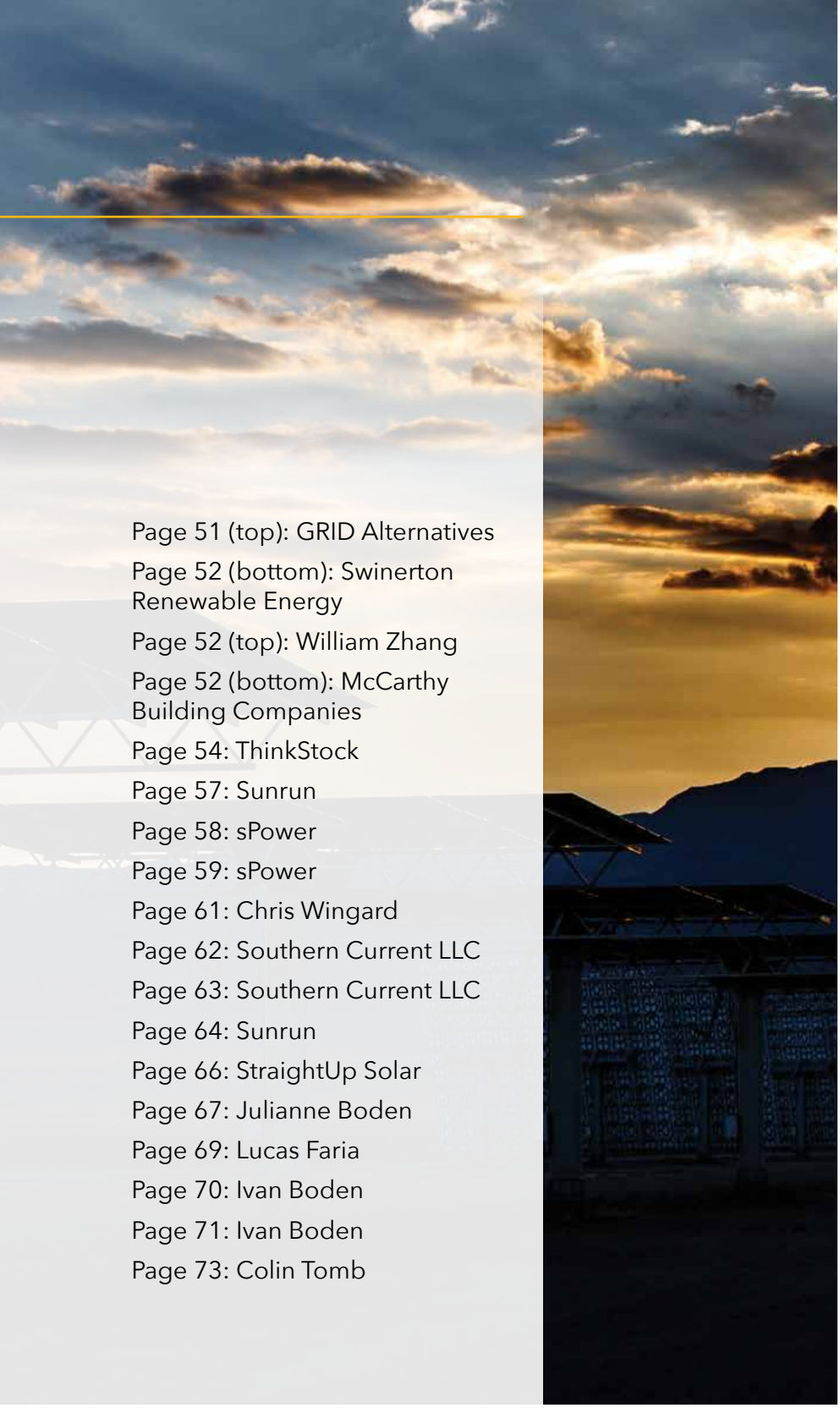

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