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Utility-Scale Solar, 2023 Edition

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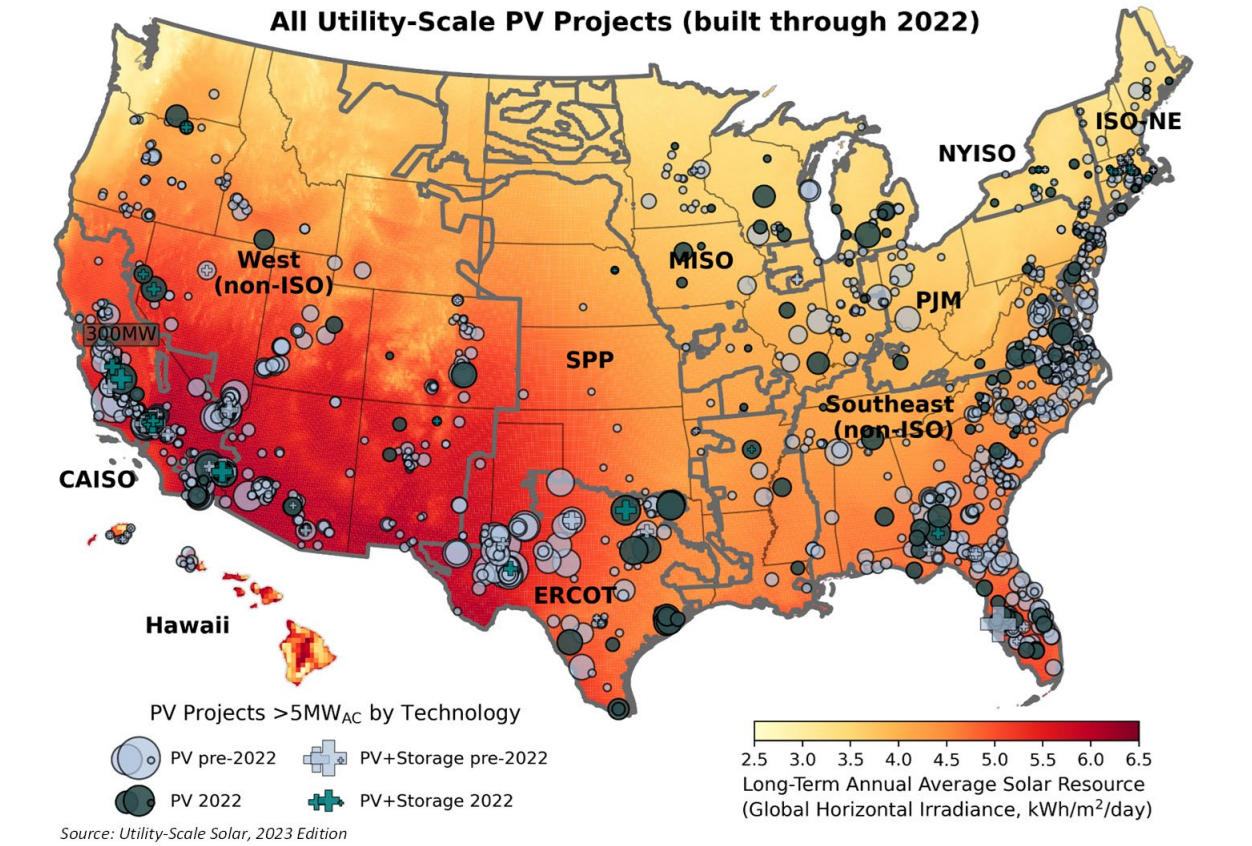
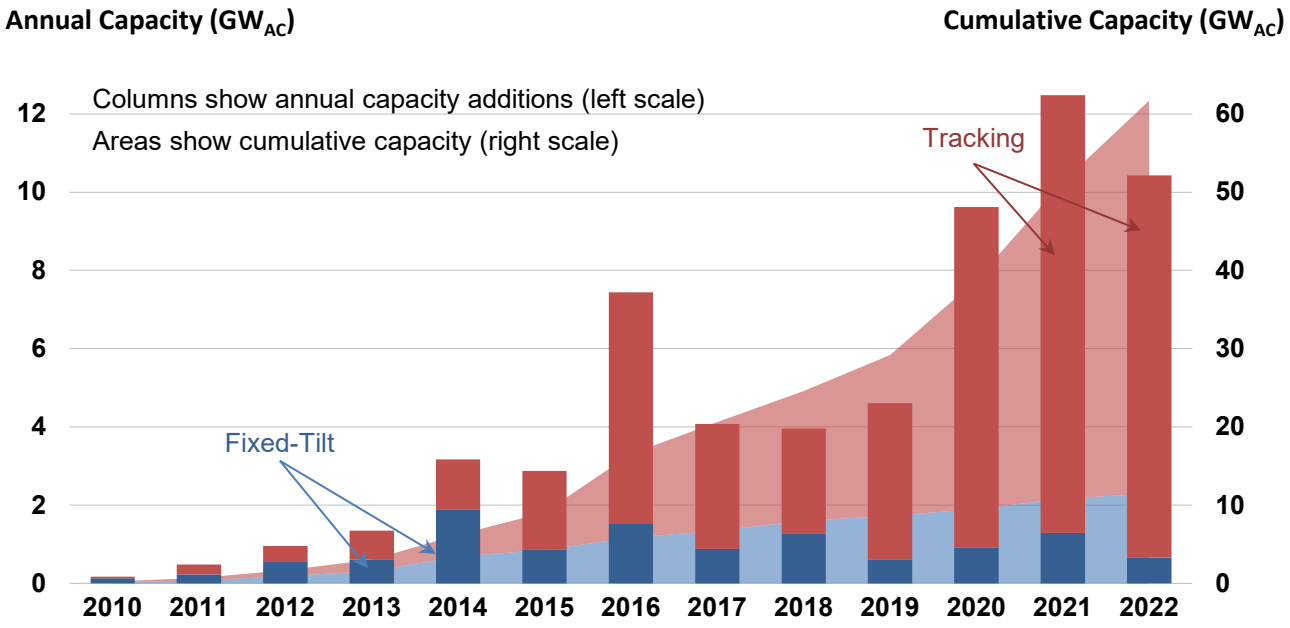
Berkeley Lab's annual *Utility-Scale Solar* report presents trends in deployment, technology, capital expenditures (CapEx), operating expenses (OpEx), capacity factors, the levelized cost of solar energy (LCOE), power purchase agreement (PPA) prices, and wholesale market value among the fleet of utility-scale photovoltaic (PV) and hybrid PV+Storage plants in the United States (where "utility-scale" is defined as any ground-mounted plant larger than 5 MW_{AC}). This executive summary highlights select key trends from the latest edition of the report, covering data on plants built through year-end 2022. For additional data, graphs, and analysis, see the full report (in slide deck form), the accompanying Excel data workbook with linked graphics, and interactive data visualizations, all available at http://utilityscalesolar.lbl.gov.

2022 was another strong year for utility-scale PV deployment. Though below 2021's record buildout of 12.5 GW_{AC}, 2022's addition of 10.4 GW_{AC} brought cumulative installed capacity to 61.7 GW_{AC} across 46 states (see map below). Texas (2.5 GW_{AC}) added the most new capacity in 2022, followed by California (2.1 GW_{AC}), Virginia (0.6 GW_{AC}), and Georgia (0.5 GW_{AC}).

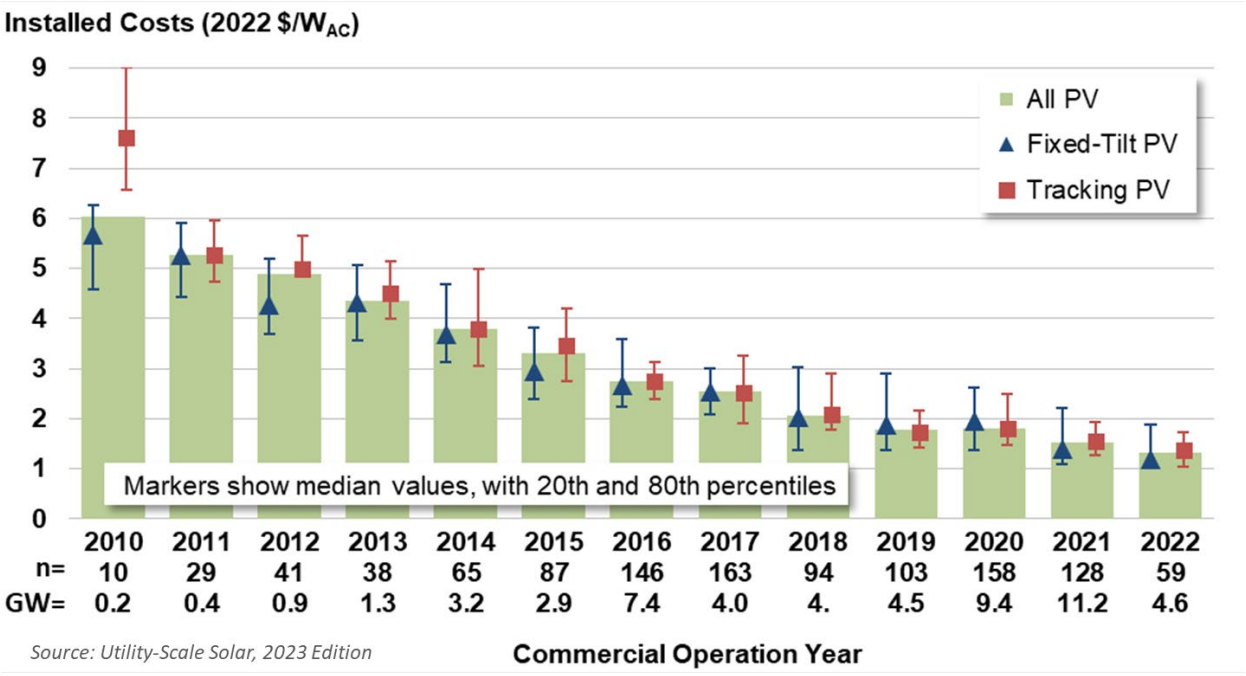


Source: Utility-Scale Solar, 2023 Edition

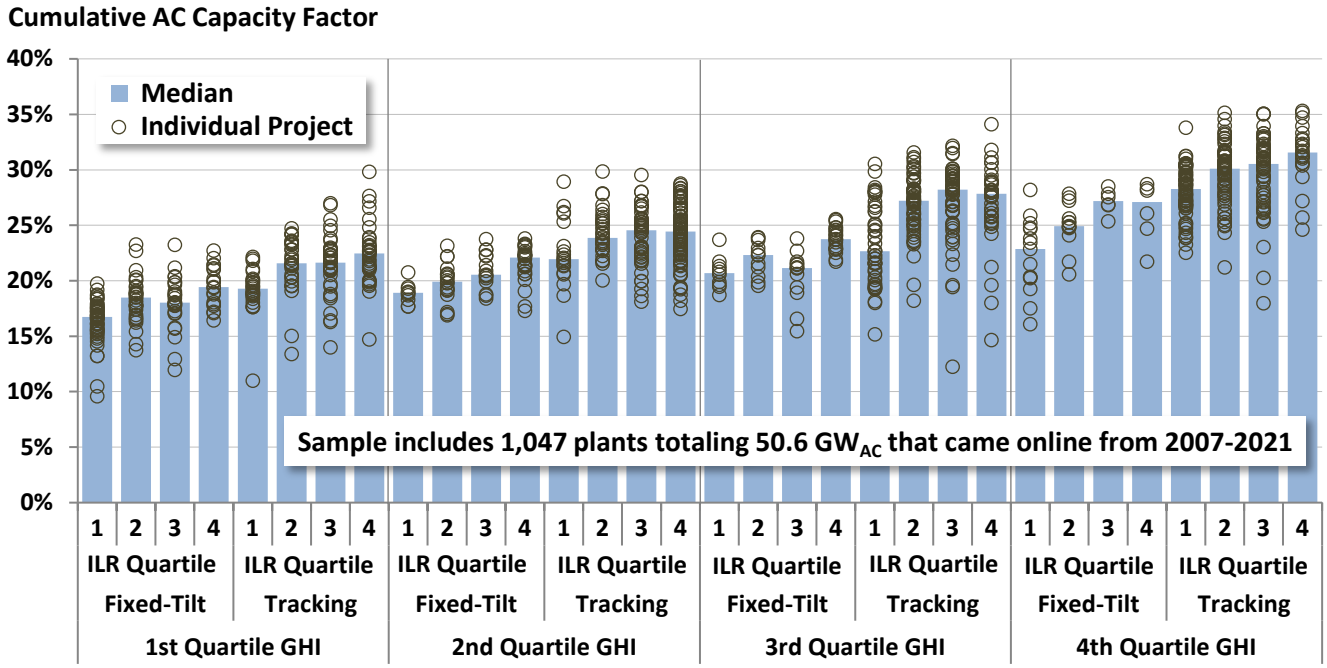
Single-axis tracking is the dominant mount type. 94% of all new utility-scale PV capacity added in 2022 uses single-axis tracking, with the remainder mounted at a fixed tilt (see figure below).



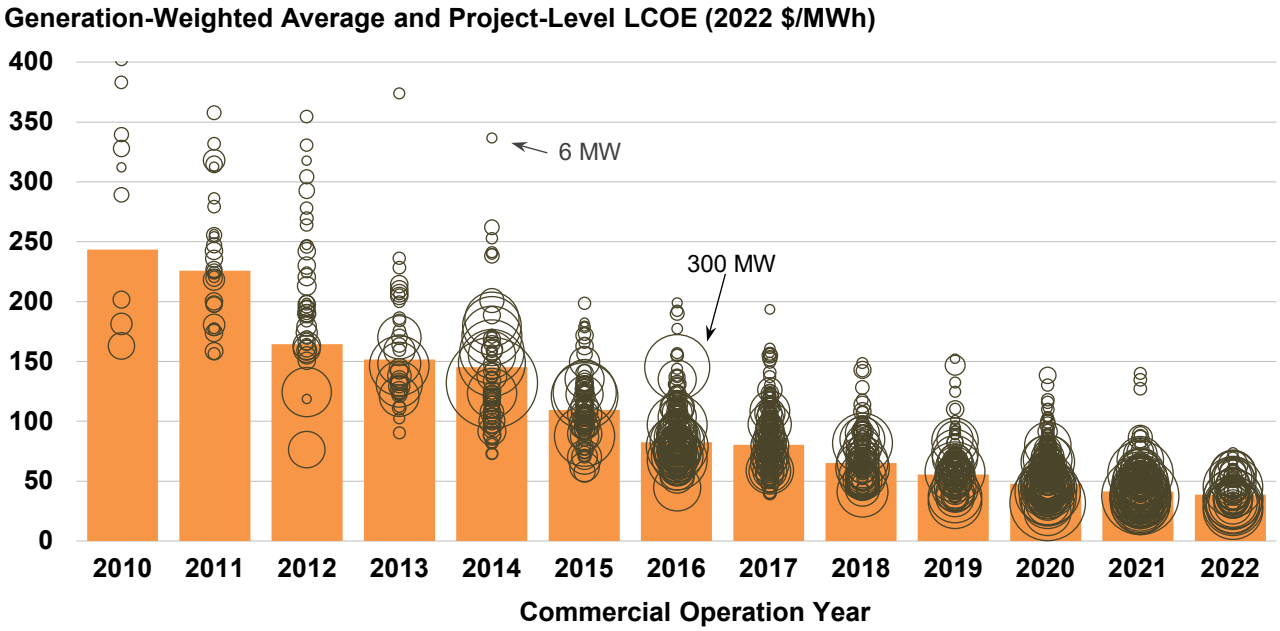
Despite inflationary pressures, installed costs continued to fall in 2022. Median installed costs declined to $1.32/W$_{AC}$ (or $1.07/W$_{DC}$) based on a 4.6 GW$_{AC}$ sample of 59 plants completed in 2022, and have fallen by 78% (averaging 10% annually) since 2010 (see figure below). The lowest-cost 20th percentile of plants in our 2022 sample cost $1.1/W$_{AC}$ ($0.8/W$_{DC}$) or less.



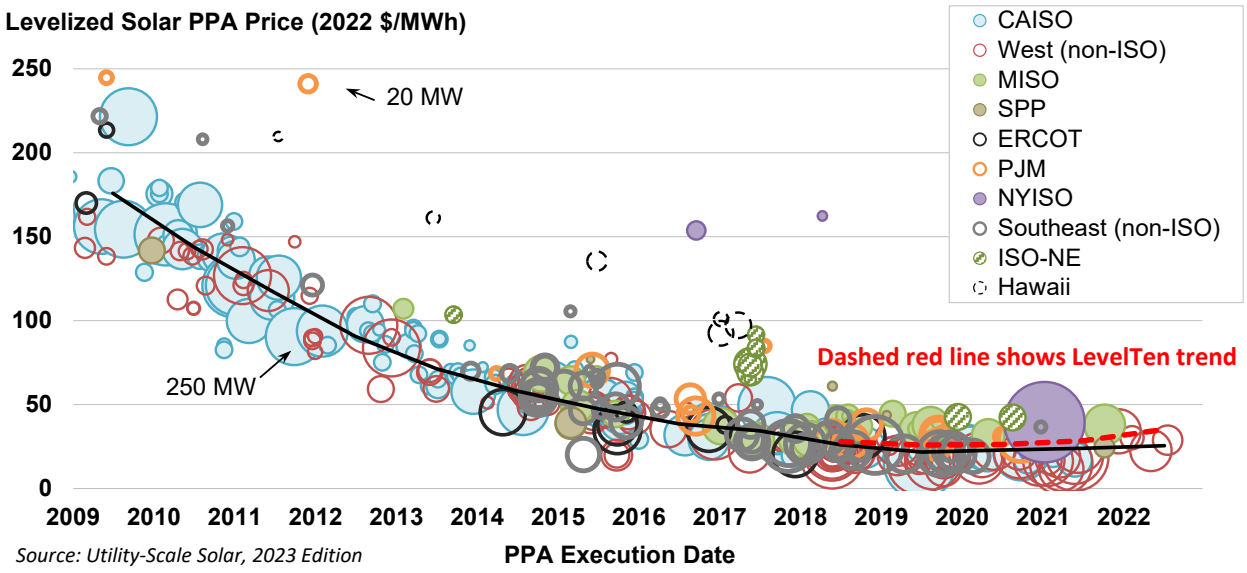
Plant-level capacity factors vary widely, from 9% to 35% (on an AC basis), with a sample median of 24%. The high degree of plant-level variation is based on a number of factors, including insolation, tracking vs. fixed-tilt mounts, inverter loading ratios, performance degradation, and curtailment (see figure below).



Utility-scale PV's LCOE fell slightly to $39/MWh on average in 2022. The average LCOE has fallen by about 84% (averaging 14% annually) since 2010, driven by lower capital costs and improving capacity factors, as well as other factors (see figure below).

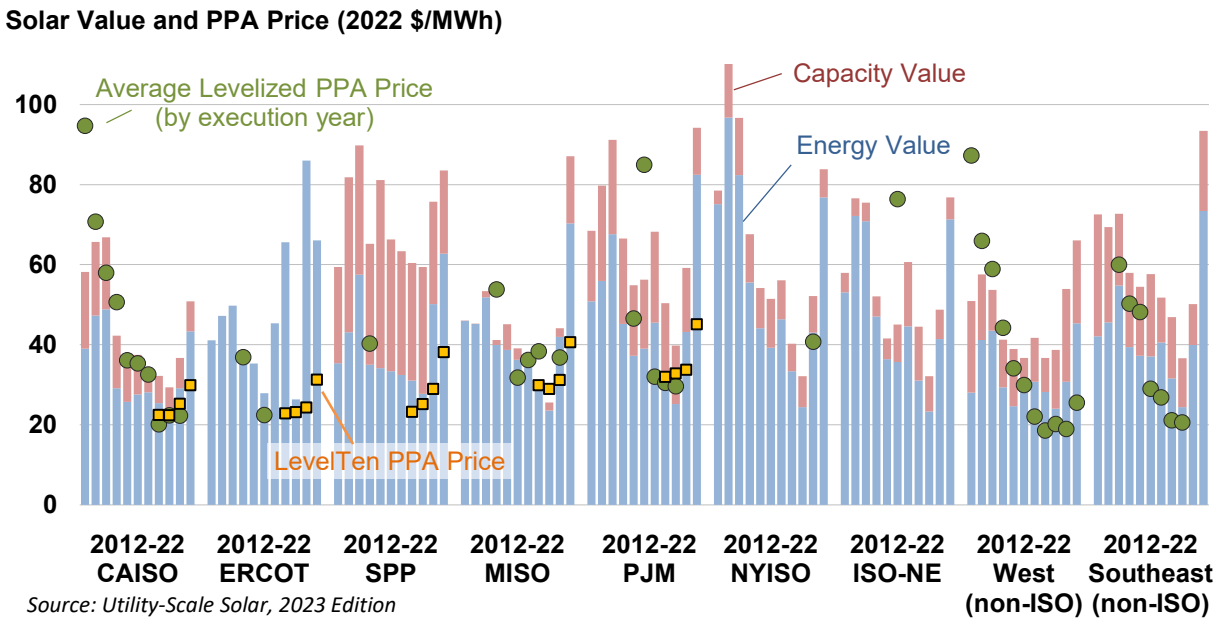


PPA prices from a small sample of contracts signed in 2022 average $25/MWh (levelized, in 2022 dollars). PPA prices, which to date reflect receipt of the federal investment tax credit (ITC), have largely followed the decline in solar's LCOE over time, but since 2019 have stagnated and even increased slightly (see figure below). Data from LevelTen Energy on shorter-term PPAs involving primarily non-utility buyers show a similar trend in recent years.



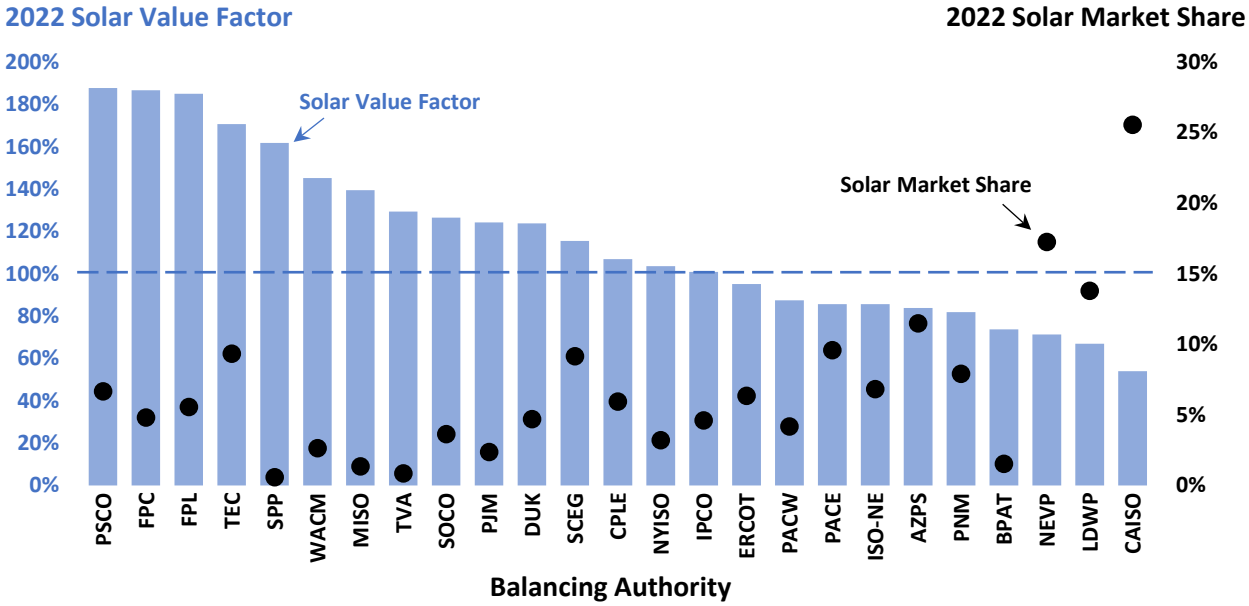
Source: Utility-Scale Solar, 2023 Edition

Rising wholesale electricity prices boosted solar's national average market value by 40% in 2022, to $71/MWh. This increase in solar's combined energy and capacity value outpaced the more-modest rise in PPA prices, thereby improving solar's competitiveness (see figure below). Solar's average market value in 2022 was lowest in CAISO ($51/MWh) and highest in Duke Energy Florida's service territory ($108/MWh).

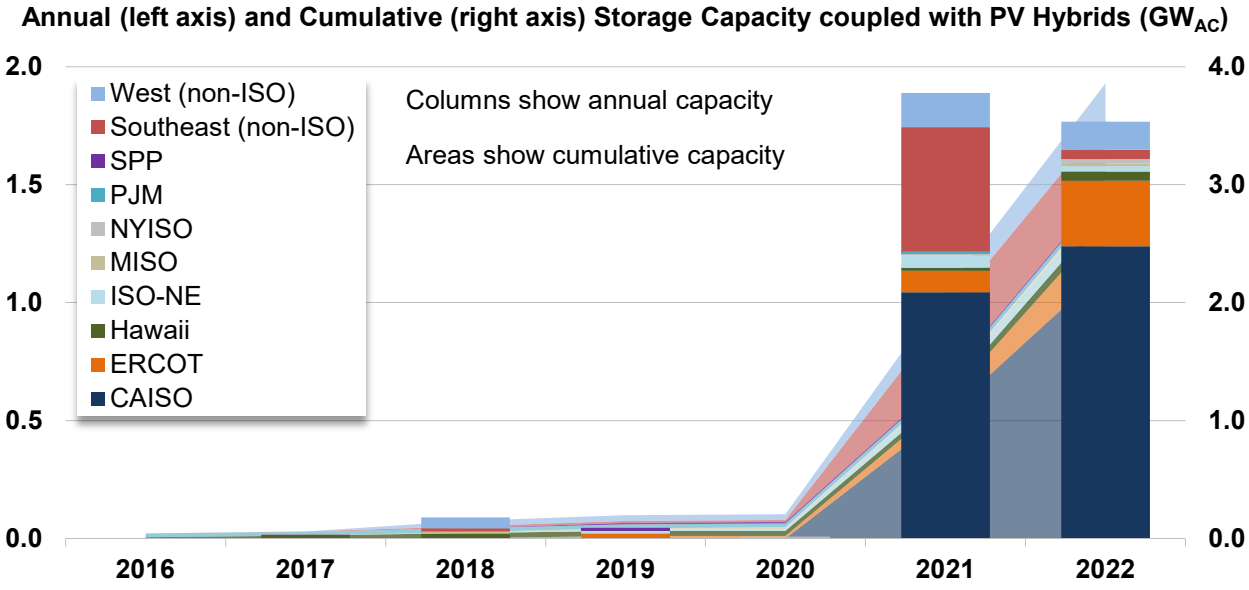


Source: Utility-Scale Solar, 2023 Edition

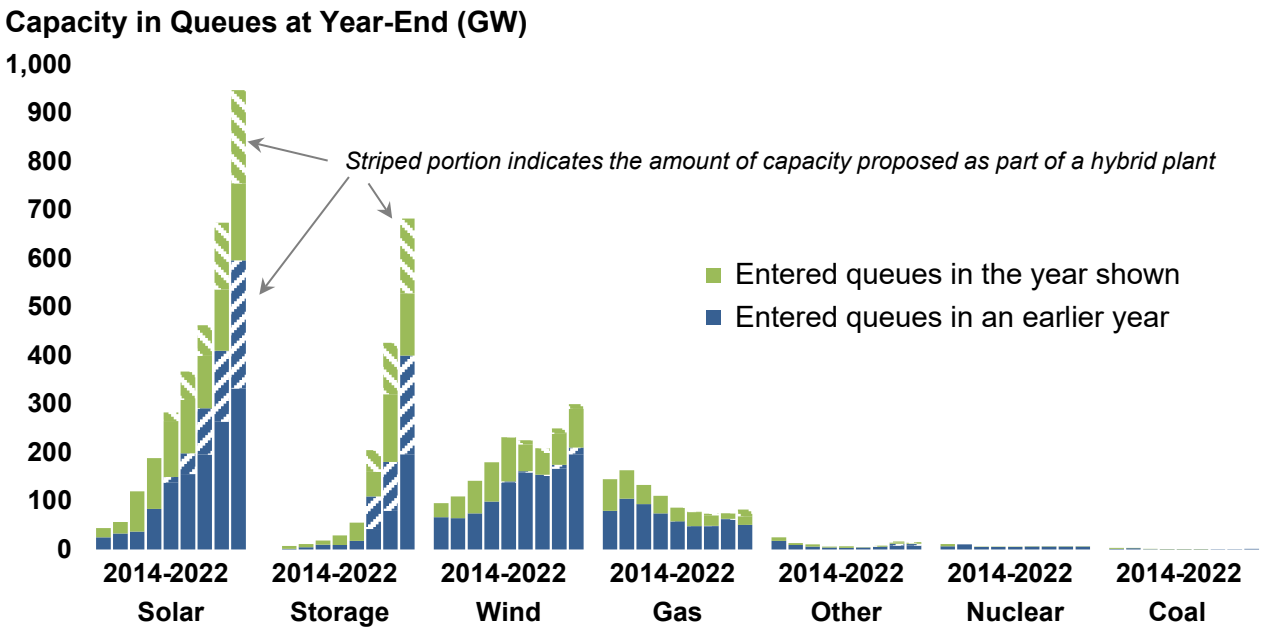
Solar's market value exceeded average electricity prices in 15 of the 25 regions analyzed in 2022. With the exception of ISO-NE and ERCOT, the regions with below-average solar market value (i.e., those with a "solar value factor" of less than 100% in the figure below) are concentrated in the West, where solar's market share is generally higher. Compared to 2021, solar's value factor contracted in 12 of the 25 regions analyzed (again, primarily in western regions).



2022 was another strong year for PV+battery hybrid plants. Adding battery storage to shift a portion of excess mid-day solar generation into evening hours is one way to increase the value of solar. These PV+battery hybrid projects are becoming increasingly common, particularly in markets with a higher share of solar generation. In 2022, 35 PV+battery hybrid plants totaling 3.6 GW_{AC} of PV and 1.8 GW / 5.4 GWh of battery storage achieved commercial operations (see figure below), while many additional hybrids entered the development pipeline. The report presents plant metadata, including installed costs and PPA prices, from a subset of these online and in-development PV+battery hybrids.



A massive pipeline of utility-scale solar plants dominate the interconnection queues across the country. Looking ahead, at least 947 GW of solar capacity was in the nation's interconnection queues at the end of 2022 (see figure below). Nearly 457 GW, or 48%, of that total was paired with a battery.



The Inflation Reduction Act (IRA), which became law in August 2022, introduced numerous provisions to stimulate additional clean energy deployment in the United States. The provisions most likely to impact the utility-scale solar market include a production tax credit for solar, along with various tax credit adders (e.g., for prevailing wages, apprenticeships, location of projects in energy communities, using domestically produced equipment). While these policy developments have generated much excitement within the industry, we do not yet see the impact of these incentives in this year's *Utility-Scale Solar* report, for several possible reasons. First, the IRA was passed relatively late in the year, with Treasury guidance on implementation coming even later, and the market naturally takes time to react. In addition, several incentives only came into effect starting in 2023, while this report focuses primarily on projects built in 2022. Meanwhile, interconnection queues from some of the bigger regions had either already closed their open application season by the time the IRA passed, or else did not accept or discouraged new interconnection requests in 2022.

Nonetheless, 2023 is shaping up to be the strongest year on record for utility-scale solar, as the first eight months have already yielded 8.6 GW of capacity additions, which is 30% more than the prior record pace through August set in 2021. Based on EIA projections of capacity additions for September through December, total new utility-scale solar capacity added in 2023 could surpass 24 GW by the end of the year.

Acknowledgements

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