

# UTILITY-SCALE SOLAR 2023

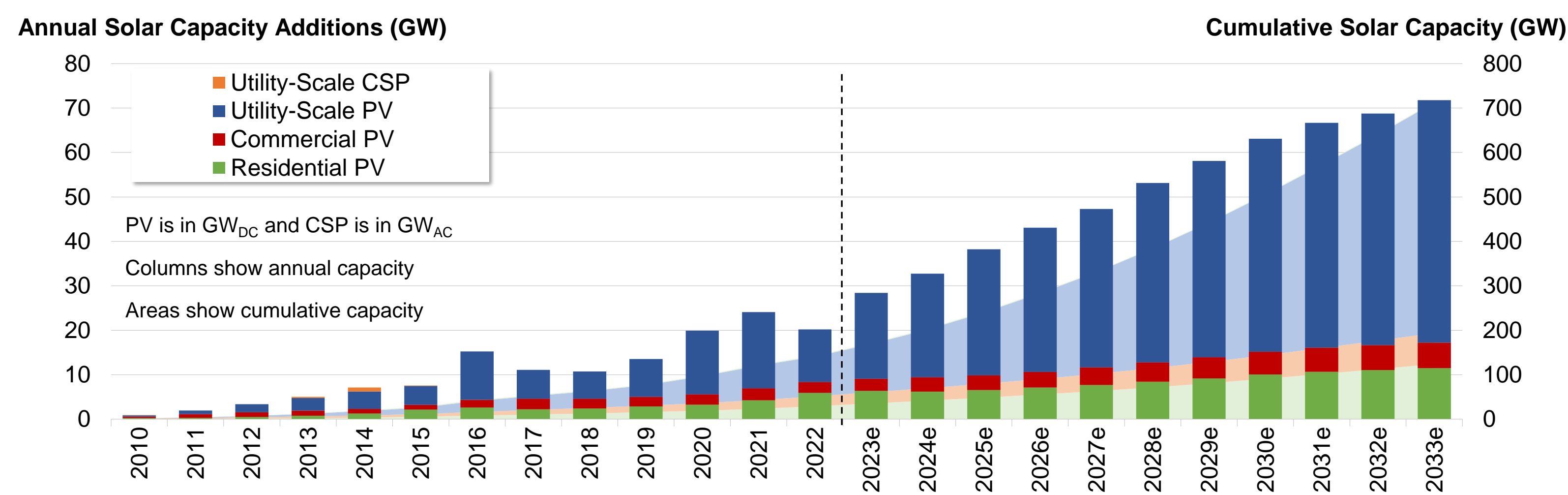
An Empirical Analysis of Project Cost, Performance and Pricing Trends in the United States



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## 1. Introduction and Sample Description

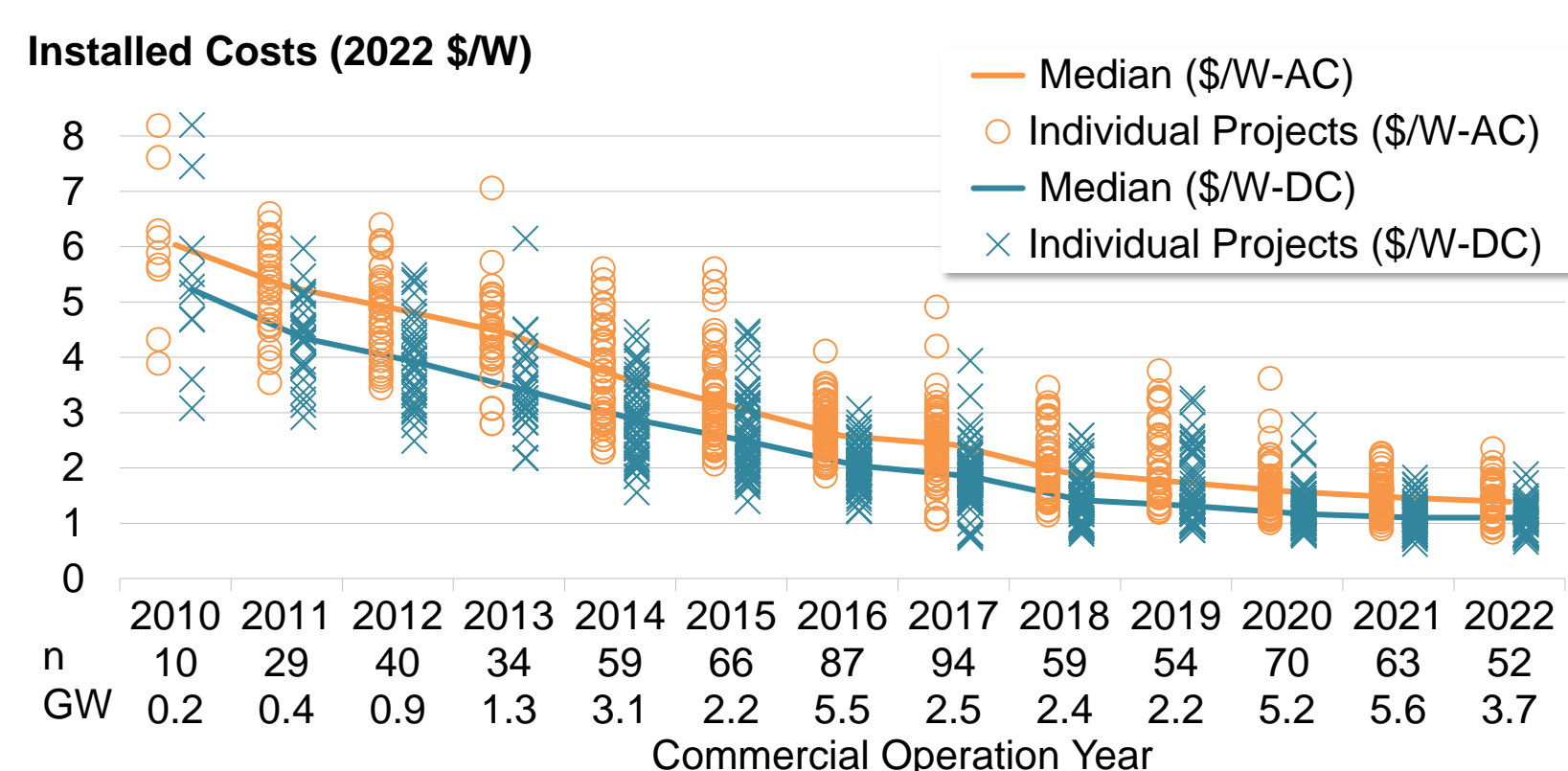
At the end of 2022, 1277 utility-scale PV projects totaling 61.7 GW<sub>AC</sub> were online in the United States. Nearly 17% of this capacity (147 projects – 10.4 GW<sub>AC</sub>) achieved commercial operation in 2022. This poster analyzes technology trends, installed prices, capacity factors, and PPA prices and wholesale market value among this population. Sample size varies across sections.



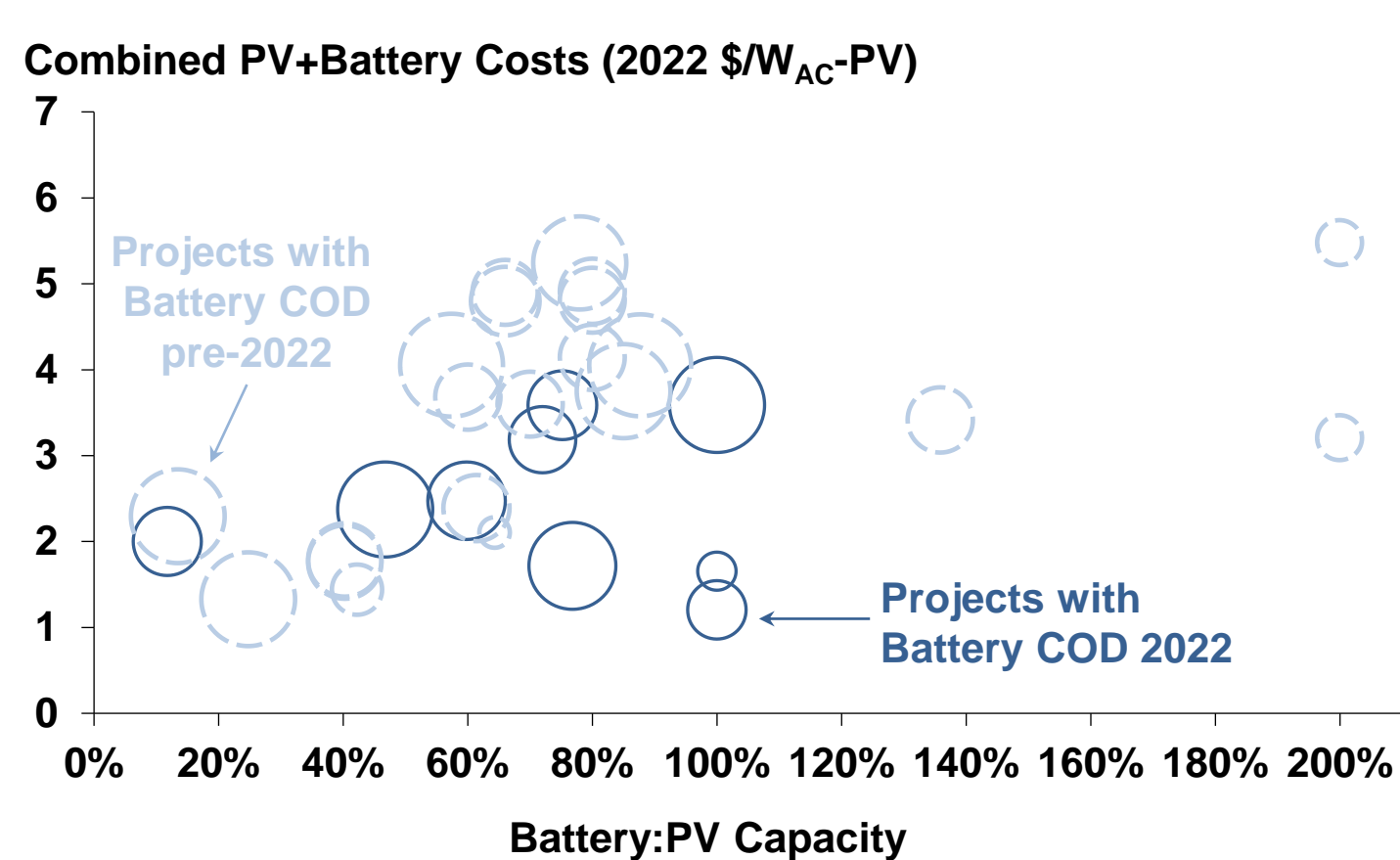
Source: Wood Mackenzie. "U.S. Solar 2021 Year in Review" and Berkeley Lab

We define "utility-scale" as any ground-mounted project > 5 MW<sub>AC</sub>. Smaller systems are analyzed in LBNL's "Tracking the Sun" series.

## 3. Project Prices



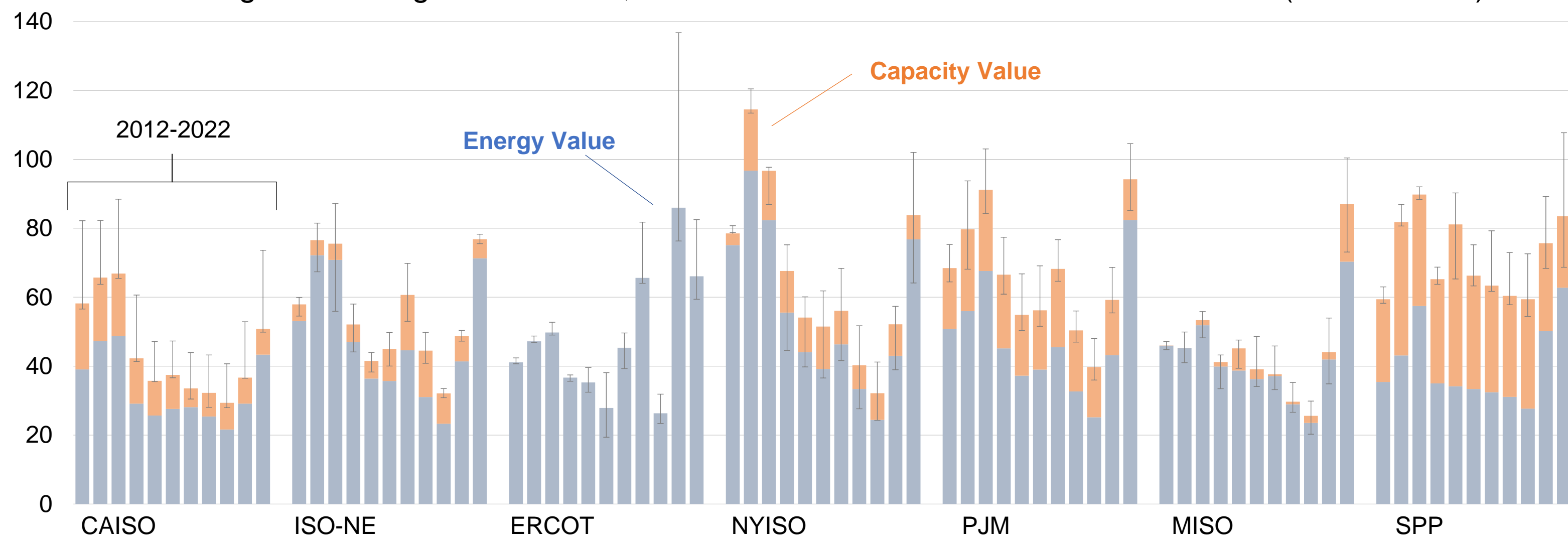
Median prices for *stand-alone* utility-scale PV (not hybridized) have declined steadily to \$1.4/W<sub>AC</sub> (\$1.1/W<sub>DC</sub>) in 2022. This represents a price decline of 76% since 2010. The 20<sup>th</sup> percentile of project Capex in our 2022 sample of 52 PV projects was ~\$1.1/W<sub>AC</sub> (~\$0.8/W<sub>DC</sub>). NYISO had the lowest (~\$1.1/W<sub>AC</sub>) and MISO has the highest costs (~\$1.7/W<sub>AC</sub>). Fixed-tilt installations had a cost advantage over tracking installations (~\$0.3/W<sub>AC</sub>).



A typical PV-battery hybrid system with 2022 COD has a battery sized to 75% of the PV capacity and storage duration slightly over 2 hours at the rated capacity. The median combined PV+battery costs dropped since 2021 to \$2.4/W<sub>AC</sub>-PV in 2022 (sample: 9).

## 5. Solar Market Value

Generation-Weighted Average Solar Value, with 10<sup>th</sup>/90<sup>th</sup> Percentiles of Combined Value (2022 \$/MWh)

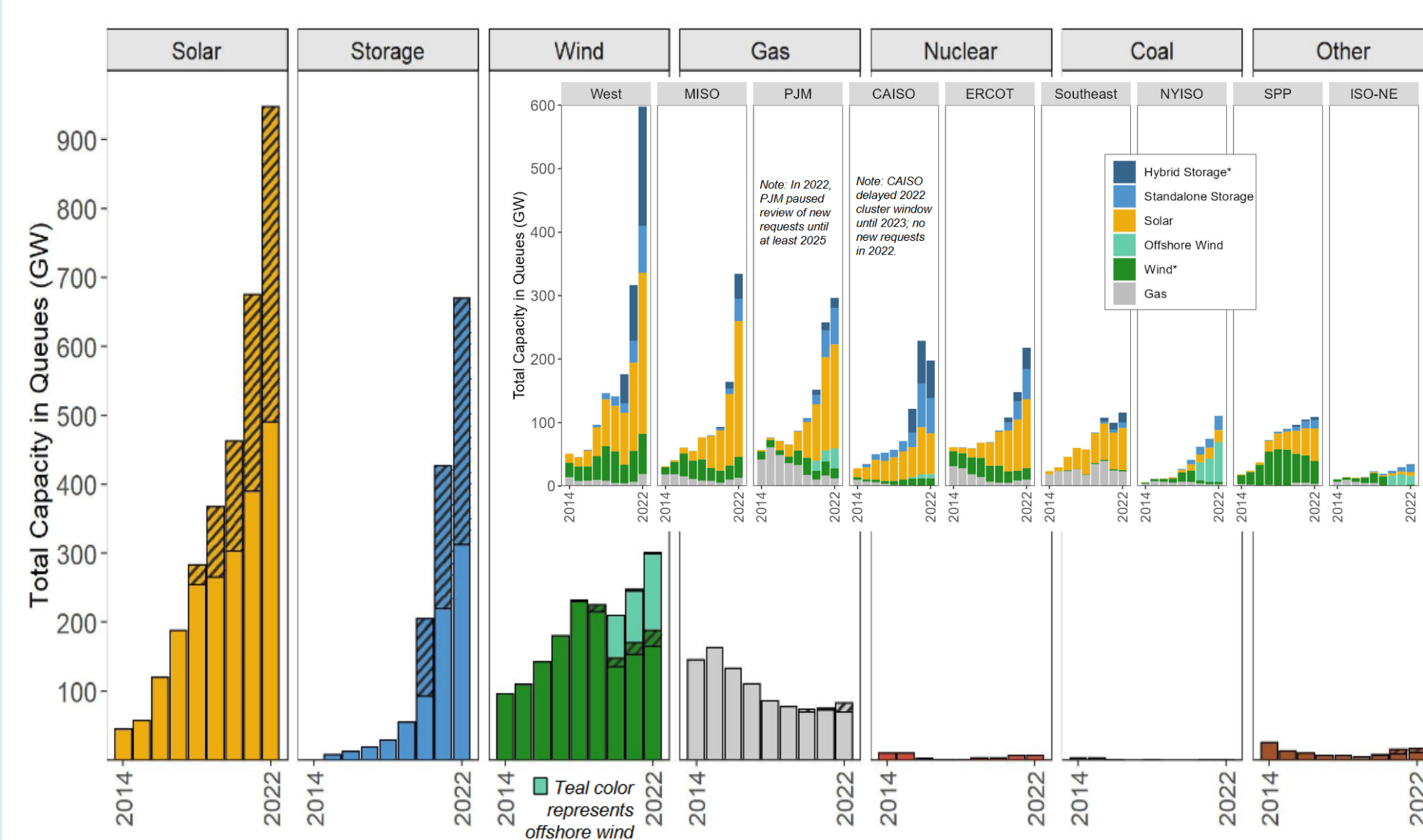


After annual declines during 2015-2020, regional solar market values have now increased for two consecutive years, with 2022 values ranging from ~\$50/MWh in CAISO to nearly \$95/MWh in PJM. The energy value makes up the bulk of total market value, but capacity value is significant in some and accounts for much of the variation between ISOs. Stand-alone solar earned only 54% of the revenue of a flat block of power in CAISO, where solar served 26% of all load. In SPP (<1% solar penetration), solar still outperformed a flat block at 162% of its revenue.

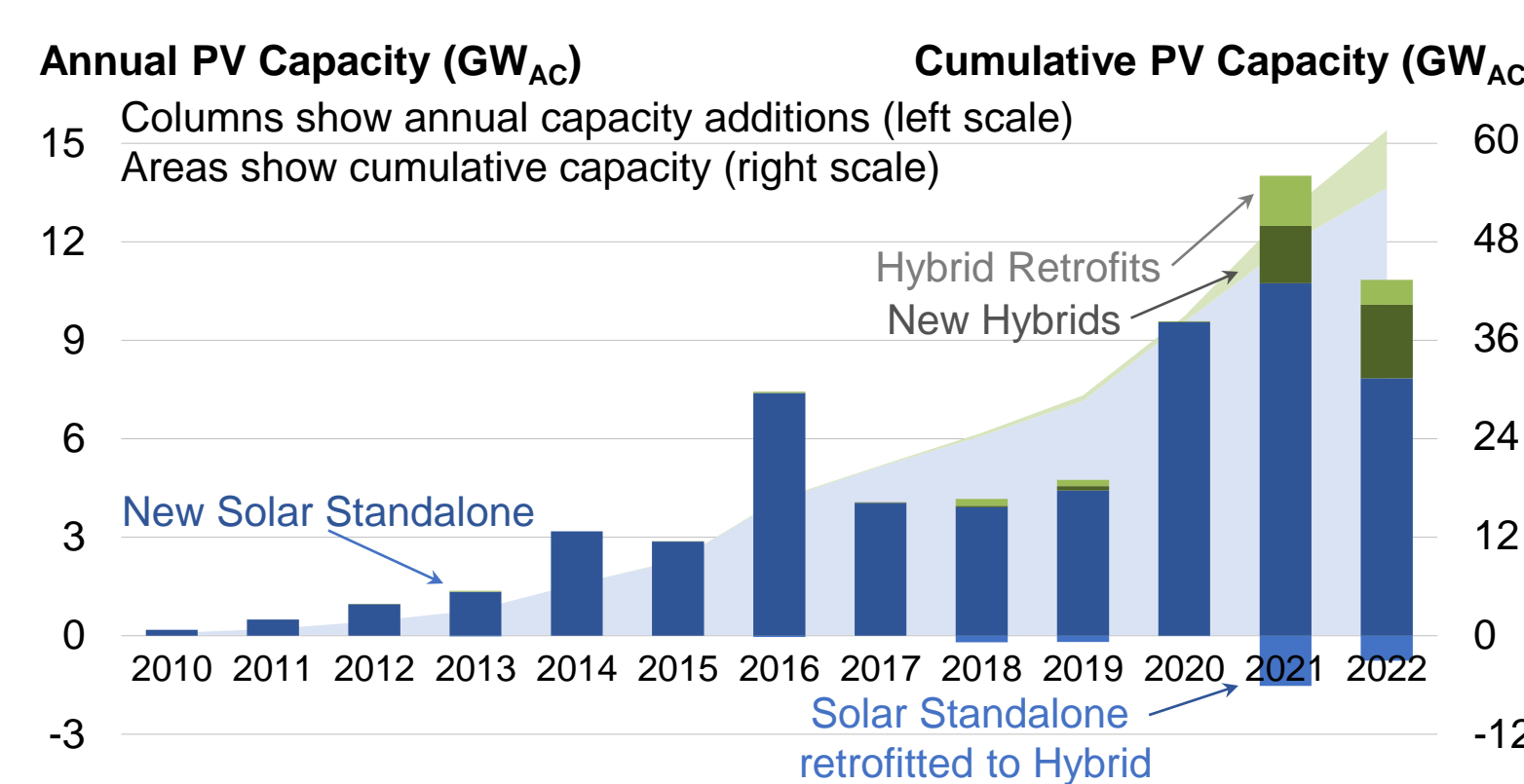
## 7. Outlook

The figure on the right tracks 947 GW of large-scale solar working its way through 42 interconnection queues of different ISOs and RTOs at the end of 2022. 332 GW of this total entered the queues in 2022 (the remainder entered in earlier years, and remain active), although not all of these projects will be built.

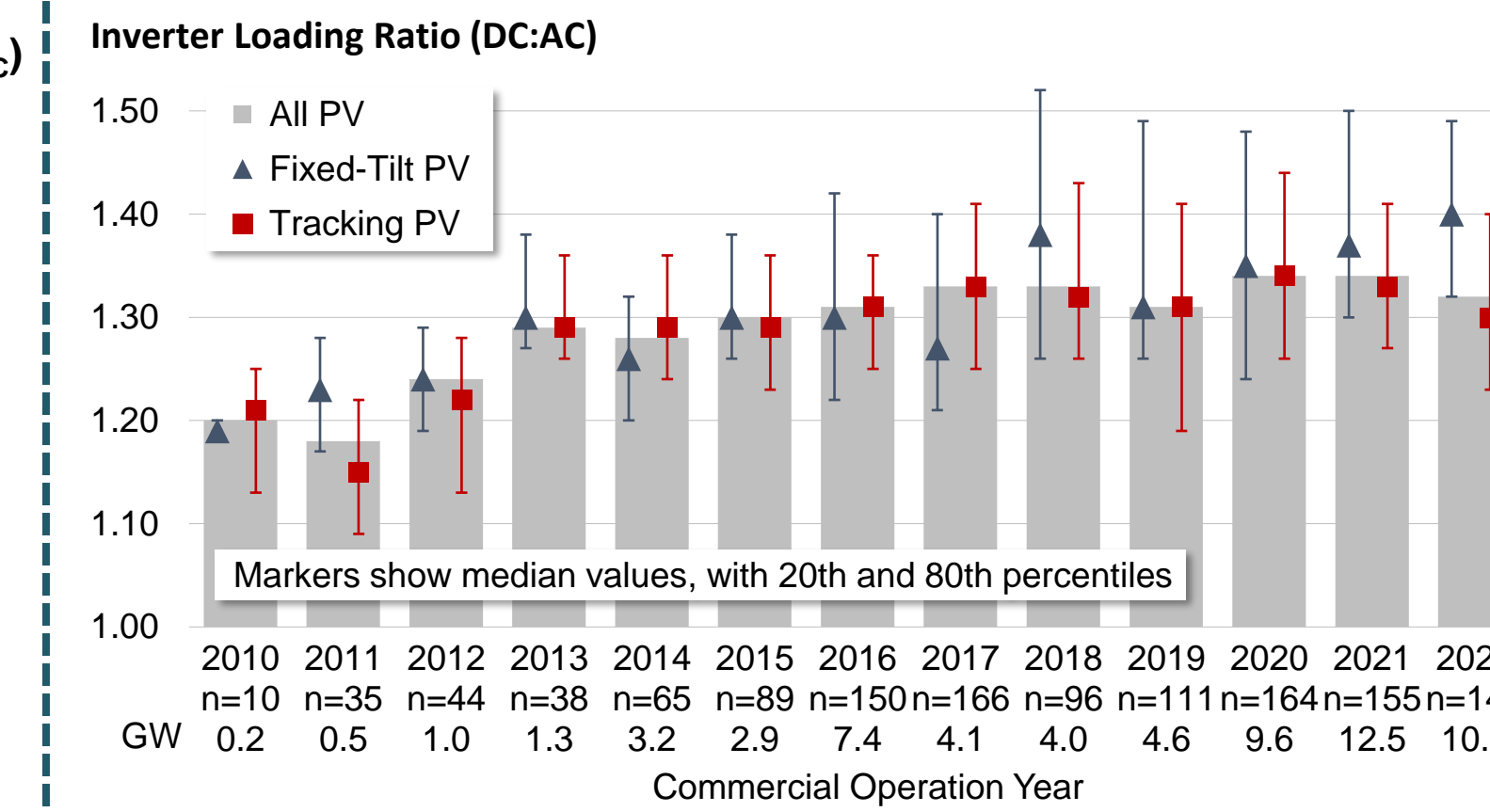
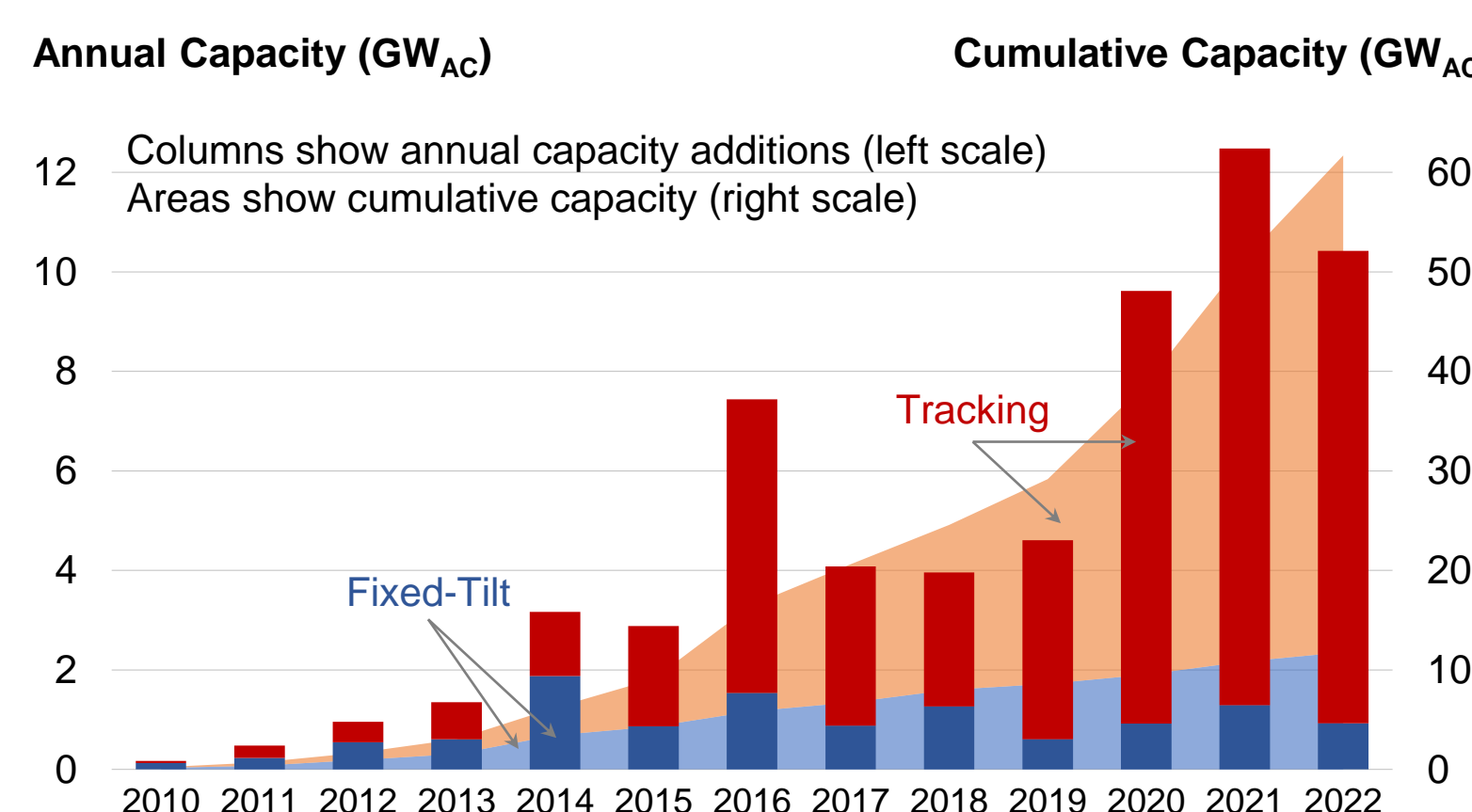
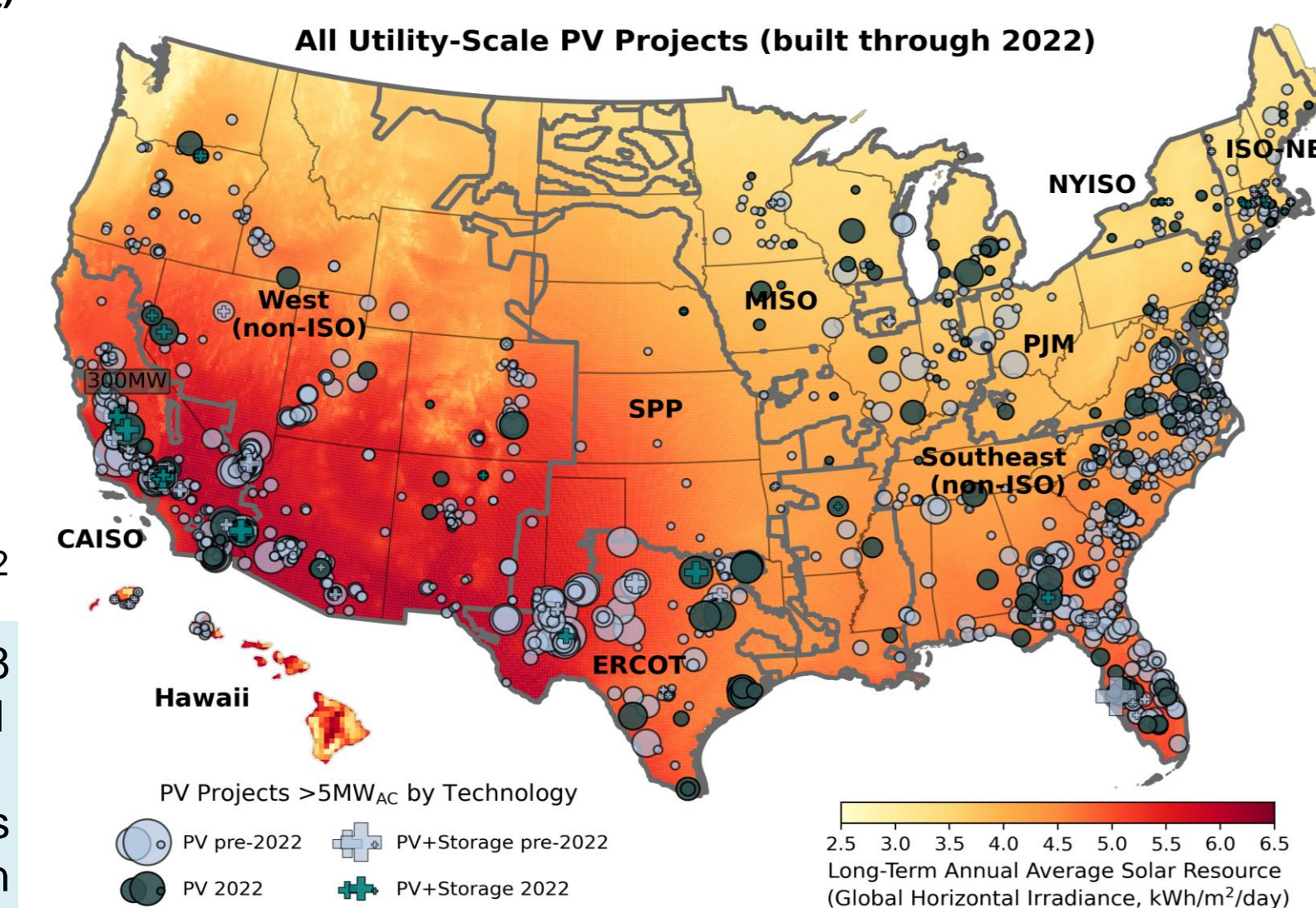
439 GW of the 947 GW of solar in the queues (46%) includes a battery in a PV hybrid configuration. Nearly all (97%) of the solar capacity in CAISO's queue at the end of 2022 was hybridized; in the non-ISO West it is 81%.



## 2. Technology Trends



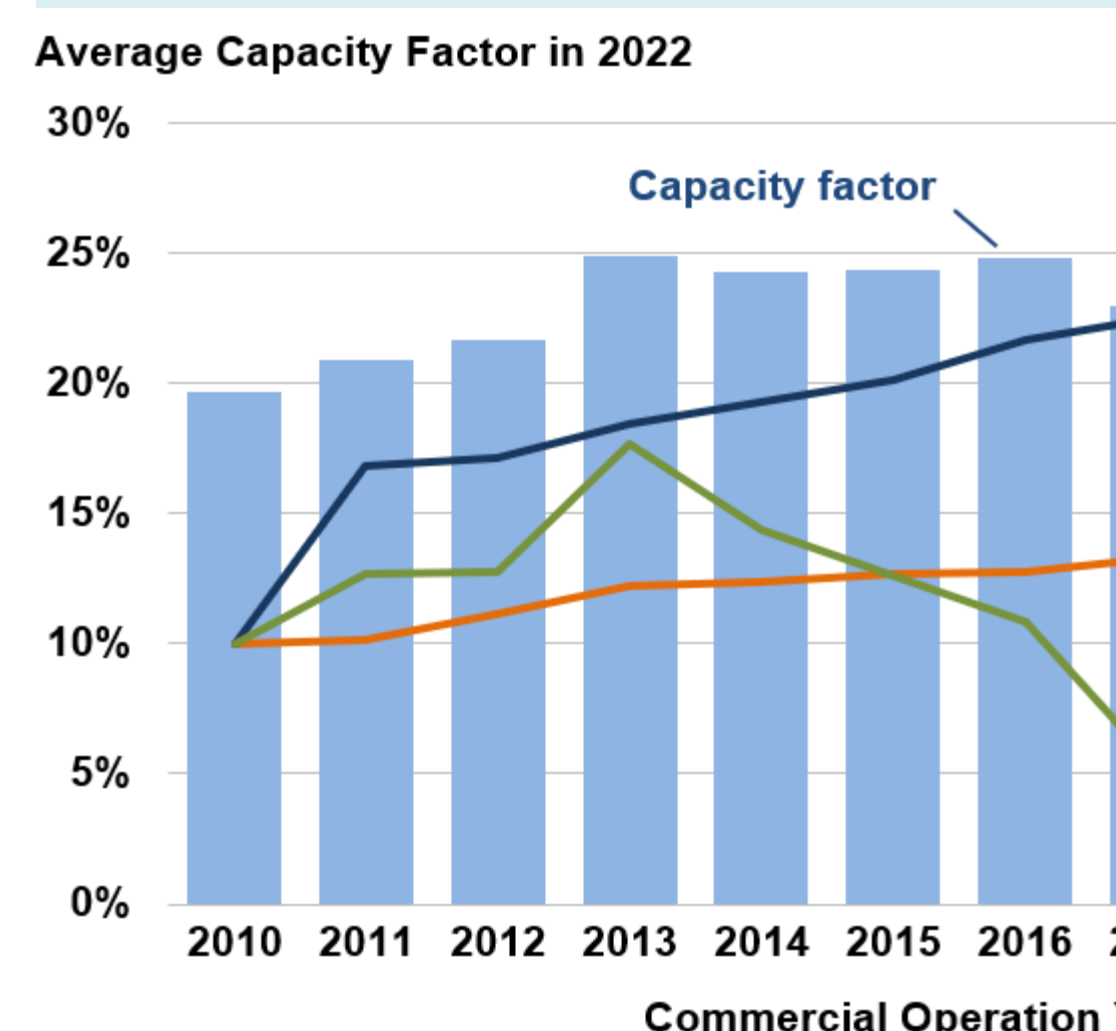
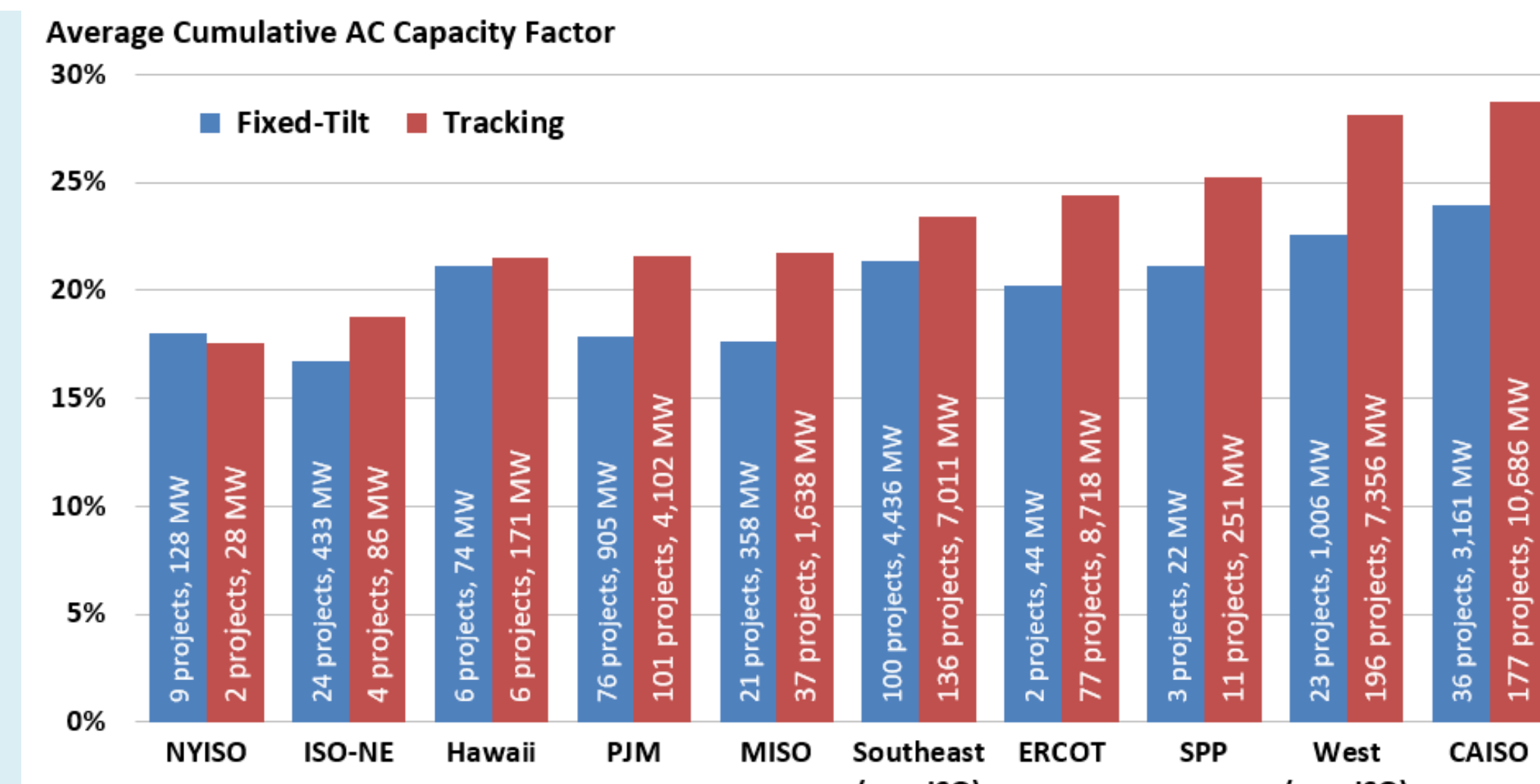
- The 26 new hybrids in 2022 nearly matched the record of 28 set in 2021, however there were fewer retrofits at just 4. (2021 saw 17 retrofits.)
- >90% of all new stand-alone PV capacity uses single-axis tracking. The DC-AC ratio is higher for fixed-tilt (1.4) than tracking (1.3) projects.



## 4. Project Performance

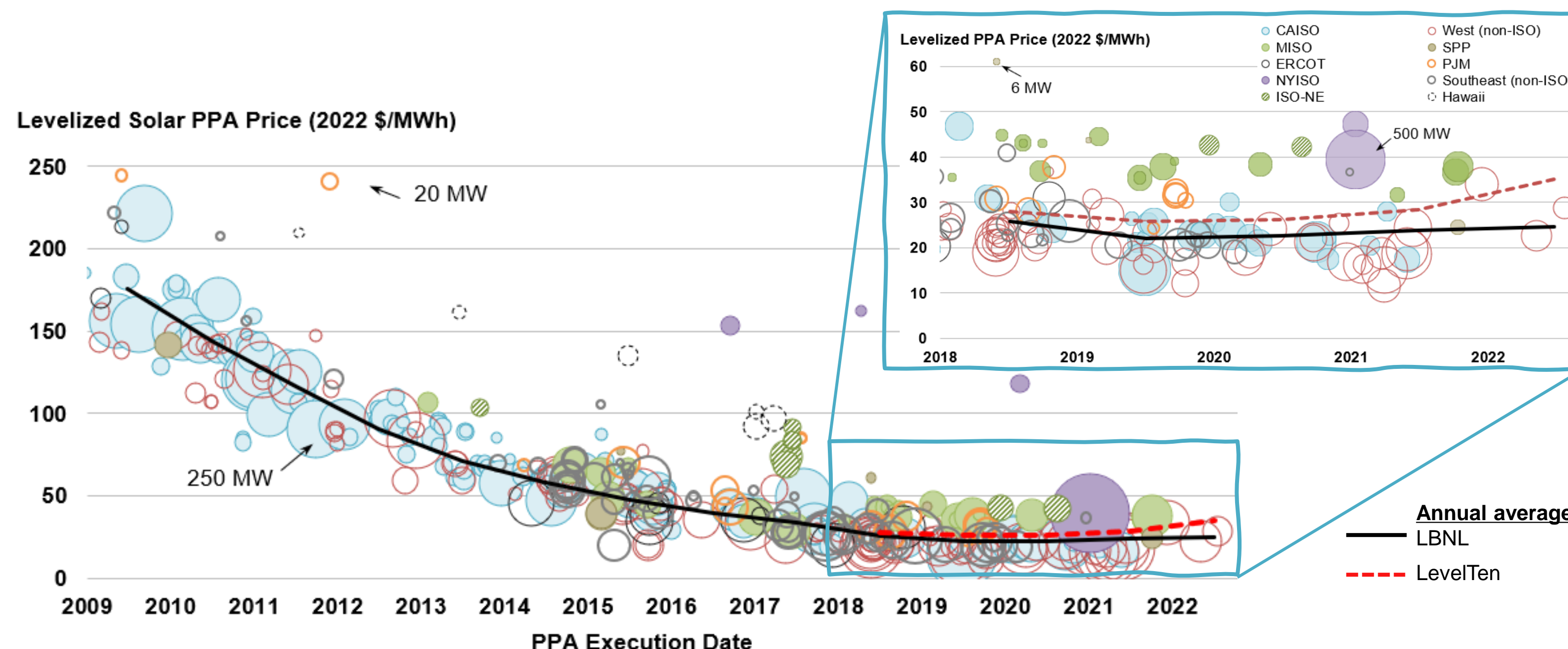
The Net Capacity Factors (NCF) of individual projects in this sample range widely, from 9% to 35%, with a median of 24%. The NCFs above are *cumulative*, calculated over as many years of data as available, rather than just 2022.

We express Capacity Factors in *net* rather than *gross* terms (accounting for a project's own consumption) and give all NCFs in AC terms (higher than NCF<sub>DC</sub>).



The 2013 project cohort performed the best on average. The utility-scale solar market has since then expanded to less sunny areas of the U.S., but increasing use of tracking technology and a higher inverter loading ratio now kept average national performance rather stable near 25%.

## 6. Power Purchase Agreement (PPA) Prices



Power Purchase Agreement (PPA) prices are levelized over the full term of each contract, after accounting for any escalation rates and/or time-of-delivery factors, and are shown in real 2022 dollars. Aided by the 30% ITC, most recent PPAs in our sample are priced around \$20/MWh for projects in CAISO and the non-ISO West, and \$25-\$50/MWh for projects elsewhere in the continental United States. This puts solar PPA prices below the wholesale market valuation of solar generation in 2022 in all ISO regions and ten additional BAs.

## 8. References

The information on this poster is an excerpt of LBNL's annual report on utility-scale solar. The series is available for free at <https://utilityscalesolar.lbl.gov>

M. Bolinger, J. Seel, J. Kemp, C. Warner, A. Katta, D. Robson. Utility-Scale Solar 2023 Edition: "Empirical Trends in Deployment, Technology, Cost, Performance, Pricing Trends, and Value in the USA". Berkeley, CA: Lawrence Berkeley National Laboratory. 2023

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<https://emp.lbl.gov/projects/solar>

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