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Utility-Scale Solar, 2024 Edition

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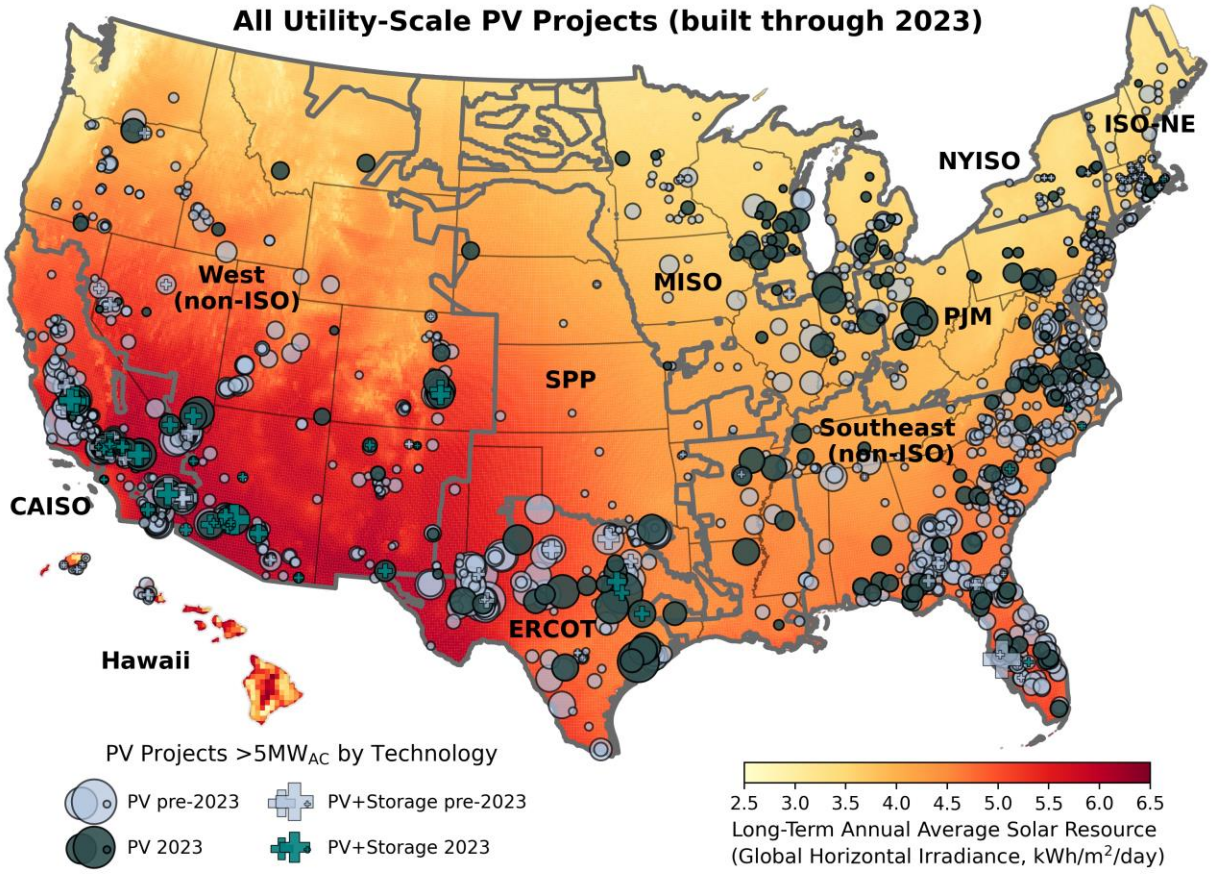
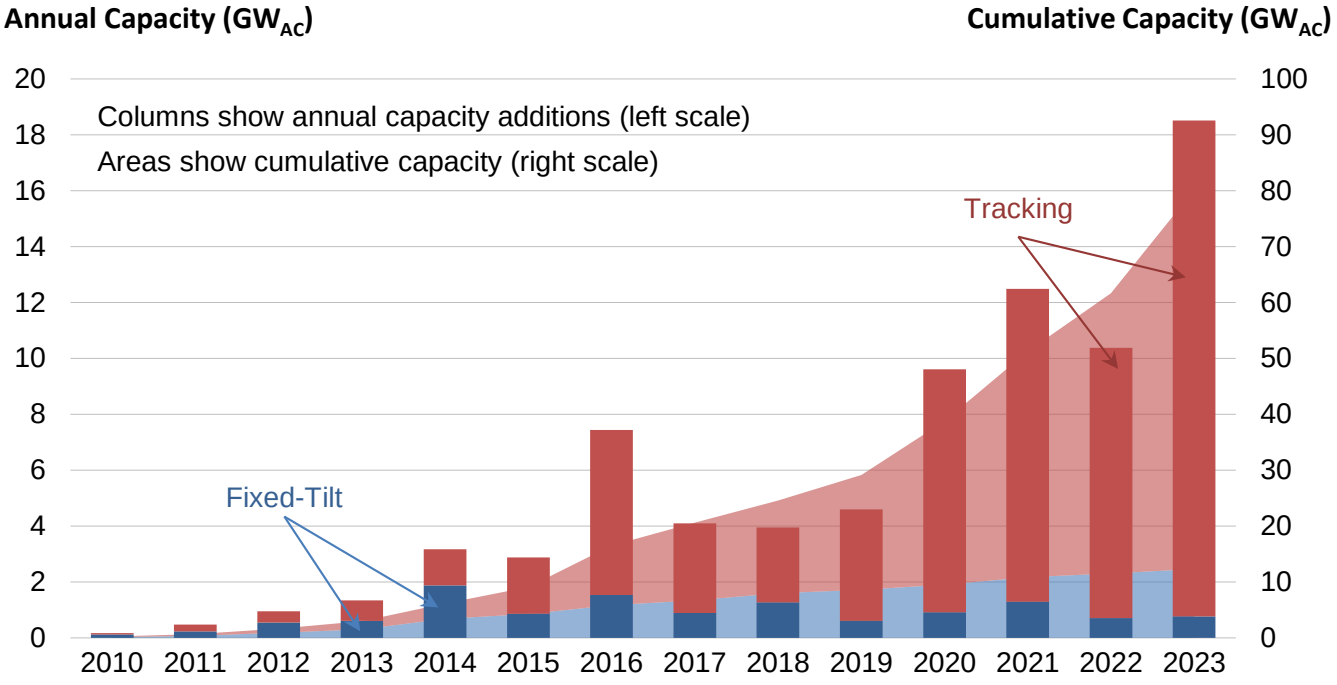
Berkeley Lab's annual *Utility-Scale Solar* report presents trends in deployment, technology, capital expenditures (CapEx), operating expenses (OpEx), capacity factors, levelized cost of solar energy (LCOE), power purchase agreement (PPA) prices, and wholesale market value among the fleet of utility-scale photovoltaic (PV) and hybrid PV+Storage plants in the United States. "Utility-scale" is defined here as any ground-mounted plant larger than 5 MW_{AC}. This executive summary highlights select key trends from the latest edition of the full report, covering data on plants built through year-end 2023. For additional insights, see the full briefing deck, the accompanying Excel data workbook with even more analyses, and interactive data visualizations, all available at http://utilityscalesolar.lbl.gov.

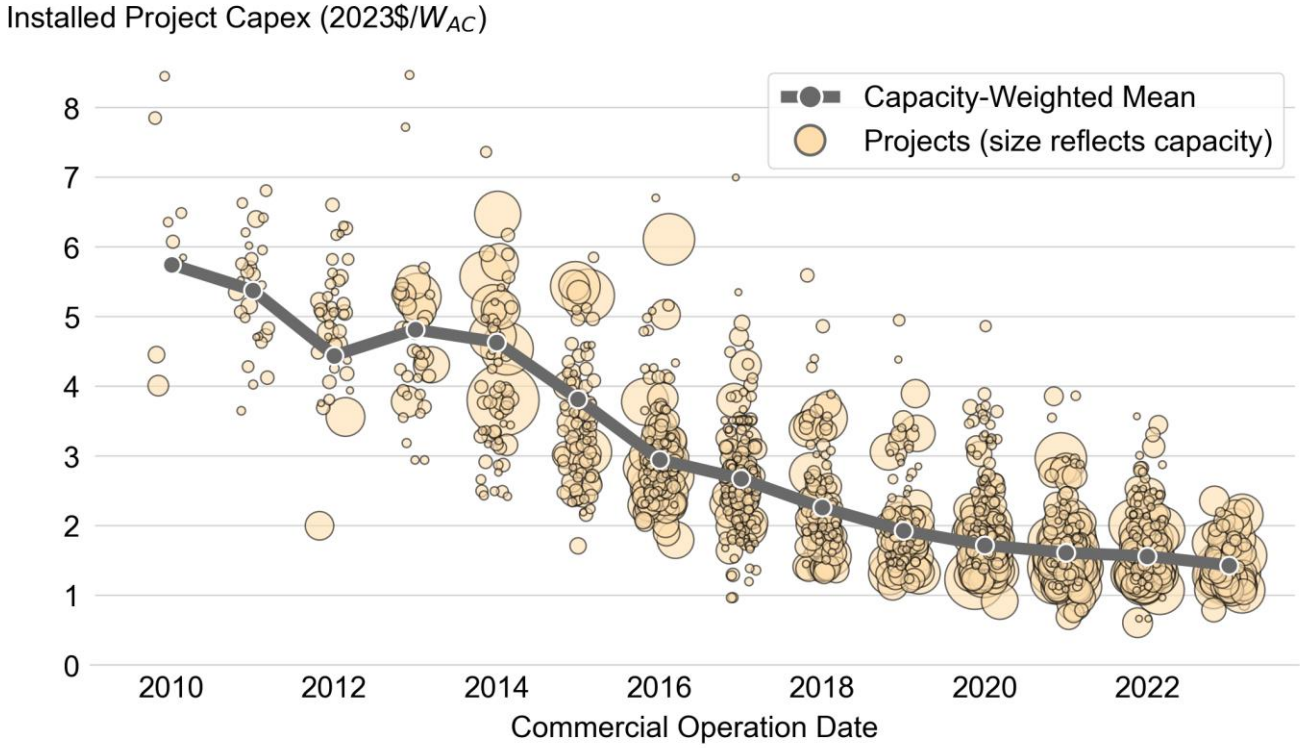
2023 was a record year for utility-scale PV deployment. 2023's addition of 18.5 GW_{AC} brought cumulative installed capacity to 80.2 GW_{AC} across 47 states (see map below). The market is becoming more geographically diverse. ERCOT in Texas added the most new capacity in 2023 (4.2 GW_{AC}), followed by the non-ISO Southeast (3.1 GW_{AC}), PJM (2.8 GW_{AC}), CAISO in California (2.7 GW_{AC}), MISO (2.7 GW_{AC}), and the non-ISO West (2.5 GW_{AC}).



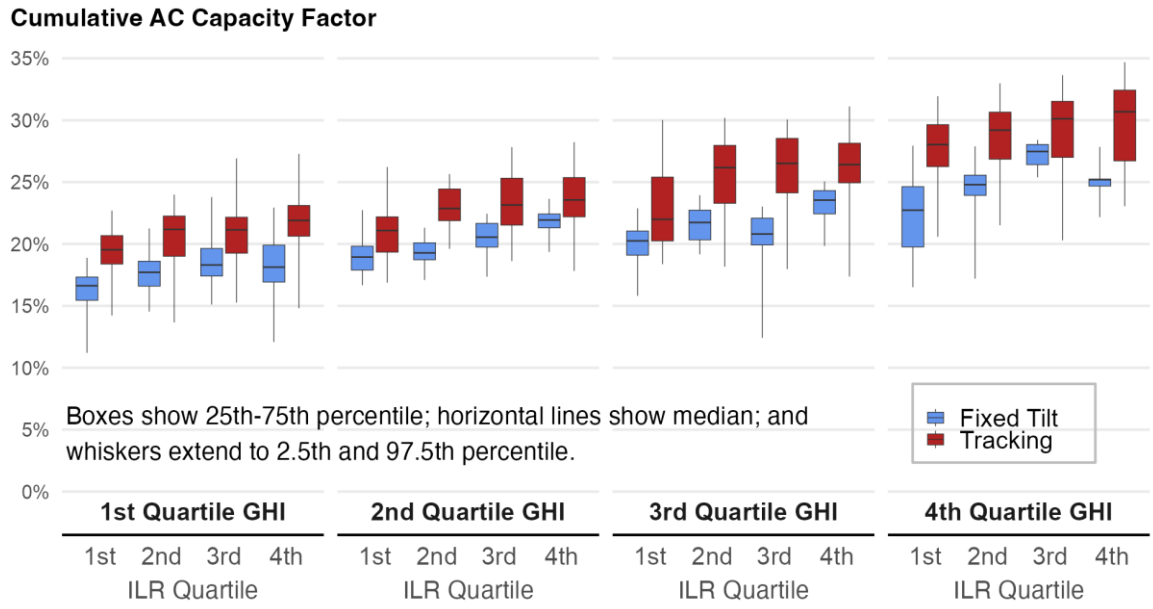
Single-axis tracking is the dominant mount type. 96% of all new utility-scale PV capacity added in 2023 uses single-axis tracking, with the remainder mounted at a fixed tilt.



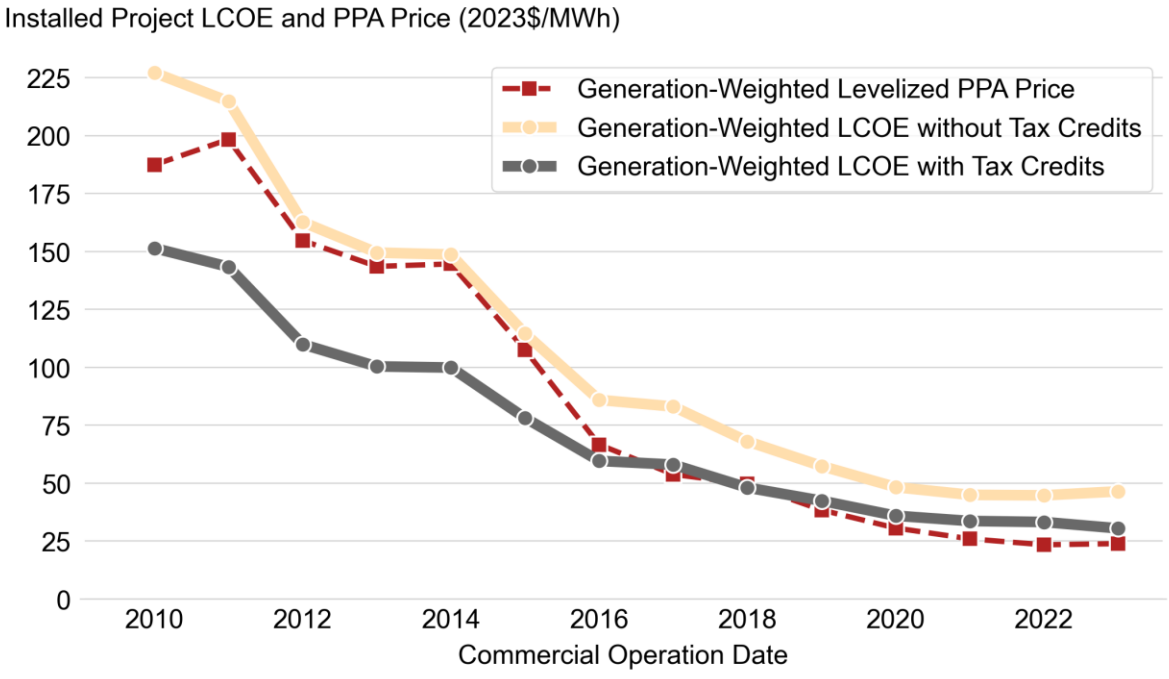
Installed costs continued to fall in 2023. Relative to 2022, capacity-weighted averages decreased by 8% to $1.43/WAC (or $1.08/WDC). Costs, based on a 7.1 GWAC sample of 76 plants completed in 2023, have fallen by 75% (averaging 10% annually) since 2010.



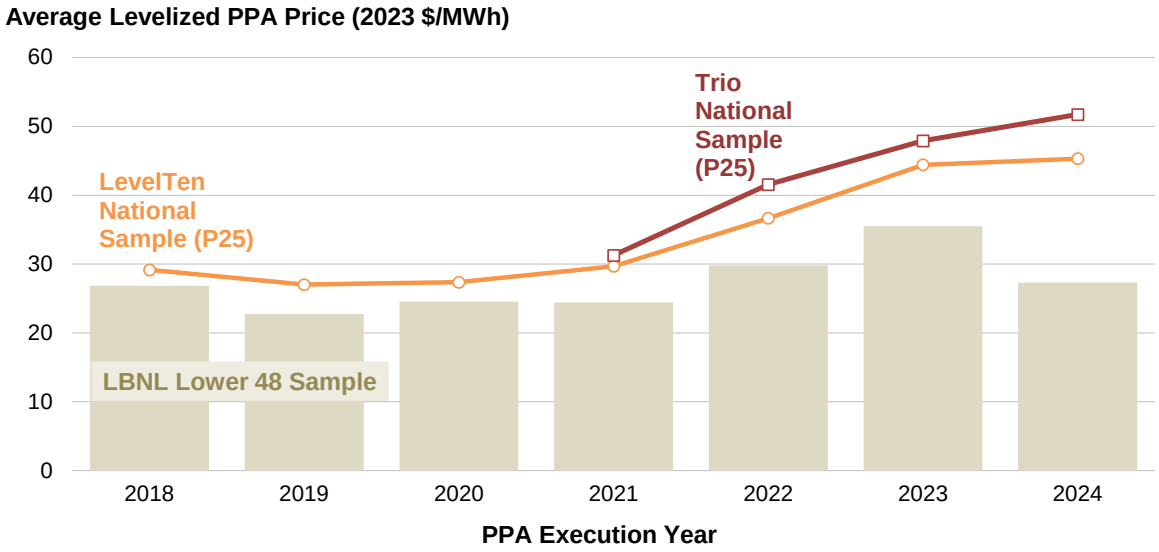
Plant-level capacity factors vary widely, from 7% to 37% (on an AC basis), with a sample median of 24%. The high degree of plant-level variation is based on a number of factors, including solar insolation, tracking vs. fixed-tilt mounts, inverter loading ratios, and curtailment. Projects that have come online more recently show less performance degradation as they age (0.9%/year) than do older plants (1.47%/year).



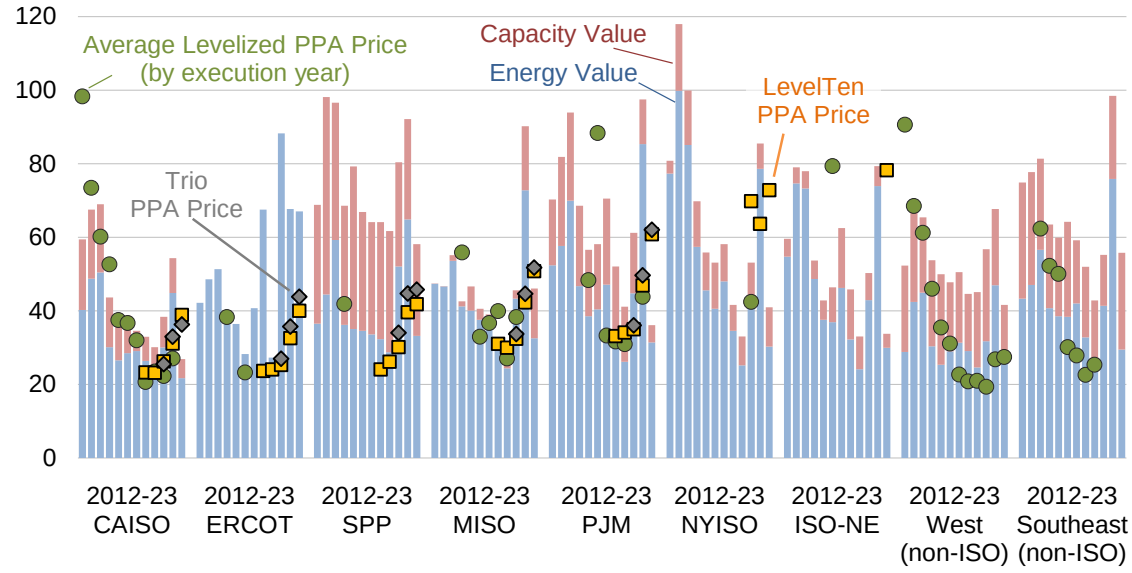
Utility-scale PV's levelized cost of energy (LCOE) increased slightly to $46/MWh prior to the application of tax credits but continued to fall to $31/MWh when accounting for federal incentives. For most new solar projects (54 out of 75) the Production Tax Credit (allowed since the Inflation Reduction Act of 2022) appears more beneficial than the longstanding Investment Tax Credit. Since 2016, Power Purchase Agreement (PPA) prices have closely tracked the LCOE accounting for tax credits, suggesting pass through of the credits to purchasers and a competitive PPA market.



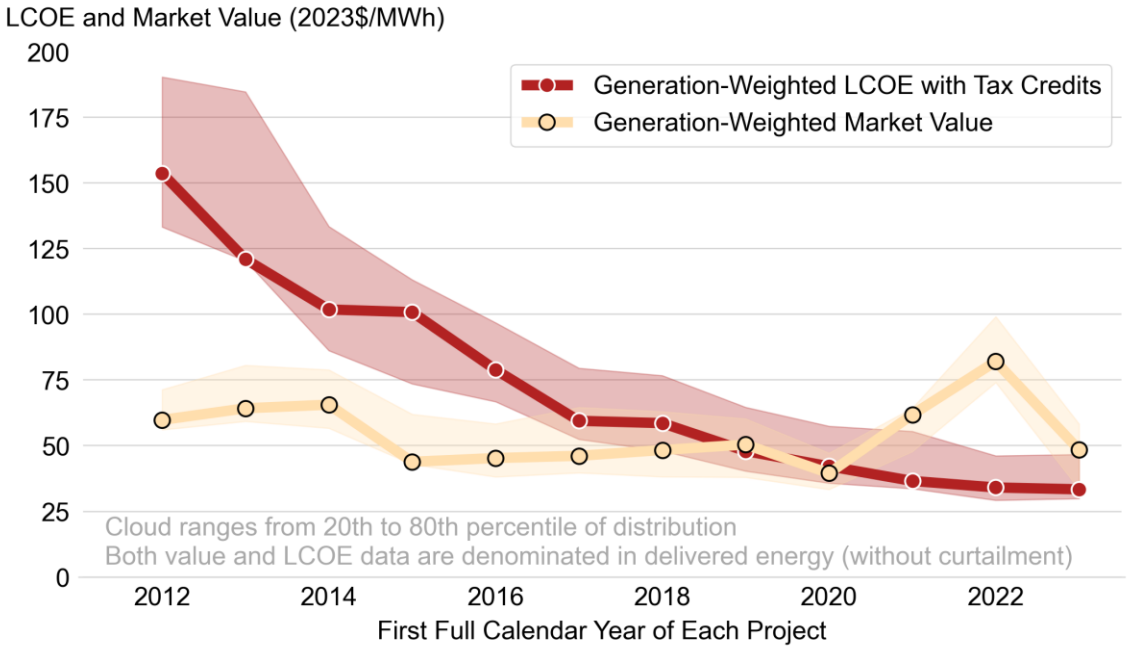
Newly signed longer-term PPA prices have increased since 2021, to an average of $35/MWh (levelized, in 2023 dollars). PPA prices have largely followed the decline in solar's LCOE over time, but since 2019 have stagnated and even increased among new contracts (graph below is by PPA execution year whereas previous graph is by the year in which a project started operation). Data from LevelTen Energy and Trio on shorter-term PPAs involving primarily non-utility buyers show an even stronger rise, to $45-$52/MWh in 2024.



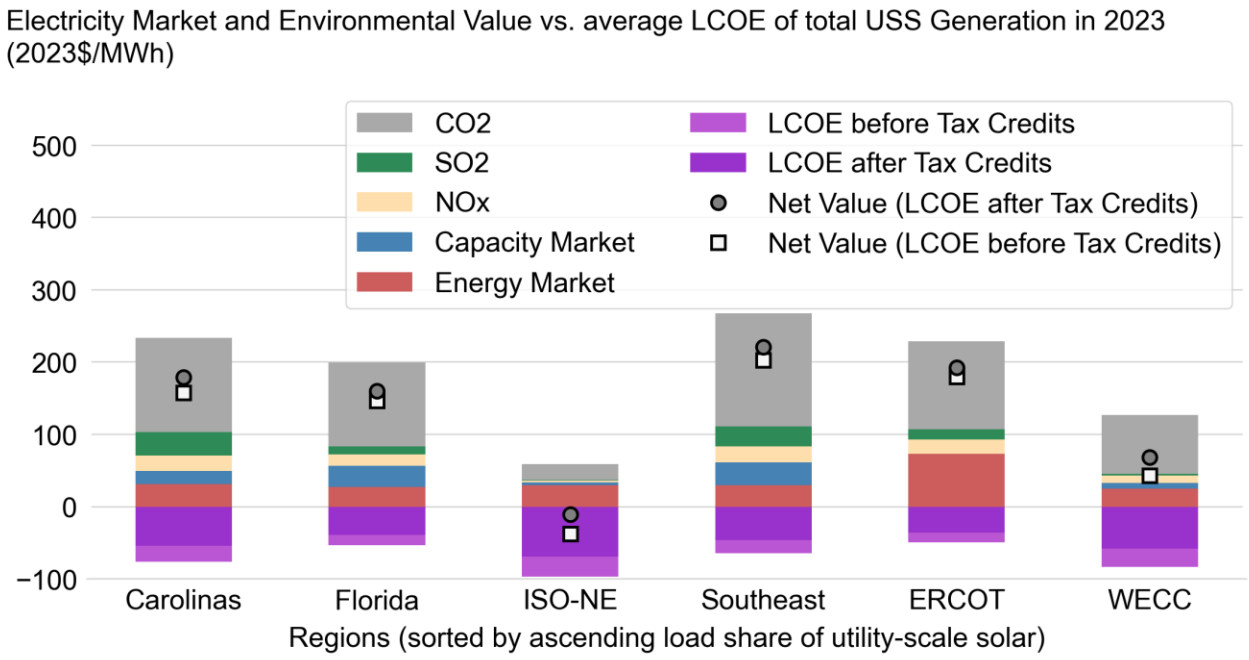
Solar's average energy and capacity value across the U.S. was $45/MWh in 2023. Energy and capacity value reflect the ability of solar electricity to offset the costs of other power generation sources. After high natural gas prices in 2022, solar's energy value returned to more normal levels of $34/MWh in 2023. Capacity value is greater in the non-ISO regions than the ISO regions and can add $30-40/MWh in some Balancing Areas. Solar's average market value was lowest in CAISO ($27/MWh), a market with the greatest solar generation share, and highest in ERCOT ($67/MWh), driven by summer heat waves and record demand for electricity during solar production hours. New PPA prices exceeded wholesale market value in 2023 in some regions.



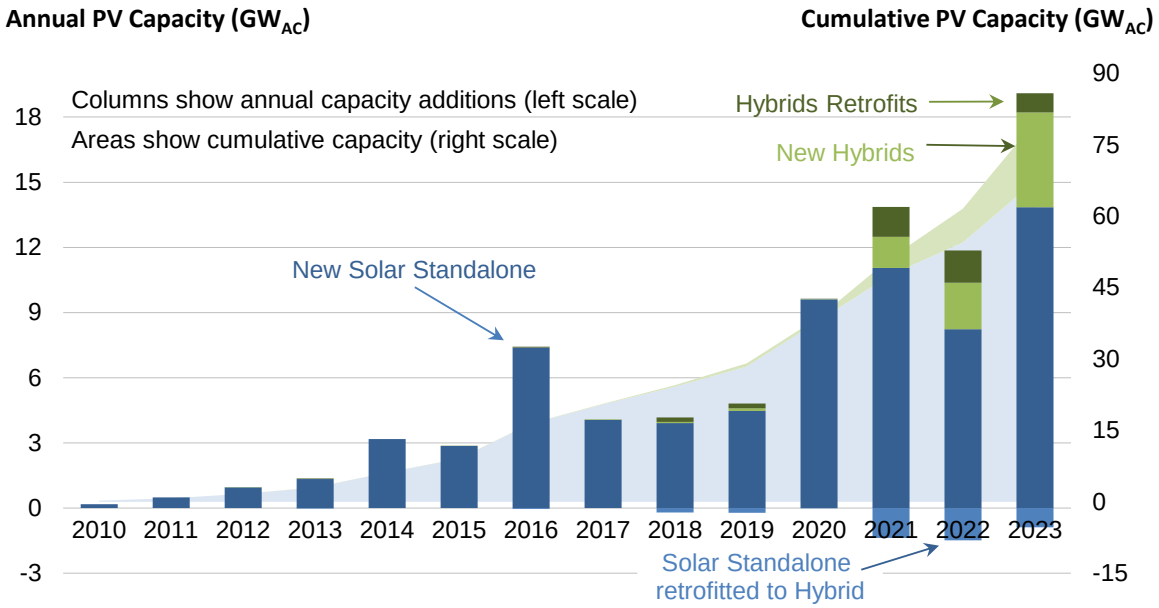
Newer solar projects had greater market value in 2023 than their generation costs, yielding $1.1 billion in benefits. Energy and capacity market value has been greater than levelized generation costs (after tax-credits) for new solar projects since 2020. Projects built in 2022 delivered on average $15/MWh more value than their costs in 2023.



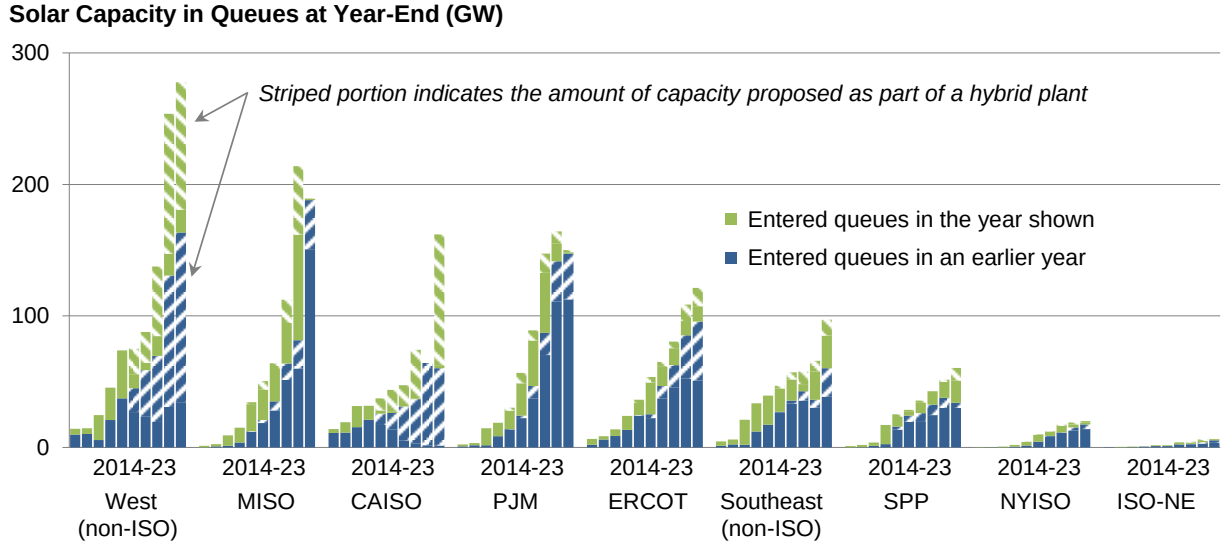
Solar's combined value from wholesale electricity markets, public health and climate damage reduction were greater than generation costs and incentives, yielding $13.7 billion in net benefits in 2023. Solar offsets fossil generation, thereby reducing health and climate damages. Using avoided emission-rates and damages from the scientific literature and air quality models we estimate U.S. health benefits of $24/MWh and reduced global climate damages of $101/MWh. Considering all solar built since 2007, solar's net value is positive in all but one region of the United States.



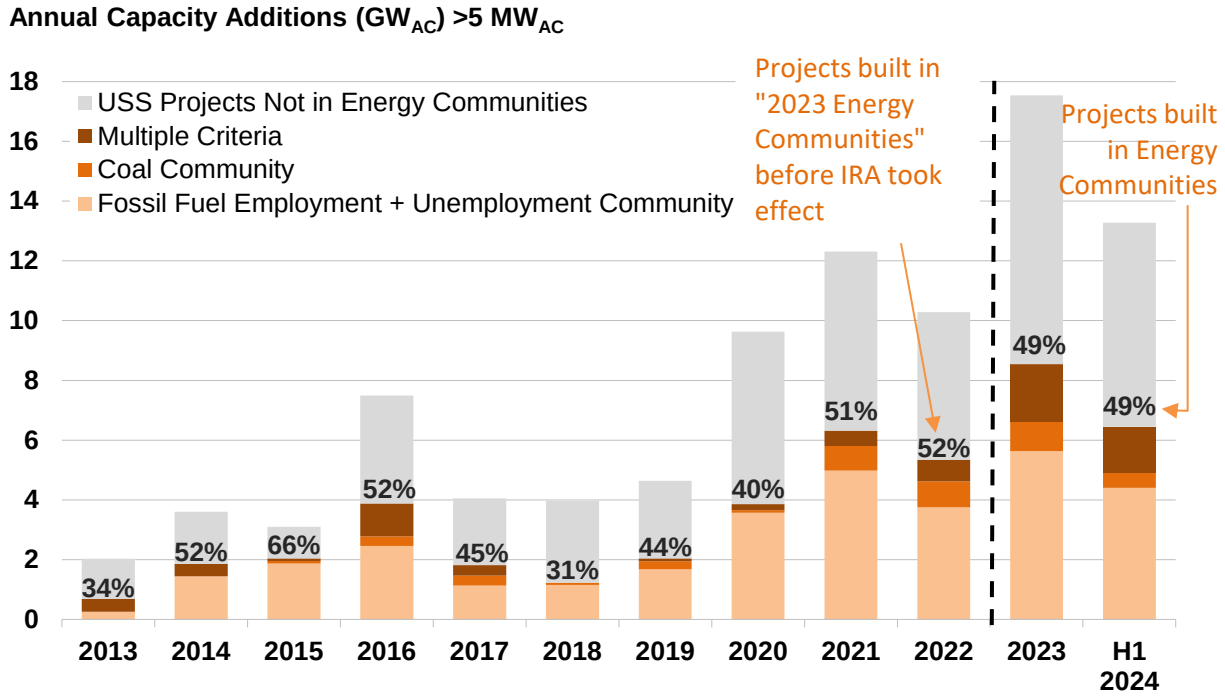
Deployment of PV+battery hybrid plants set a record with 5.3 GW built in 2023. Adding battery storage to shift a portion of mid-day solar generation into the evening hours is one way to increase the value of solar. PV+battery hybrid projects are becoming increasingly common, particularly in markets with a higher share of solar generation. In 2023, 52 PV+battery hybrid plants totaling 5.3 GW_{AC} of PV and 3.0 GW / 10.5 GWh of battery storage achieved commercial operations, both as new greenfield developments and storage retrofits to existing solar projects. Most of the new storage capacity was built in CAISO and the non-ISO West. The full report presents plant metadata, including installed costs and PPA prices, from a subset of online and in-development PV+battery hybrids.



A massive pipeline of more than 1 TW of utility-scale solar plants dominates the interconnection queues across the country. Looking ahead, at least 1,085 GW of solar capacity was in the nation's interconnection queues at the end of 2023. Nearly 571 GW, or 53%, of that total was paired with a battery – in CAISO it was a staggering 98%. Historically only 10% of the requested solar capacity is built, as companies may submit exploratory interconnection requests or may face high interconnection costs or other development challenges.



The Inflation Reduction Act (IRA), which became law in August 2022, introduced numerous provisions to stimulate additional clean energy deployment in the United States. This year's *Utility-Scale Solar* report marks some of the first results, especially the impact of the new incentives on solar's (post tax-credit) generation costs and the new deployment record. But markets naturally take time to react to new incentives. For example, the IRA introduced a new tax credit adder for solar projects located in "Energy Communities." We find that a sizable fraction (around 50%) of solar projects is in such energy communities but have not yet observed a large change in that share over time, likely because solar projects have multi-year development cycles and IRA impacts will therefore manifest over the coming years.



2024 is shaping up to be the strongest year on record for utility-scale solar in the United States, as the first eight months have already yielded additions of 14.3 GW_{AC}–70% more than the capacity built over the same period in 2023.

Acknowledgements

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