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Office of Energy Efficiency and Renewable Energy

U.S. Department of Energy

Before the

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Good afternoon Chairman Weber, Ranking Member Veasey, and members of the Committee. Thank you for inviting the Department of Energy to testify. My name is Daniel Simmons, and I am the Principal Deputy Assistant Secretary for Energy Efficiency and Renewable Energy (EERE) at the U.S. Department of Energy. Solar energy technologies are an important source of electricity for our nation and I thank you for the opportunity to discuss our research to advance solar technologies.

Industry overview

Ten years ago, the solar market looked very different. There were only 1.1 gigawatts installed in the United States, representing less than 0.01% of the nation's energy mix. Now, there are nearly 50 gigawatts[1] installed, providing nearly 2% of U.S. electricity in the first nine months of 2017,[2] and growing quickly. Over 80% of solar ever installed was installed *in the last five years*, and in the next five years, it is projected to *triple*.[3]

In the first half of 2017, 25% of all new electricity capacity installed came from solar[4] and those systems are being deployed all across the United States. While California leads the country in solar installations, 14% of all domestic installations in the first 9 months of 2017 were located in Texas and another 13% in North Carolina.[5]

Over the past ten years, solar costs have declined dramatically. Earlier this year, the Solar Energy Technology Office announced that the industry met the utility-scale cost goal of 6 cents per kilowatt hour three years early. That's measured without including incentives and with an average amount of sunshine.[6] Globally, in sunny locations, such as Arizona and Mexico, we are already seeing solar installations being delivered at even lower cost.

[1] Capacity total converted to DC using EIA, Electric Power Monthly.
[2] Measured in the first nine months of 2017. EIA, Electric Power Monthly, Table 1.17.b
[3] SEIA/GTM, Solar Market Insight Report
[4] 2016: EIA, "Electric Power Monthly" Table 6.1; 2017 (solar): EIA, "Electric Power Monthly" Table 6.1A; 2017 (remainder): FERC, "Energy Infrastructure Update."
[5] 2016: EIA, "Electric Power Monthly" Table 6.2b; August/Feb 2017
[6] Kansas City was used as an average sunlight measure for this goal.

The importance of early stage research and development

While there are many reasons why solar prices have declined and installations have risen, federal research and development (R&D) certainly plays a role. This Administration is committed to developing a wide range of energy resources through R&D, and believes that federal funding should prioritize basic and early-stage applied research. As stated in the joint Office of Management and Budget and Office of Science and Technology policy memorandum to the heads of executive departments and agencies, M-17-30, the following are R&D priority areas for FY 2019 Budget formulation:[7]

> American Prosperity
> American leadership in science and technology is critical to achieving this Administration's higher priorities: national security, economic growth, and job creation. American ingenuity combined with free-market capitalism have driven, and will continue to drive, tremendous technological breakthroughs. American inventions have fundamentally changed the course of human history: the incandescent light bulb, the airplane, satellite navigation, and the internet have improved the lives of millions of Americans and billions around the world. In spurring future advances, Federal funding of research and development (R&D) programs and research infrastructure can play a crucial role.
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> American Energy Dominance
> A consistent, long-term supply of lower-cost American energy will provide security through energy independence and help create a stable supply of high-paying jobs, while lower prices for electricity and fuel will spur American prosperity. Development of domestic energy sources should be the basis for a clean energy portfolio composed of fossil, nuclear, and renewable energy sources. Agencies should invest in early-stage, innovative technologies that show promise in harnessing American energy resources safely and efficiently. As proposed in the President's FY 2018 budget, federally-funded energy R&D should continue to reflect an increased reliance on the private sector to fund later-stage research development, and commercialization energy technologies.
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> Supporting Innovative Early-Stage Research
> Basic and early-stage applied research are critical components of the American research enterprise and the basis of new technological development and commercialization. However, in the development of high-payoff technology, early-stage research often involves greater uncertainty and may not provide the economic incentive needed to attract private sector investment. Therefore, agencies should give priority to funding basic and early-stage applied research that, supplemented by private sector financing of later-stage R&D, can result in the development of transformative commercial products and services. Strong partnerships with the private sector will be critical to maximizing the efficacy of Federal funding. Furthermore, agencies should take advantage of innovation from the private sector, where possible, to adapt to Federal needs, rather than re-inventing solutions in parallel.

Expanded mission for solar R&D

EERE is dedicated to making energy more affordable and reliable through early-stage applied research in three broad areas: energy efficiency, renewable power, and sustainable transportation. Within the

[7] https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/m-17-30.pdf

renewable power area, EERE's Solar Energy Technologies Office (SETO) focuses primarily on reducing the cost of various solar technologies, including photovoltaic and concentrating solar thermal power.

The dramatic cost reductions in solar technology provide an opportunity for the Administration to re-focus SETO's research on a longer-term challenge: grid integration. In the long term, the primary challenge facing solar is not cost, but reliability. While lower prices have helped drive new capacity installations, more work is needed to make solar a reliable, on-demand energy resource.

Solar has dramatically grown over the past decade, but adding large amounts of solar to the grid presents grid reliability challenges. To explain these challenges, it is important to note how electricity is used throughout the day. Consumers use the least amount of electricity at night, when they are asleep. Demand starts rising as people wake and generally peaks in the afternoon and early evening before tapering off. Utilities balance this relatively predictable demand profile by ramping up and ramping down power plants to balance supply with demand.

Photovoltaic solar helps meet demand when the sun is up, but obviously when the sun sets, production stops. This means that on-demand sources of electricity generation are required to ramp up quickly to meet early evening demand. While mainstream awareness of these challenges is emerging, SETO is refocusing its efforts on utility demand and grid forecasting strategies.

This year, DOE has approved over $100 million in financial assistance to advance our new early-stage research priorities around solar reliability. Examples include:

- **Concentrated Solar Power (CSP):** Up to $62 million will support advances in CSP technologies to enable on-demand solar energy. CSP technologies use mirrors to reflect and concentrate sunlight onto a focused point where it is collected and converted into heat. This thermal energy can be stored and used to produce electricity when the sun is not shining or integrated into other applications, such as producing fresh water or supplying process heat.[8]
- **Power Electronics:** Up to $20 million is dedicated to early-stage projects to advance power electronics technologies. Such innovations are fundamental to solar PV as the critical link between PV arrays and the electric grid. Advances in power electronics will help grid operators rapidly detect problems and respond, protect against physical and cyber vulnerabilities, and enable consumers to manage electricity use.[9]
- **Solar Forecasting:** The Solar Forecasting 2 funding program builds on the Improving Solar Forecasting Accuracy funding program to support projects that generate tools and knowledge to better predict solar power generation. These projects will improve the ability to manage the variability of solar power, and will enable more reliable and cost-effective integration of solar power onto the grid. This funding program supports the Energy Department's broader Grid Modernization Initiative, a crosscutting effort that helps to better integrate all sources of electricity, improve the security of our nation's grid, solve challenges of energy storage and

[8] Energy Department, "Energy Department Announces Achievement of SunShot Goal, New Focus for Solar Energy Office," September 12, 2017.
[9] Energy Department, "Energy Department Announces Achievement of SunShot Goal, New Focus for Solar Energy Office," September 12, 2017.

distributed generation, and provide a critical platform for U.S. competitiveness and innovation in a global energy economy.[10]

Each of these research areas will help make it easier to integrate solar energy into the electric grid. In addition to this work, EERE works with the Office of Electricity Delivery and Energy Reliability (OE) through DOE's Grid Modernization Initiative. For example, researchers at Lawrence Livermore National Lab, funded by EERE and OE through the Grid Modernization Laboratory Consortium, are researching PV plus storage. Energy storage allows variable sources of energy, such as solar, to be used when it's needed.

This DOE-funded research aims to show that distributed solar PV and storage can help communities recover quickly from a major disaster like an earthquake, hurricane or flood. Currently, once electricity is lost, restarting the grid is performed manually using special generators. It's an extremely slow process that does not account for electricity that could be generated by distributed sources. Using "agile islanding"—forming microgrids around local solar customers—solar electricity can help to restart local power supplies and jumpstart critical grid functions. This project is one of seven Resilient Distribution Systems projects announced earlier[11] this year with up to $32 million in early-stage R&D funding for DOE national laboratories.

While DOE is focusing its solar R&D on reliability issues, the Department will continue work to reduce costs. Photovoltaic technologies have made major advances in recent years, but there is still potential to improve photovoltaic performance and lower cost. A typical commercial photovoltaic system that you would install on your roof converts about 16% of the light that strikes it into electricity. Increasing the amount of energy generated by that same system is a win-win—you get more energy without having to install more solar panels.

One innovation being developed by the National Renewable Energy Laboratory uses different materials within a single solar cell that are tailored to capture more of the light spectrum. These researchers designed and fabricated a four junction solar cell that set a world record of 45.7% conversion efficiency, and they are now aiming to continue their world leadership and hit 50% efficiency.

What the Future Holds

Making solar available when energy is needed is the most critical challenge for the solar industry. The new foundation for DOE's solar R&D is on these critical energy challenges of grid reliability, resilience, and integration. EERE will continue to focus on early-stage research and development to advance solar technologies, while forging strong partnerships with the private sector to maximize the impact of federal funding.

Thank you for the opportunity to testify today, and I look forward to answering your questions.

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[10] Energy Department, "Energy Department Announces More than 90% Achievement of 2020 SunShot Goal, Sets Sights on 2030 Affordability Targets," November 14, 2016.

[11] Energy Department, "Energy Department Invests Up to $50 Million to Improve the Resilience and Security of the Nation's Critical Energy Infrastructure," September 12, 2017.