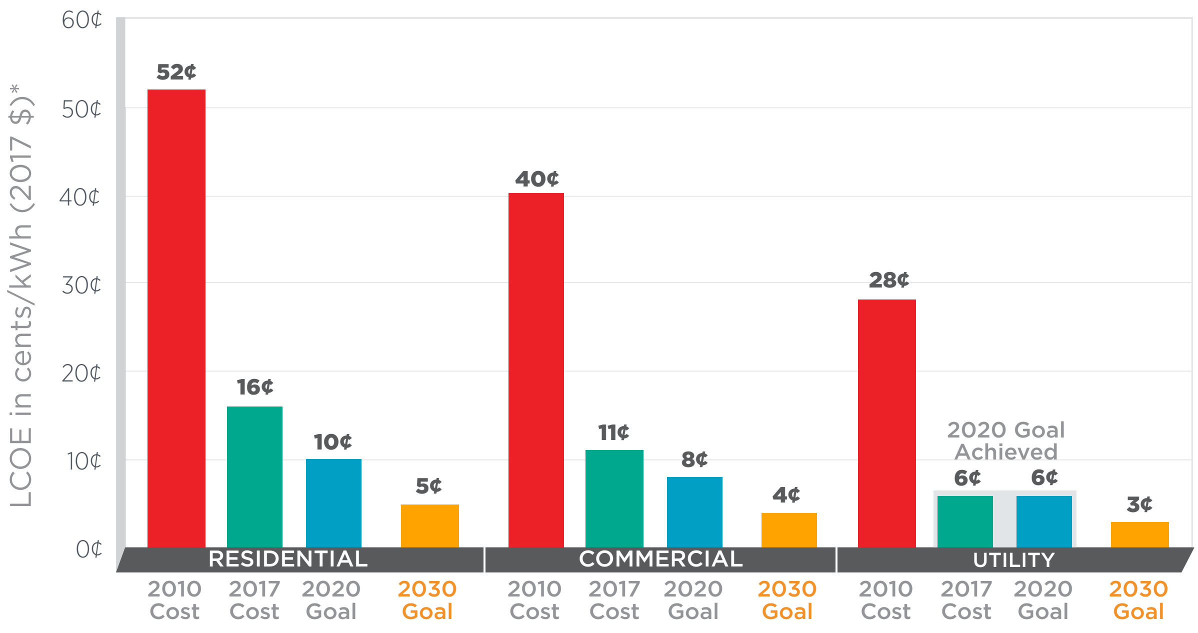
The SunShot 2030 Goals:
3¢ per Kilowatt Hour for PV and 5¢ per Killowatt Hour for Dispatchable CSP

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 market-competitive with fuel-based electricity by 2020 without subsidies. At the time, this meant reducing photovoltaic (PV) and concentrating solar thermal power (CSP) prices by approximately 75% across the residential, commercial, and utility-scale sectors. In 2017, DOE's Solar Energy Technologies Office (SETO) announced that the industry had achieved the 2020 cost goal for utility-scale solar of 6¢ per kilowatt hour (kWh)[1]. Rapid progress has been made in accelerating achievement of these cost reductions, and SETO sees clear pathways to meeting the remaining 2020 PV 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 2030 Goals



*Levelized cost of electricity (LCOE) progress and targets are calculated based on average U.S. climate and without the ITC or state/local incentives. The residential and commercial goals have been adjusted for inflation from 2010–17.

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

[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.

In recognition of the transformative solar progress to date and the potential for further innovation, the solar office 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. In parallel, SETO is targeting concurrent reductions for commercial and residential rooftop PV costs to 4¢/kWh and 5¢/kWh by 2030, respectively.

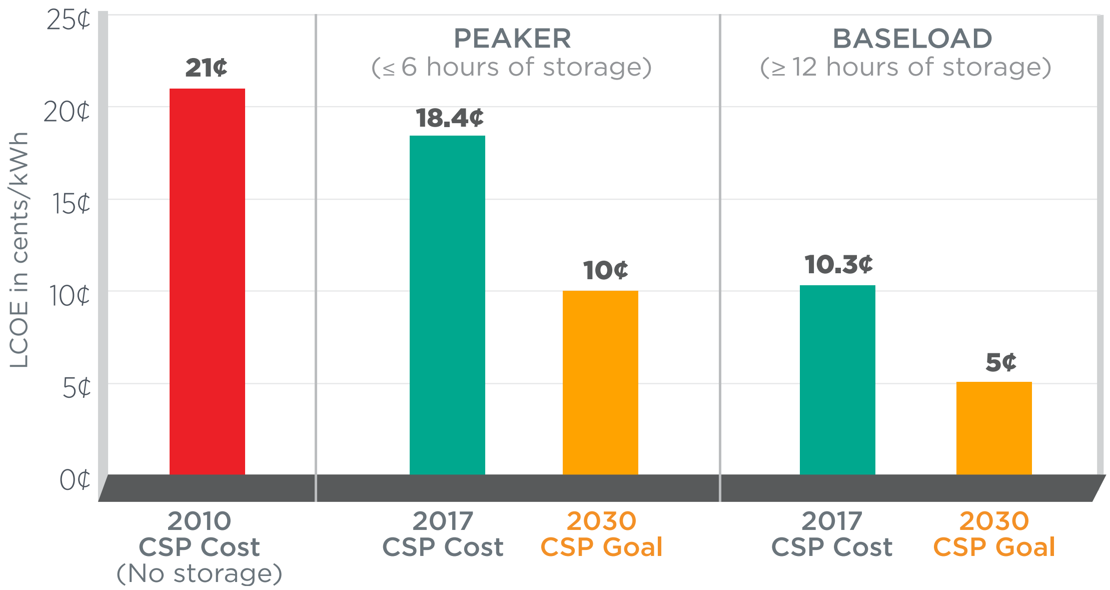


Figure 2. LCOE values and CSP SunShot Goals for baseload and peaker configurations.

CSP with thermal energy storage directly addresses grid integration challenges with the incorporation of thermal energy storage that allows the solar-generated heat to be stored until it is needed, even well after the sun sets. Reflecting this increased value of dispatchable solar, the SunShot 2030 targets are 5¢/kWh for baseload CSP (with ≥ 12 hours of storage) and 10¢/kWh for a peaker configuration (≤ 6 hours of storage) that would be designed to deliver electricity only when it is most highly valued by grid operators.

Achieving these goals 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.

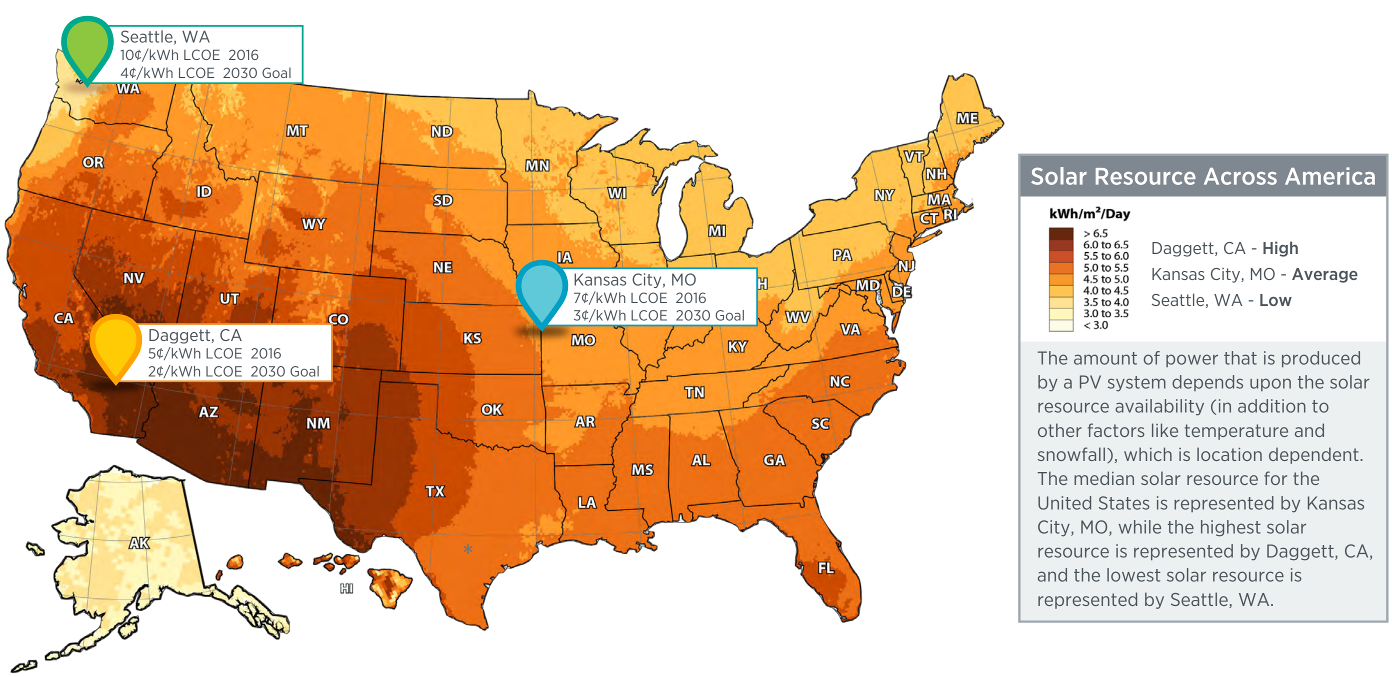


Figure 3. Solar resource across America, showing 2016 LCOE values and 2030 targets for three cities representing average (Kansas City), high (Daggett) and low (Seattle) solar resource.

The SunShot 2030 PV LCOE targets are defined for an area having average U.S. climate. For utility-scale PV, 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, snow loading and wind speed. Figure 3 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 PV would be among the least expensive options for new power, and it would be below even the variable cost of most existing electricity generators. The CSP targets would be highly competitive with other dispatchable power generators and would enable greater overall penetration of solar electricity on the grid. Commercial and residential rooftop PV applications would also be highly competitive within their respective markets.

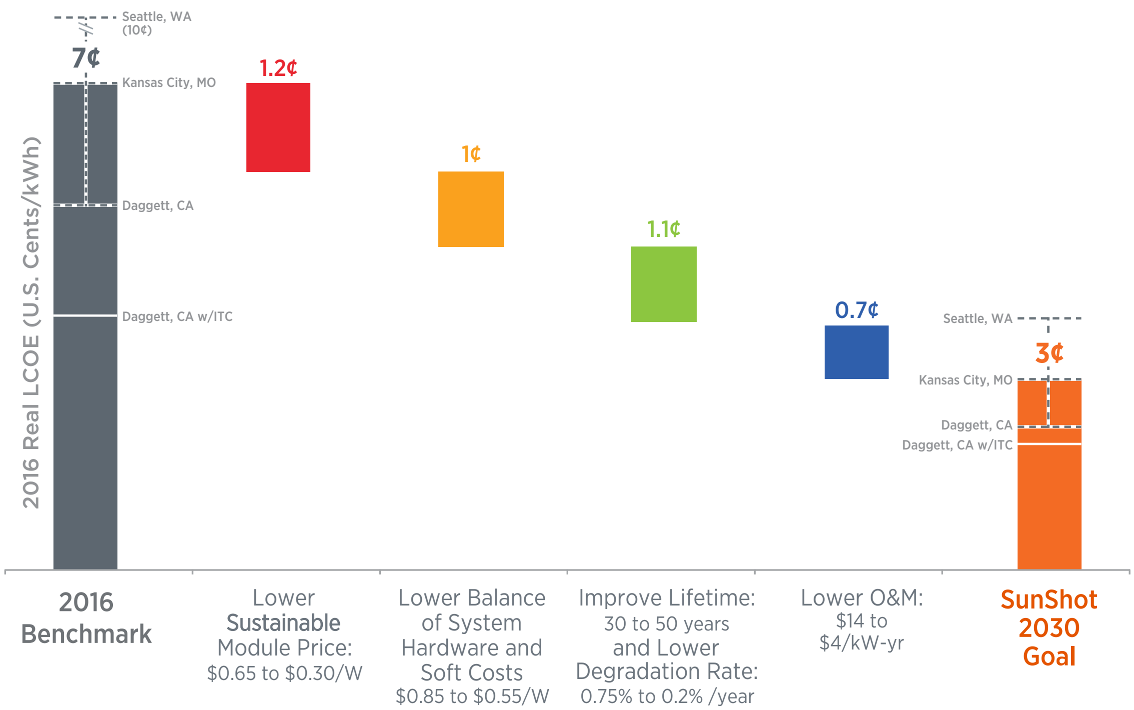


Figure 4. Example modeled pathway toward 3¢/kWh for utility-scale systems.
100 MWDC, one-axis tracking systems with 1,860 kWhAC/kWDC. Includes five-year MACRS, 7% cost of capital and 2.5% inflation.
*The price at which the supply chain recovers the cost of capital.

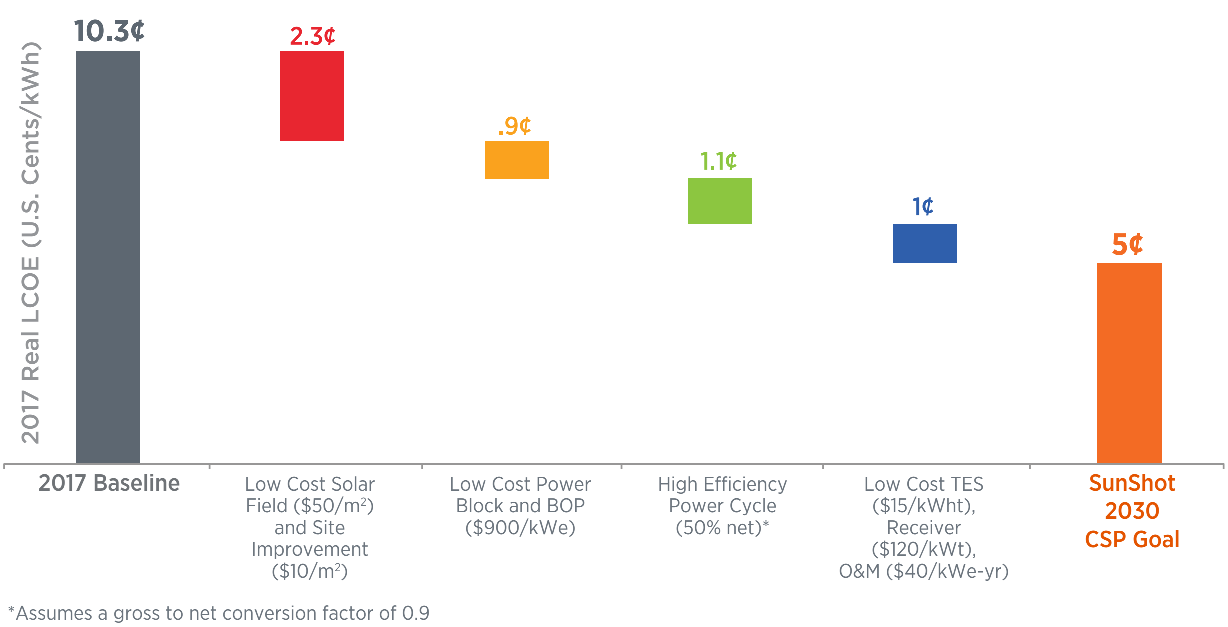


Figure 5. Example modeled pathway toward 5¢/kWh for baseload CSP.

Although these targets are aggressive, there are multiple realistic pathways toward achieving them; Figures 4 and 5 show potential routes for PV and CSP systems. All pathways require significant improvements in the categories shown, but greater progress in one can allow for smaller reductions in others. 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 6 illustrates the multiple pathways for PV module technology enabled by tradeoffs between module cost, efficiency and reliability. For CSP, there are numerous component capital costs and performance parameters to consider. Figure 7, below, illustrates the tradeoffs that are available at different sub-system costs, as a function of the major capital cost (installed solar field cost) and the major performance metric (gross power cycle efficiency). Among all the possibilities for PV and CSP technologies, one common theme emerges—the need for sustained, multifaceted innovation.

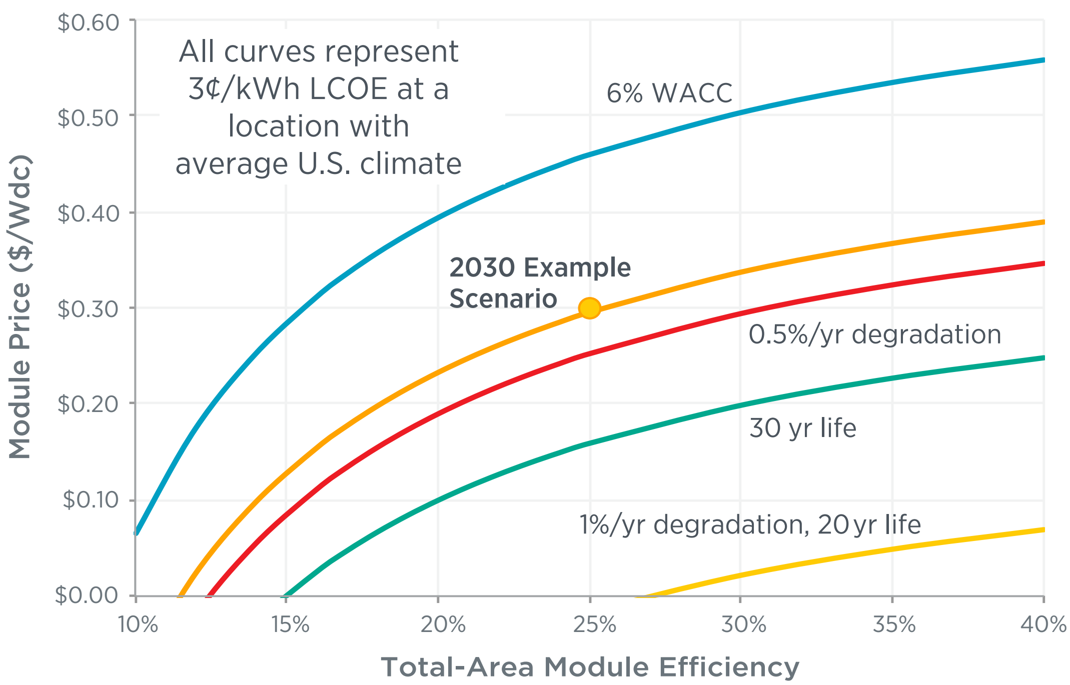


Figure 6. Curves illustrating numerous module technology pathways to reach the SunShot 2030 utility-scale PV goal. Every point on each curve corresponds to a 3¢/kWh LCOE. Unless otherwise noted, all scenarios assume one-axis tracking systems with 1,860 kWh(AC)/kW(DC), five-year MACRS, 7% weighted average 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.

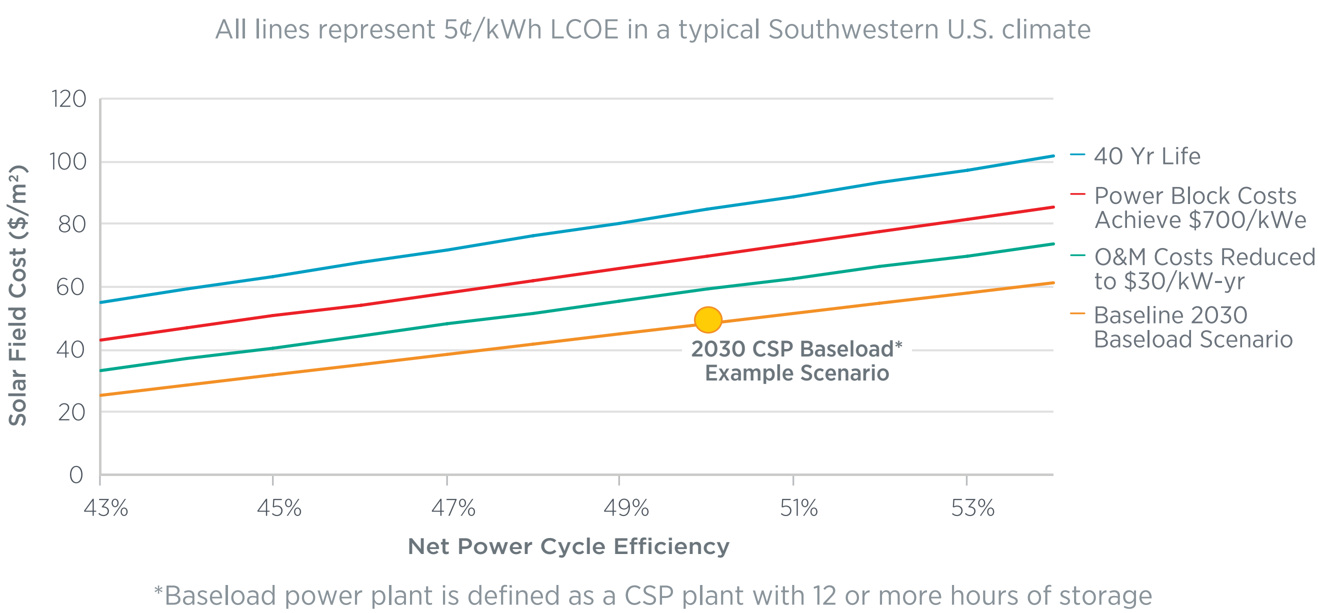


Figure 7. Curves illustrating numerous sub-system costs to reach the SunShot 2030 baseload CSP goal.

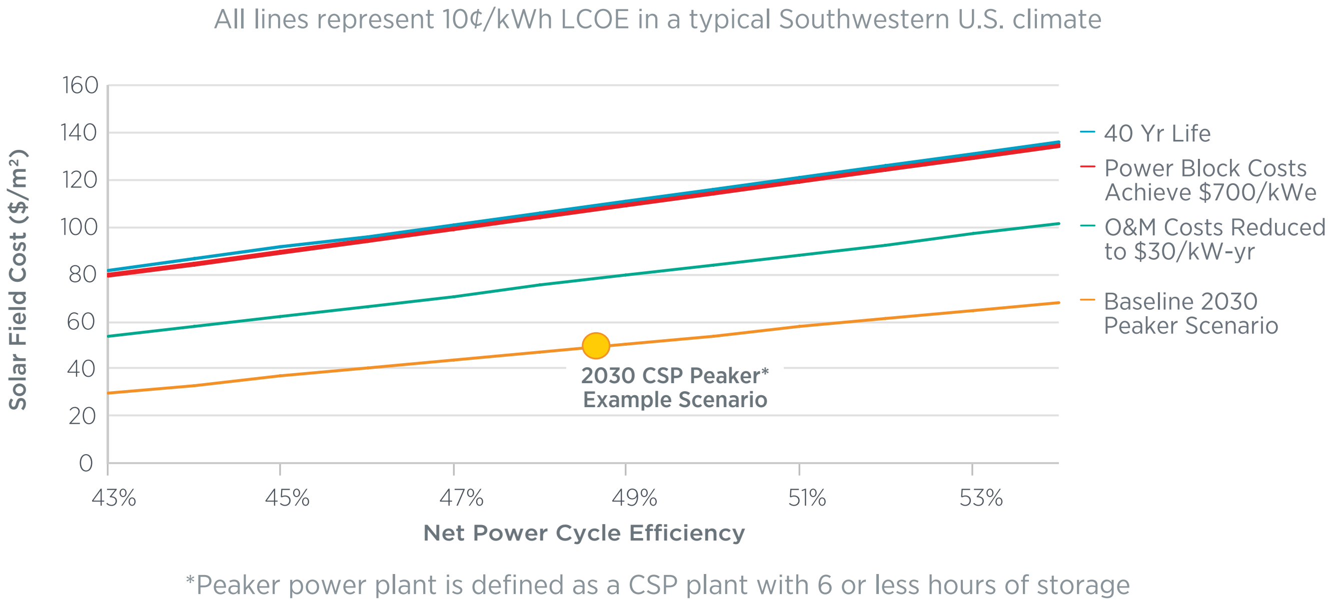


Figure 8. Curves illustrating numerous sub-system costs to reach the SunShot 2030 peaker CSP goal.

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 (especially PV)—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 with PV, 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 PV 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 50% of U.S. electricity by 2050.[3]

In addition to innovation on the technology and integration fronts, potential market barriers need to be addressed to enable greater solar adoption. Here SETO 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 goals will unlock a great potential for solar power throughout the nation.

[3] 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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