SUNSHOT 2030 FOR CONCENTRATING SOLAR POWER (CSP): EVOLVING ECONOMICS OF CSP TECHNOLOGY

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Overview

Concentrating Solar Power (CSP) with thermal energy storage (TES) is a dispatchable renewable technology. Unlike photovoltaic (PV) systems and other variable renewable technologies, CSP-TES plants capture and store solar energy in the form of heat and generate electricity through a turbine, which makes CSP-TES a synchronous generator that provides inertia to the system. In turn, CSP-TES is able to provide grid stability, flexibility and reliability benefits.

In 2017, the U.S. Department of Energy (DOE) announced a new “SunShot” cost target of 5 cents/kWh by 2030 for CSP-TES systems. This work builds off of previous analysis that considered the impact of achieving the DOE SunShot targets for PV (Cole et al. 2017) by modeling the impacts of how the power system would evolve if the CSP-TES cost targets were also achieved. Specifically, we analyze a SunShot cost target scenario (for both PV and CSP) in comparison with a baseline scenario assuming more-modest solar cost reductions. With the SunShot solar cost assumptions, we project and explore the evolution of the U.S. electricity system using the Regional Energy Deployment System (ReEDS) capacity expansion model, including capacity expansion, generation mix, CSP deployment, electricity price and system cost, transmission expansion, emissions, and other impacts with detailed geographic resolution. We also analyze the sensitivity of the SunShot cost scenario to various market assumptions, and evaluate the impacts of natural gas prices and the relative competitiveness of CSP-TES to variable renewable energy with storage options, such as grid-tied batteries. This work helps provide a better understanding on the broader impacts of the SunShot target, the technical and economic potential of CSP technology, and economic competitiveness of CSP under different market conditions.

Methods

This study utilizes the National Renewable Energy Laboratory (NREL) ReEDS model, a linear optimization model which determines the capacity expansion of both traditional and renewable technologies from present to 2050 (Eurek et al. 2016). ReEDS models 134 balancing areas (BAs) for the contiguous United States, and has 356 resource regions to provide detailed spatial granularity in the representation of renewable resources.

The primary focus of this ReEDS analysis is on CSP-TES systems in a tower-based configuration with molten salt as the heat transfer and a thermal storage media. ReEDS uses a supply curve formulation to represent the technical potential of CSP resources and the incremental cost for the plants to connect the site to load, which allows the model to assess trade-offs between site resource quality and grid connection cost. In this study, we use an updated version of solar resource data from National Solar Radiation Database (NSRDB version PSM 3), and assign CSP resource groups by annual average direct normal irradiance (DNI) data collected from geostationary satellites. With new resource assessment technique, the database indicates a broader geography of acceptable DNI resources (>5 kWh/m^2/day) for CSP deployment than previous versions.

In this study, we analyze a SunShot scenario in comparison to a baseline scenario. The SunShot scenario assumes that DOE’s 2030 LCOE targets are achieved for all solar technologies, including residential, commercial and utility-scale PV systems and CSP technology, and that costs continue to decline after 2030. More specifically, PV cost targets and projections follow Cole et al. 2017, and CSP LCOE reaches $0.05/kWh target in 2030 with an additional 20% reduction by 2050. The baseline scenario assumes the NREL Annual Technology Baseline (ATB 2017) mid-case PV and CSP costs.

In addition to the core scenario, we also examine the sensitivity of the SunShot scenario to various market assumptions, including natural gas prices and battery storage costs. Other sensitivity scenarios include electricity demand growth, conventional generator retirements, non-solar renewable technology costs, and alternative post-2030 CSP cost reductions.

Results

Several key projected impacts of achieving the SunShot scenario include:

First, achieving the SunShot CSP cost target, together with the PV target, makes CSP much more economically competitive as a generation technology, especially in areas that are close to high-demand centers. Although 2050 CSP penetration is sensitive to the post-2030 cost reduction assumption, cumulative installed CSP capacity increases by one-to-two orders of magnitude relative to today's deployment levels.

Second, using the latest version of NSRDB solar resource data leads to a broader geography of acceptable DNI solar resources, and therefore more developable sites for CSP-TES in the Southeast and Midwest of the United States. When combined with aggressive cost reductions for CSP-TES, this expanded available DNI solar resource indicates a need for more detailed analysis of plant configurations and developable sites for CSP-TES in new regions of the United States.

Third, the model projects new CSP builds to be primarily at high capacity factor configuration. Large solar multiples and relatively long storage hours are especially prevalent in low-DNI regions like the Southeast and Midwest. Such configuration allows CSP plants to provide reliability and flexibility benefits to the grid via renewable electricity generation.

Finally, sensitivity scenarios suggest that CSP deployment is very sensitive to natural gas prices and alternative low-cost storage options. When low-cost storage *and* low-cost PV are available to the model, significantly less CSP is deployed even when SunShot CSP cost target is reached.

Conclusions

This study projects the impacts of achieving SunShot 2030 LCOE target for both CSP and PV, and examines the economics of CSP deployment under different market conditions. Modeling results suggest that achieveing the SunShot CSP LCOE target could lead to orders of magnitude larger CSP deployment than what has been experienced over the last decade. Ultimately, however, CSP deployment is sensitive to many factors including natural gas prices, storage costs, and CSP resource availability.

References

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