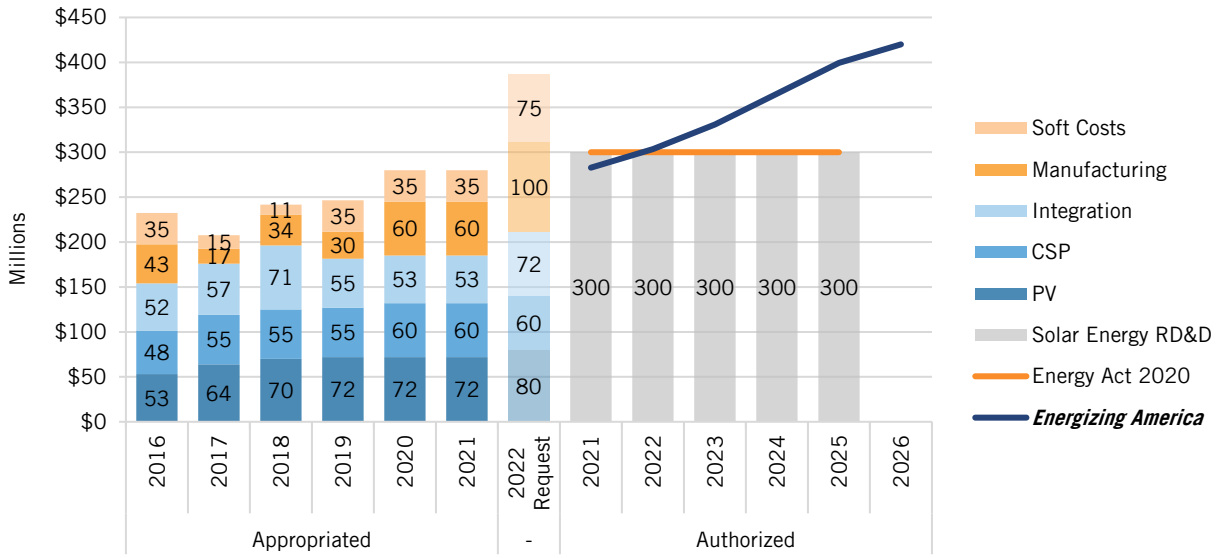
Federal Energy RD&D: Solar Energy

BY COLIN CUNLIFF AND LINH NGUYEN | JUNE 2021

The Department of Energy's (DOE) Solar Energy program embraces two complementary technologies: photovoltaics (PV), which convert light to electricity via semiconductors, and concentrating solar power (CSP), which converts light to heat in order to run a steam turbine to generate electricity—and may also be stored for electricity generation at a later time. The program also works to integrate these generation technologies more effectively into the transmission and distribution grid, and to transfer DOE solar innovations to domestic manufacturing capabilities.[1]

Figure 1: *Energizing America* recommends ramping up solar energy research, development, and demonstration (RD&D) by 50 percent by FY 2026.[2]



What's at Stake

DOE's research programs have contributed to impressive cost declines for utility-scale solar PV (82 percent) and rooftop solar PV (64 percent) in the last 10 years, making solar energy a competitive source for electricity generation in areas of the country with good solar resources and low penetration.[3] These cost declines have led to record-breaking growth: New solar installations accounted for 43 percent of all new electricity-generating capacity installed in the United States in 2020, recording the industry's largest growth even despite the economic contraction caused by the COVID-19 pandemic.[4]

In March 2021, DOE's SunShot Initiative announced an ambitious new target to drive down the costs for utility-scale solar PV by more than half, from a current cost of 4.6 cents per kilowatt-hour ($0.046/kWh) to $0.02/kWh, by 2030.[5] The initiative builds on prior success and ratchets up the ambition of the Solar Energy program. SunShot had already achieved its 2020 goal of $0.06/kWh in 2017—three years early.[6] If DOE's new cost targets for solar PV are met, solar power could grow to supply 50 percent of U.S. electricity by 2050.[7]

SunShot's 2030 goals for commercial solar ($0.04/kWh) and residential solar ($0.05/kWh) are similarly ambitious, requiring cost reductions of more than 60 percent from 2018 benchmark costs.[8] Residential- and commercial-scale solar PV costs have come down at a slower pace as "soft" costs—such as installation labor, permitting, grid interconnection, and other non-hardware costs—remain high. In the United States, the rules and regulations for how to adopt solar from 18,000 jurisdiction and 3,000 utilities act as barriers to solar adoption and inflate soft costs.[9] For residential systems installed in the United States, soft costs accounted for 63 percent of total system costs in 2018.[10] However, soft costs in Germany (15 percent) and Australia (25 percent) were substantially lower, indicating that there is significant potential to lower soft costs in the United States.[11]

The eight CSP systems operating in the United States today have demonstrated solar power's ability to provide 24-hour energy to the grid—although not yet at a competitive cost.[12] As of 2021, only two CSP developers were operating in the United States. DOE's 2030 goal for baseload CSP systems is $0.05/kWh, or almost 50 percent below the 2018 benchmark of $0.098/kWh.[13] These targets are competitive with other dispatchable power generators and would enable greater overall penetration of solar electricity into the grid, while also enabling more reliable solar generation and increasing its value to the grid.

The Energy Act of 2020 provides the first reauthorization of DOE's Solar Energy program in over a decade. The bill targets innovations in solar PV and CSP that build on DOE's past success in driving down costs and improving the performance of solar technologies. It also directs DOE to explore a range of advanced solar energy technologies, including perovskites, thin-film devices, solar heating and cooling, and integration technologies, and establishes an advanced solar energy manufacturing initiative to support the domestic solar industry as well. The bill authorizes $300 million annually for the program from FY 2021 through FY 2025.[14]

Figure 1 shows historical DOE investment in solar energy RD&D by subprogram, for FY 2016 through FY 2021, and the FY 2022 budget request. The orange line shows authorized funding levels from the Energy Act of 2020. The blue line shows recommended funding levels from the *Energizing America* report, which envisions a ramp-up in funding of 50 percent over the next five years (see box 1).

Box 1: An Innovation Agenda for Solar

The *Energizing America* report co-authored by the Information Technology and Innovation Foundation (ITIF) and Columbia University's Center on Global Energy Policy offers several recommendations to accelerate solar energy innovation. Similarly, ITIF's December 2020 report "An Innovation Agenda for Advanced Renewable Energy Technologies" makes recommendations to DOE and Congress to maximize the effectiveness of DOE's solar energy programs:

- Congress should ramp up funding for solar energy RD&D by 50 percent over the next five years to ensure DOE can address a full range of technology challenges and meet its innovation targets for solar energy.[15]

- Congress and DOE should create a new solar fuels program that both supports the direct conversion of sunlight to synthetic fuels in the applied solar energy office and builds on the basic research from the Joint Center for Artificial Photosynthesis in the Office of Science.[16]
- Congress should increase funding for DOE's soft costs team and programs that support balance-of-systems hardware, such as its work in power electronics, given the outsized impact of these expenses on total solar energy cost.[17]
- DOE should support the demonstration of microgrids and autonomous energy systems with high levels of solar penetration, such as the pilot "energy shed" management systems proposed by the Senate Appropriations Committee.[18]
- DOE should partner with the Department of Defense to develop the next generation of solar PV technologies, including low-cost and scalable manufacturing technologies.[19]

Solar Energy RD&D Subprograms

RD&D in the Solar Energy program is spread across five subprograms:[20]

- **Photovoltaics** funds RD&D to enable improved PV performance, including advanced silicon processes, multijunction solar-cell efficiency, advanced materials science for cadmium-telluride solar cells, hybrid organic-inorganic perovskites, multicrystalline and tandem device models, and impacts of outdoor soiling, temperature cycling, ultraviolet light, and humidity.
- **Concentrating Solar Power** focuses on component-level RD&D in solar collectors, receivers, heat-transfer fluids, power conversion, and thermal-energy storage, as well as on the integration of subcomponents.
- **Systems Integration** coordinates with the DOE Grid Modernization Initiative to address key grid-integration challenges, including generation variability, voltage control, frequency regulation, system stability, and cybersecurity.
- **Balance-of-Systems Soft-Cost Reduction** focuses on reducing non-hardware costs—including financing, customer acquisition, permitting, installation, labor, and inspection—which constitute over half the costs of total system prices for residential, commercial, and community PV systems.
- **Manufacturing and Competitiveness** funds the development and demonstration of innovative solar manufacturing technologies in order to increase U.S. competitiveness in solar energy manufacturing.

Key Elements of the FY 2022 Budget Proposal[21]

The budget proposal seeks $386.58 million for the Solar Energy program, a 38 percent boost from FY 2021 enacted levels. Some highlights include:

- **A 115 percent increase in the Balance of Systems Soft Cost Reduction subprogram.** Soft costs are the non-hardware costs of installing solar projects, including permitting, inspection, and financing. Soft costs accounted for 64 percent of total system costs of residential PV

systems, 55 percent of commercial PV systems, and 35 percent of utility-scale systems in 2020.[22] Reaching DOE's solar cost targets will require significant reductions in soft costs.

- **A 67 percent increase in the Manufacturing and Competitiveness subprogram,** including an additional round of funding for the American-Made solar prize competition to seed new solar technologies, and a $35.9 million boost in funding for solar manufacturing and value-chain RD&D. The United States' share of global solar PV manufacturing is very small even though tariffs have been imposed on imports on multiple occasions.
- **A 35 percent increase in the Systems Integration subprogram,** with increased funding in solar microgrids and hybrid systems that integrate solar with other technologies.
- **An 11 percent increase in the Photovoltaic Technologies subprogram,** including funding for research in thin-film PV materials such as cadmium telluride and perovskites, which might allow the industry to break away from the dominant crystalline-silicon technology, and for projects that improve the durability of balance of systems components (i.e. inverters).
- **No significant change in funding for the Concentrating Solar Power subprogram.** Industrial applications RD&D will receive a small increase in funding to support the development of novel solar technologies to produce ammonia and hydrogen.

Further Reading

- Varun Sivaram et al., *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University SIPA Center on Global Energy Policy, 2020), http://www2.itif.org/2020-energizing-america.pdf.
- Robert Rozansky, "An Innovation Agenda for Advanced Renewable Energy Technologies" (ITIF, 2020), http://www2.itif.org/2020-advanced-renewables-energy.pdf.
- Dorothy Robyn and Jeffrey Marqusee, "The Clean Energy Dividend: Military Investment in Energy Technology and What It Means for Civilian Energy Innovation," (ITIF, 2019), http://www2.itif.org/2019-clean-energy-dividend.pdf.

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About the Authors

Colin Cunliff is a senior policy analyst for clean energy innovation with ITIF. He previously worked at the U.S. Department of Energy on energy sector resilience and emissions mitigation. He holds a Ph.D. in physics from the University of California, Davis.

Linh Nguyen is a research assistant for clean energy innovation with ITIF. She previously worked for Climate Advisers and Resource Energy. Linh holds a master's degree in energy policy from Johns Hopkins University.

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ENDNOTES

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7. DOE, "The SunShot 2030 Goals" (August 2017), 5, https://www.energy.gov/sites/prod/files/2020/09/f79/SunShot%202030%20White%20Paper.pdf.

8. All PV cost targets are nationwide-average, unsubsidized costs. The 2018 benchmarks for utility-scale, commercial, and residential PV are $0.05/kWh, $0.11/kWh, and $0.15/kWh, respectively. DOE, FY 2021 Congressional Budget Justification Volume 3 Part 1, 92.
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