U.S. DEPARTMENT OF ENERGY

ISSUE BRIEF

Investing in a Clean Energy Future: Solar Energy Research, Deployment, and Workforce Priorities

August 2021

Executive Summary

The immediate need for action on climate change has been made clear in the recent report from the Intergovernmental Panel on Climate Change (IPCC). Limiting the rise in global temperatures would help avoid future catastrophic changes, but the path to limit warming to 1.5 degrees Celsius is narrowing. Without immediate and large-scale reductions in greenhouse gas emissions to reach net-zero emissions by 2050, this warming goal will be beyond reach.

President Biden's goal to achieve a carbon pollution-free power sector by 2035, in conjunction with a proposal for historic investments in U.S. infrastructure, are critical steps toward combatting the climate crisis and reducing greenhouse gas emissions at the right pace and scale. America's shift to a clean energy future requires investment in a vast renewable energy technologies portfolio, which includes solar energy.

Solar is the fastest-growing source of new electricity generation in the nation – growing 4,000 percent over the past decade – and will play an important role in reaching the administration's goals.

According to preliminary results of an upcoming analysis by the National Renewable Energy Laboratory (NREL), to reach a largely decarbonized electricity sector by 2035, solar deployment would need to accelerate to three to four times faster than its current rate by 2030. Large-scale decarbonization of the electricity sector could move solar from 3 percent of generation today to over 40 percent by 2035.

Meeting these goals will require billions in investment and market opportunities through 2050 across clean energy generation, energy storage, electricity delivery, and operations and maintenance – including in low-income and community solar. Investments that lower both the hardware and soft administrative costs of solar will save consumers thousands of dollars on their residential systems and help lower their utility bills.

The widespread adoption of solar power will also create new jobs. A pathway to a largely decarbonized electricity sector by 2035 can add millions of new jobs across clean energy technologies, including potentially 500,000–1,500,000 people working in solar by 2035. Ensuring that federal investments include strong labor standards, project labor agreements, prevailing wages, and a free and fair choice to join a union and bargain collectively can diversify pathways to high-quality solar jobs.

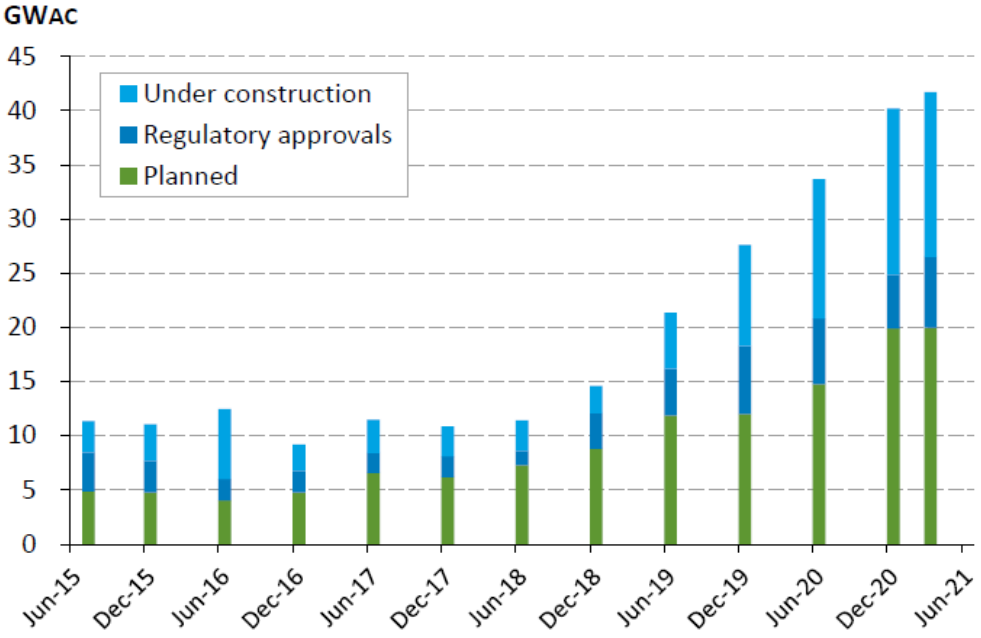
This brief summarizes the evidence of how key investment in solar research and deployment, along with support from the U.S. Department of Energy (DOE), can help realize these opportunities for American workers, consumers, and communities.

Solar Investment Supports the U.S. Clean Energy Revolution

Solar will play an important role in reaching President Biden's 2035 clean electricity goal – alongside other important clean energy sources, including onshore and offshore wind power, carbon capture, and clean hydrogen, as well as keeping our nuclear fleet online. The strategic energy investments proposed by President Biden will support the rapid deployment of solar and help the United States build a zero-carbon and resilient clean energy system.

Solar is already the fastest-growing source of new electricity generation in the nation – growing from about 2.5 gigawatts (GW_{DC}) of solar capacity in 2010 to over 100 GW_{DC} today.[1],[2] That equals about 3 percent of U.S. electricity supply and is enough to power over 18 million homes.[3],[4] Despite the impact of the pandemic on the economy, the United States installed nearly 20 GW_{DC} of solar photovoltaics (PV) in 2020 – the largest yearly total ever – and the pipeline of new projects for 2021 is on target to hit record highs (Figure 1). According to recent Energy Information Administration figures, 15 GW_{AC} of utility-scale PV projects are currently under construction, 7 GW_{AC} have received regulatory approval, and 20 GW_{AC} are planned. At the end of 2020, over 450 GW of solar and solar plus storage projects had applied for interconnection to the bulk power system – or 54 percent of all active projects.[5] Not all of these projects will be constructed, but this project list is a useful indicator of the strong growth in solar.

Figure 1. Pipeline of utility-scale PV projects in the United States as of March 2021.



Note: Pipeline is defined as all planned PV projects that have been submitted in EIA's Form 860M. All projects have a scheduled placed-in-service date between 2021 and 2024.

Source: H1 2021 Solar Industry Update, National Renewable Energy Laboratory. From EIA Form 860M (March 2021).

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[1] Gigawatts, direct current (GW_{DC}) represents the generating capacity of the installed solar panels, as opposed to alternating current (GW_{AC}) which is lower and represents the power output of the system after it has been converted from direct current.

[2] Wood Mackenzie Power & Renewables/SEIA U.S. Solar Market Insight. In 2019 and 2020, solar represented 40% and 43% of new electricity generation, respectively.

[3] U.S. Energy Information Administration (EIA).

[4] Wood Mackenzie/SEIA Solar Data Cheat Sheet: https://www.seia.org/research-resources/solar-data-cheat-sheet.

[5] Generation, Storage, and Hybrid Capacity in Interconnection Queues, Lawrence Berkley National Laboratory.

Solar deployed at scale, when combined with energy storage, can make America's energy supply more resilient, particularly from power disruptions in the event of manmade and natural threats. Smaller-scale solar, as part of microgrids or hybrid plants, can drive greater local self-sufficiency and community-level resilience. Solar with storage solutions can already provide hours of backup power for individual buildings and, in the future, could provide days of backup power and even seasonal stored power. This storage option can help manage the grid, prevent outages, and even restart the grid after a power outage.

Seizing this Growth Opportunity Through New Investments

According to preliminary results of an upcoming NREL analysis, to reach a largely decarbonized grid by 2035, solar deployment would need to accelerate to three to four times faster than its current rate by 2030. That could move solar from 3 percent of generation today to over 40 percent by 2035.[6]

Realizing this potential for solar generation requires significant investments to accelerate deployment of residential, commercial, and utility-scale solar systems, including in disadvantaged and low-income communities. The clean energy transition will need a multi-billion dollar investment through 2050 across clean energy generation, energy storage, transmission, and operations and maintenance.

The following identifies types of investments that could be effective tools to help meet the President's goals for clean energy deployment:

Clean Energy Tax Credits – Investment and production tax credits (ITCs and PTCs) have been successful tools in helping to expand solar and wind energy generation. In particular, over the past couple of decades, ITCs and PTCs have lowered the cost to invest in clean energy. These credits were recently extended for the near term; the PTC will expire at the end of 2021, while the ITC will phase down for residential solar in 2023 and commercial and utility-scale solar in 2024. Previous NREL research confirmed that the extension of these tax credits results in larger additions of new solar and wind generation than without the credits in place.[7]

Transmission and Storage – Faster solar deployment requires further investment in grid operations to deliver clean energy to businesses and households, as well as to ensure the reliability and resilience of the nation's electricity supply. This can occur through federal programs that invest directly in transmission lines to connect and deliver clean electricity and support better regional planning. Direct pay tax incentives for transmission and storage, similar to the successful investment tax credits for solar generation, could help mobilize billions of dollars of private capital into much-needed transmission lines and new battery storage.

Innovation and Advanced Manufacturing – The solar industry has its roots in America, and a key part of lowering the costs of solar involves investing in technology innovation, manufacturing, and the solar supply chain. The United States pioneered the manufacturing and scale-up of solar PV technologies, beginning with the first solar manufacturing line, which was built in 1979 in California.[8] U.S. research and development has helped lower manufacturing costs, increase efficiency and performance, and improve reliability of solar technologies. Over

[6] From the forthcoming *Solar Futures Study*, National Renewable Energy Laboratory

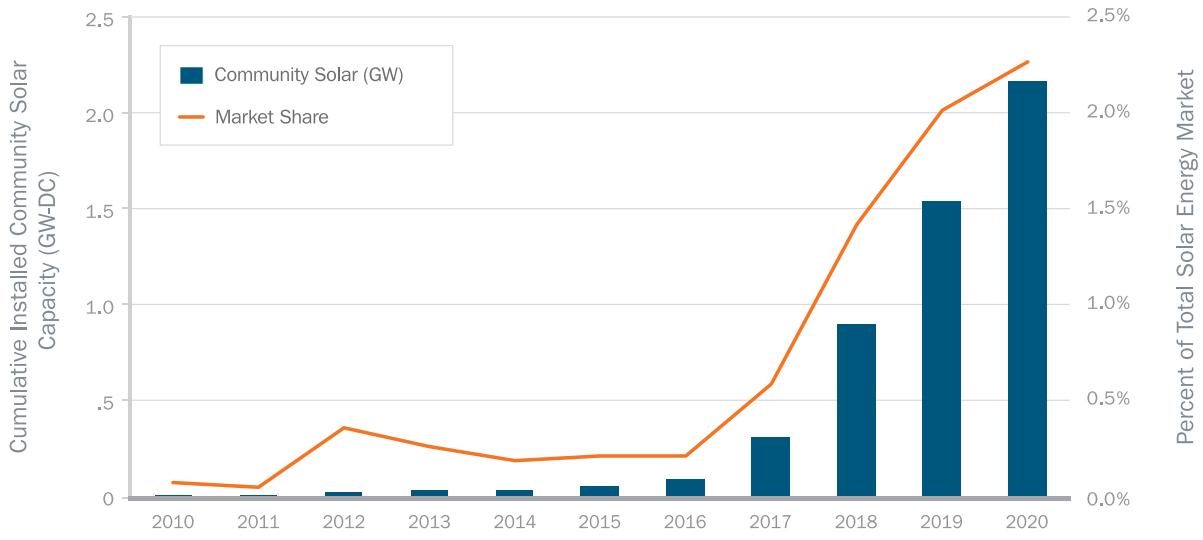
[7] Impacts of Federal Tax Credit Extensions on Renewable Deployment and Power Sector Emissions, National Renewable Energy Laboratory

[8] ARCO Solar built the first manufacturing line in the U.S. in 1979.

the past 35 years, DOE solar awardees achieved nearly half of all solar cell efficiency world records[9] and pioneered the development of molten salt in concentrating solar-thermal power (CSP) plants, which is used as a blueprint for CSP plants around the world. U.S. innovators continue to pioneer technology advancements that can be manufactured domestically. Today, the United States has over 2 GW of thin-film solar PV manufacturing capacity and another 3 GW of PV silicon module assembly. Given concerns about forced labor in the solar energy supply chain in China, the need for domestic capacity to meet goals has expanded. The growth of U.S. solar will require continued research and development investments in new solar materials, solar demonstration projects, critical material supply chains, and the building or retooling of manufacturing facilities for the production of advanced energy technologies.

Low-income and Community Solar – Increasing solar deployment nationally must include households and communities that have historically lacked access to affordable solar technology. Low- and moderate- income Americans are less likely to adopt solar due to issues like lack of access to financing, which perpetuates energy inequalities and leads to lower overall levels of solar deployment. In particular, access to credit is a key barrier to solar adoption for low- and moderate-income households; almost 90 percent of 2018 solar adopters have either prime or super-prime credit scores.[10] To address this, DOE is investing in innovations in community solar business models that could mitigate credit needs. Community solar can extend the benefits of affordable solar to multiple customers – including individual, businesses, nonprofits, and other groups – regardless of whether their homes or buildings can support rooftop solar panels. In fact, community solar projects are on the rise and span 39 states and the District of Columbia (Figure 2), but the bulk are in just four states and represent about 4 percent of solar capacity. Green banks and other financing mechanisms that invest in community solar can help families and businesses gain access to zero-carbon solar.

Figure 2. The sharp rise in community solar in the United States.



Sources: "U.S. Solar Market Insight" (Wood Mackenzie)
Graphic courtesy of the U.S. Department of Energy Solar Energy Technologies Office.

[9] Based on DOE analysis of the National Renewable Energy Laboratory's efficiency chart.

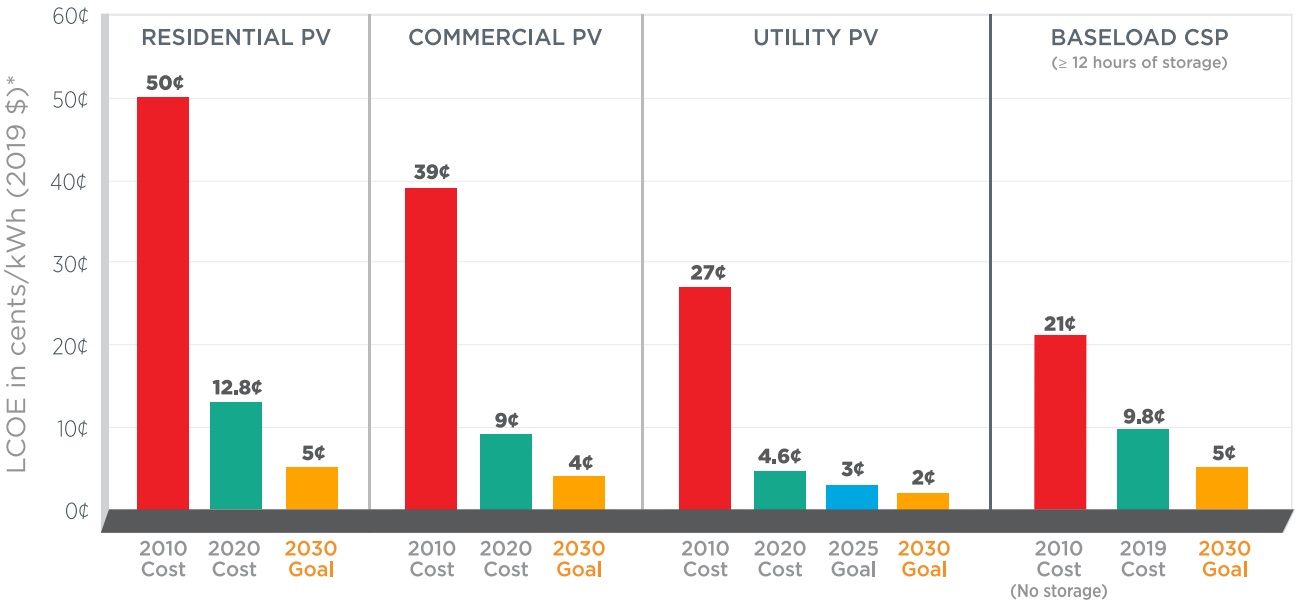
[10] https://eta-publications.lbl.gov/sites/default/files/solar-adopter_income_trends_report.pdf

Solar Innovation Can Lower Energy Costs for Consumers and Communities

In support of the Biden Administration goal to make solar more affordable, DOE is committed to continually investing in solar innovation and lowering the cost of energy for households and communities. Growing solar power means making it more affordable to deploy. Thanks in part to DOE investments, solar costs have declined between 70 percent and 80 percent since 2010. For example, the price of a typical 6 kW residential system was almost $30,000 cheaper in 2020.[11]

While solar PV is already the least expensive option in dozens of states, it is important to bring this low-cost, zero-carbon electricity to more parts of the country to provide air quality and jobs benefits, as well as to fully decarbonize the grid. This is why DOE set a new 2030 goal to cut the cost of solar PV to $0.02 and $0.05 per kilowatt-hour without subsidies for utility and residential scales, respectively (Figure 3). This would make utility-scale solar the cheapest option for new electricity generation. DOE also set a cost target of $0.05/kWh for next-generation CSP plants, which incorporate thermal energy storage. Similar to solar PV plus storage, combining CSP with thermal energy storage allows solar-generated heat to be stored until electricity is needed, regardless of the weather or time of day.

Figure 3. Levelized cost of energy (LCOE) progress between 2010 and 2020, and the 2030 targets for solar PV and CSP.



*Levelized cost of energy (LCOE) progress and targets are calculated based on average U.S. climate and without the Investment Tax Credit or state/local incentives.

Reducing these costs of energy through innovation and investment will translate directly to lower energy and technology costs for consumers. For example, the $0.05/kWh goal for residential systems is lower than what most homeowners pay today for retail electricity.[12] The national average

[11] U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark Q1 2020, National Renewable Energy Laboratory

[12] Retail electricity charges may include more than what is covered by the solar cost target (e.g. transmission and distribution infrastructure), though this comparison is likely to drive individual homeowner investment decisions.

is about $0.14/kWh, and it can exceed $0.40/kWh for homes with high consumption.[13] Achieving an electricity cost of $0.05/kWh translates to an installed cost of about $1.40 per watt – or around $8,400 for a typical 6 kW residential system. This cost target is considerably less than the current national average of $3.80/watt[14] – a potential savings of $14,000. Achieving this goal could save money for the average American both in the upfront installation cost and on their monthly bills over the lifetime of their system.

DOE is investing in numerous drivers to achieve these cost reductions, including technology innovation that reduces the costs of solar panels and increases their efficiency of turning solar energy into usable electricity. Leveraging the benefits of increased economies of scale can lower project installation costs, as well as regular operating and maintenance costs over the lifetime of the system, as the solar workforce and productivity grow in parallel. Finally, lowering upfront capital and finance costs – like from investment tax credits, lower interest rates, and loan guarantees – adds up to reduced costs for ratepayers.

Soft costs include customer acquisition, siting, permitting, interconnection, installation, operation and maintenance, and often represent over 60 percent of the total cost of a new residential solar PV system.[15] These costs have been slower to fall and represent a greater share of the remaining cost reductions necessary to achieve residential solar PV system cost targets. To address one of the main soft costs drivers, permitting, DOE, in partnership with NREL, industry, and local governments, developed a new, free, web-based tool – the Solar Automated Permit Processing (SolarAPP+) – that helps local governments speed up the review and approval of permits for residential solar and solar plus storage systems. Faster permitting times will attract businesses to work in jurisdictions that use it. After implementing a similar tool to fast-track permits in San Jose, CA, residential solar installations increased by 600 percent.[16]

Solar Power is a Job Creator

In 2020, there were over 300,000 people employed in the solar industry – 230,000 of whom worked in solar for a majority of their time.[17],[18] Employment in the solar industry has been one of the fastest growing sectors over the past decade – increasing by 150 percent between 2010 and 2020 across all 50 states, the District of Columbia, and Puerto Rico (Figure 4).[19] The relatively flat growth in jobs over the past several years is due to an increase of labor productivity in both residential and utility-scale solar deployment since 2010 – at 19 percent and 32 percent, respectively.[20] These workers are employed by over 10,000 solar businesses across the country – many of which are small businesses.

The industry was hit by the economic shutdown due to the COVID pandemic, as the number of workers who spend at least half of their time on solar-related work dropped 6.7 percent.[21]

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[13] Energy Information Administration, Electric Power Monthly, May 2021.

[14] Lawrence Berkeley National Laboratory, Tracking the Sun Distributed Solar 2020 Data Update.

[15] NREL Q1 2020 Benchmark, not yet published.

[16] https://insideclimatenews.org/news/29072016/california-fast-track-solar-permits-let-sun-shine-faster-cheaper-san-jose-los-angeles/

[17] 2021 U.S. Energy & Employment Jobs Report (USEER), U.S. Department of Energy.

[18] National Solar Jobs Census 2020, Solar Energy Industries Association.

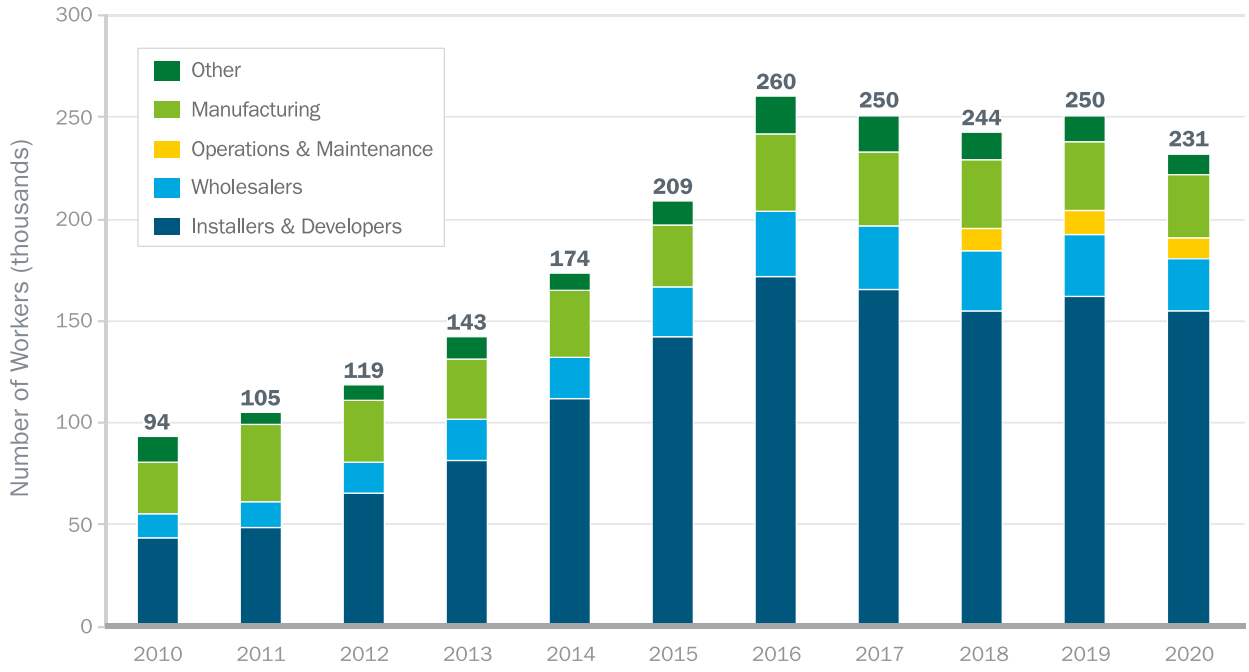
[19] Ibid.

[20] Ibid.

[21] Ibid.

However, the renewable energy jobs industry, including solar, bounced back faster than the broader construction and manufacturing sectors as a whole – adding back almost 63,000 jobs, or 14 percent, over the past year.

Figure 4. U.S. employment in the solar industry, representing workers who spend at least half their time on solar-related work.



Source: "2020 National Solar Jobs Census" (The Solar Foundation)
Graphic courtesy of the U.S. Department of Energy Solar Energy Technologies Office.

Investing in A Highly-Trained and Well-Paid Solar Workforce

For the solar industry to continue its growth and put it on a trajectory to help accomplish Administration decarbonization goals requires significant new investment in solar and solar workers. Importantly, DOE recently estimated that a pathway to a largely decarbonized electricity sector by 2035 can add millions of new jobs across clean energy technologies, including potentially 500,000–1,500,000 people working in solar by 2035.[22]

The challenge is that solar job growth will quickly outpace the labor supply, requiring investments to expand the talent pipeline by increasing access to training opportunities from workforce development stakeholders, such as labor unions, community colleges, non-profits, and other training providers.[23] DOE will need to support training opportunities for the workforce, which could include apprenticeship-based career pathways that contain solar work as part of a broad-based career path. Supporting high-quality jobs also includes advancing prevailing wage and good benefits, increasing diversity in the workforce, and ensuring workers have the option of joining a union. While the industry has made progress recently on unionization, gender, and racial diversity – for example, the union participation rate in the solar industry was 10 percent in 2020, compared to 6 percent union

[22] From the forthcoming *Solar Futures Study*, National Renewable Energy Laboratory

[23] Clean Energy Labor Supply Report, American Clean Power and BW Research Partnership

participation in the national workforce – there is still room to improve.[24] Ensuring that federal investments include strong labor standards, project labor agreements, prevailing wages, and a free and fair choice to join a union and bargain collectively may improve the quality of solar jobs.

DOE will continue working with stakeholders to identify ways to prioritize workers and communities who have been hit hardest by economic exclusion and market transformations, including former oil and gas workers. DOE also engages with union representatives, training organizations, the solar industry, and other stakeholders to identify potential paths forward where the solar energy can grow and ensure employees are centered in the clean energy future.

Conclusion

The United States is undergoing a clean energy revolution, and solar energy will play an important role in that transition. The country can build upon the success in solar innovation and growth of the past two decades. Bold investments can accelerate solar deployment nationally and, in the process, create thousands of high-quality jobs at home, expand manufacturing, and make solar more affordable for all communities. DOE will continue playing a key role in the investment in clean energy research, demonstration, deployment, and workforce development. This can position the United States to lead once again in solar energy and put us on track to meet President Biden's climate goals.

[24] 2021 U.S. Energy & Employment Jobs Report (USEER), U.S. Department of Energy

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For more information, visit: energy.gov/eere/solar

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