SunShot U.S. Department of Energy

THE SUNSHOT INITIATIVE

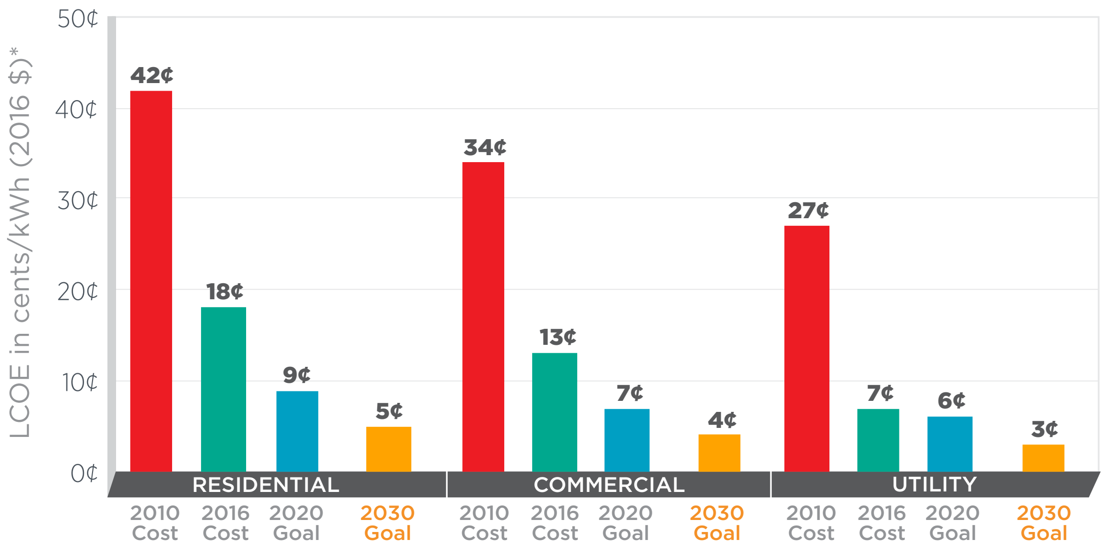
The SunShot Initiative's 2030 Goal: 3¢ per Kilowatt Hour for Solar Electricity

New Solar Opportunities for a New Decade

In 2011, when solar power comprised less than 0.1% of the U.S. electricity supply, the U.S. Department of Energy (DOE) launched the SunShot Initiative with the goal of making solar electricity cost-competitive with traditionally generated electricity by 2020 without subsidies. At the time, this meant reducing photovoltaic (PV) and concentrating solar power (CSP) prices by approximately 75% across the residential, commercial, and utility-scale sectors. For utility-scale solar, this target is a levelized cost of energy (LCOE) of 6¢ per kilowatt hour (kWh)[1]. Rapid progress has been made in accelerating achievement of these cost reductions, and DOE's Solar Energy Technologies Office (SETO) sees clear pathways to meeting the SunShot 2020 cost targets on schedule.[2]

Enabled by the cost reductions to date, solar-generated electricity has become mainstream. In 2014 and 2015, solar represented about one-third of new electrical generating capacity installed in the United States Halfway through 2016, solar was supplying 1% of U.S. electricity demand and growing with an installed capacity of 30 gigawatts.

SunShot's 2030 Goals



*LCOE progress and targets are calculated based on average U.S. climate and without the ITC or state/local incentives. Utility-scale PV uses one-axis tracking.

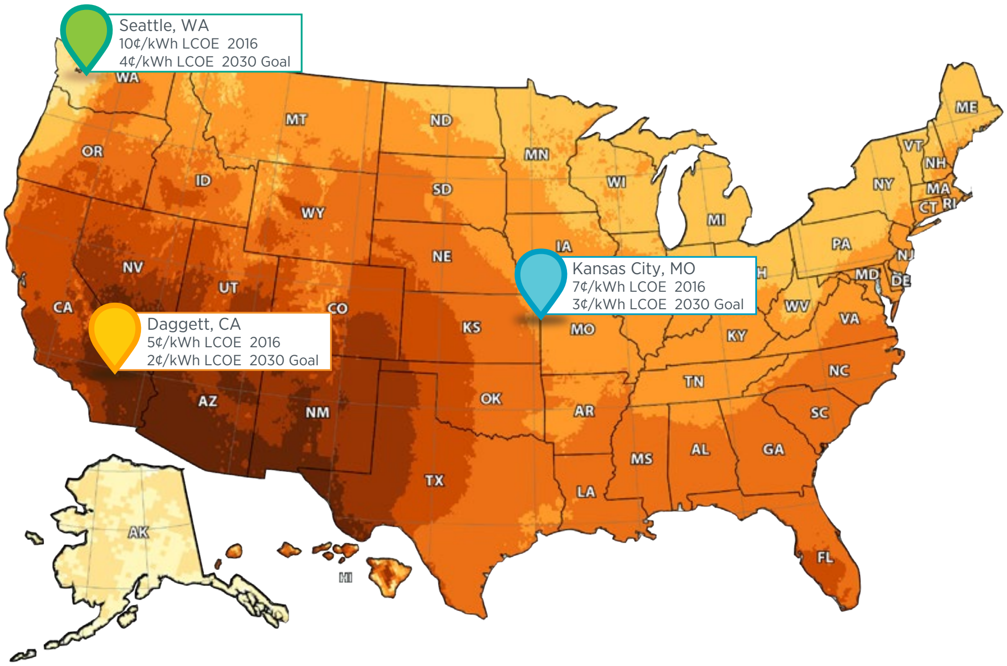
Figure 1. LCOE values and SunShot goals for the residential, commercial and utility-scale sectors.

In recognition of the transformative solar progress to date and the potential for further innovation, the SunShot Initiative is extending its goals to reduce the average unsubsidized levelized cost of energy (LCOE) of utility-scale PV to 3¢/kWh by 2030, while enabling greater adoption by addressing grid integration challenges and market barriers.[3] In parallel, SunShot is targeting concurrent reductions for commercial and residential rooftop PV costs to 4¢/kWh and 5¢/kWh by 2030, respectively. Achieving this goal is expected to more than double the projected amount of electricity demand met by solar compared to the 2020 goal alone, further supporting national goals of energy security, low cost electricity, and environmental stewardship.

[1] The LCOE target is for an area with average climate and without the investment tax credit (ITC) or state or local incentives. For commercial and residential-scale solar, the 2020 targets are 7¢/kWh and 9¢/kWh, respectively.

[2] LCOE values for utility-scale, commercial and residential solar are 7¢/kWh, 13¢/kWh and 18¢/kWh, respectively, in 2016.

[3] Concentrated Solar Power (CSP) systems that incorporate thermal energy storage have a higher LCOE target to reflect the increased value that thermal energy storage provides to the grid. CSP systems in 2030 are envisioned to be dispatchable, intermediate load power plants that enable greater overall penetration of solar electricity on the grid.



Solar Resource Across America

kWh/m²/Day: > 6.5; 6.0 to 6.5; 5.5 to 6.0; 5.0 to 5.5; 4.5 to 5.0; 4.0 to 4.5; 3.5 to 4.0; 3.0 to 3.5; < 3.0

Daggett, CA - **High**
Kansas City, MO - **Average**
Seattle, WA - **Low**

The amount of power that is produced by a PV system depends upon the solar resource availability (in addition to other factors like temperature and snowfall), which is location dependent. The median solar resource for the United States is represented by Kansas City, MO, while the highest solar resource is represented by Daggett, CA, and the lowest solar resource is represented by Seattle, WA.

Figure 2. Solar resource across America, showing 2016 LCOE values and 2030 targets for three cities representing average (Kansas City), high (Daggett) and low (Seattle) solar resource.

The SunShot 2030 LCOE targets are defined for an area having average U.S. climate. For utility-scale solar, 3¢/kWh translates to 2-4¢/kWh across the continental United States due to differences between locations in the amount of sunlight and in temperature, snowfall and wind speed. Figure 2 illustrates the differences in solar resource across the country, showing the SunShot 2030 LCOE targets for areas of high, moderate, and low solar resource exemplified by Daggett, CA, Kansas City, MO, and Seattle, WA. At these costs, electricity from utility-scale solar would be among the least expensive options for new power, and it would be below even the variable cost of most existing electricity generators. Commercial and residential rooftop PV applications would also be highly competitive within their respective markets.

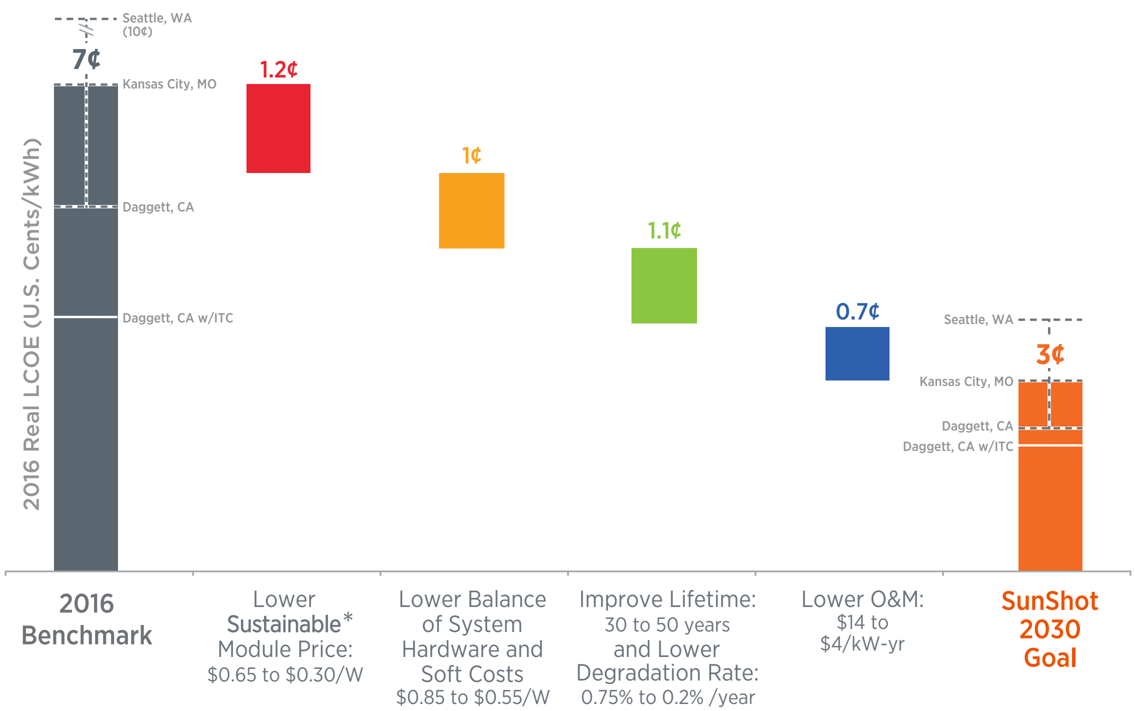


Figure 3. Example modeled pathway toward 3¢/kWh for utility-scale systems.
100 MWDC, one-axis tracking systems with 1,860 kWhAC/kWDC. Includes five-year MACRS, 7% cost of capital and 2.5% inflation.
*The price at which the supply chain recovers the cost of capital.

Although these targets are aggressive, there are multiple realistic pathways toward achieving them; Figure 3 shows one potential route. All pathways require significant improvements in module price and efficiency, non-module hardware and soft costs, system reliability, and operations and maintenance (O&M) costs. Reductions in the cost of capital can also be a major lever. However, the interdependencies and tradeoffs among cost- and performance-improvement factors create numerous technology options. Figure 4 illustrates the multiple pathways for module technology enabled by tradeoffs between module cost, efficiency and reliability. Among all the possibilities, one common theme emerges—the need for sustained, multifaceted innovation.

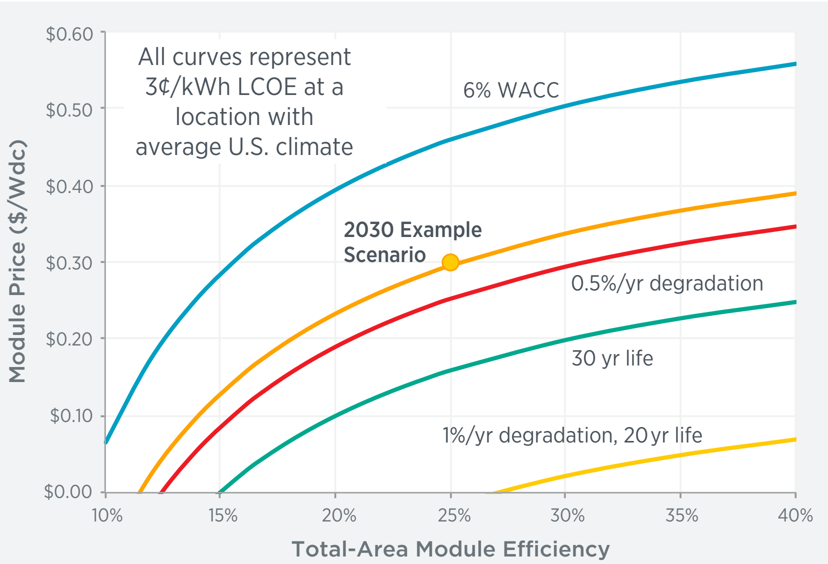


Figure 4. Curves illustrating numerous module technology pathways to reach the SunShot 2030 utility-scale goal. Every point on each curve corresponds to a 3¢/kWh LCOE. Unless otherwise noted, all scenarios assume one-axis tracking systems with 1,860 kWh(AC)/kW(DC), five-year MACRS, 7% weighted average cost of capital (WACC), 2.5% inflation, $0.85/W system cost, $4/kW-year O&M, 0.2%/year degradation and a 50-year system lifetime.

Solar Synergy

The discussion above focuses on solar technology advancements alone. However, parallel advancements in other aspects of the electricity system could significantly increase the potential of solar—and enable the broader development of the entire future clean energy system—while providing added value to electricity consumers and producers.

Combining lower cost storage as well as grid-integration approaches enabled by the emergence of the smart grid—such as enhanced grid flexibility, enhanced communications and controls to enable two-way power flow, increased demand response, and optimized charging of electric vehicles (EVs)—could enable much greater levels of solar deployment, while also facilitating greater deployment of other variable-generation renewable sources. An electricity system with such flexibility, which is a focus of the Department's Grid Modernization Initiative, could accommodate and enhance high penetration of EVs, hydrogen fuel cell vehicles, and a myriad of other complementary technologies. Rooftop PV, along with complementary technologies, have the potential to transform distributed power systems, providing customers with increased value, more choices, greater grid reliability, and lower cost. As an example of the potential for solar coupled with complementary advancements, recent models suggest that achieving the 2030 goals along with low cost storage could enable solar to supply nearly 50% of U.S. electricity by 2050.[4]

In addition to innovation on the technology and integration fronts, potential market barriers need to be addressed to enable greater solar adoption. Here SunShot will focus on streamlining processes to reduce project time cycles, expanding access to solar, and accurately representing solar's value in a more integrated energy system.

While the actual fraction of U.S. electricity needs that will be supplied by solar depends on many factors, including the progress of other energy technologies and evolving electricity demand, it is clear that the ambitious SunShot 2030 goal will unlock a great potential for solar power throughout the nation.

[4] Modeling by the National Renewable Energy Laboratory using the Regional Energy Deployment System version 2016 with default assumptions from the 2016 Annual Energy Outlook and the Annual Technology Baseline except for solar and storage costs.

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Energy Efficiency & Renewable Energy

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