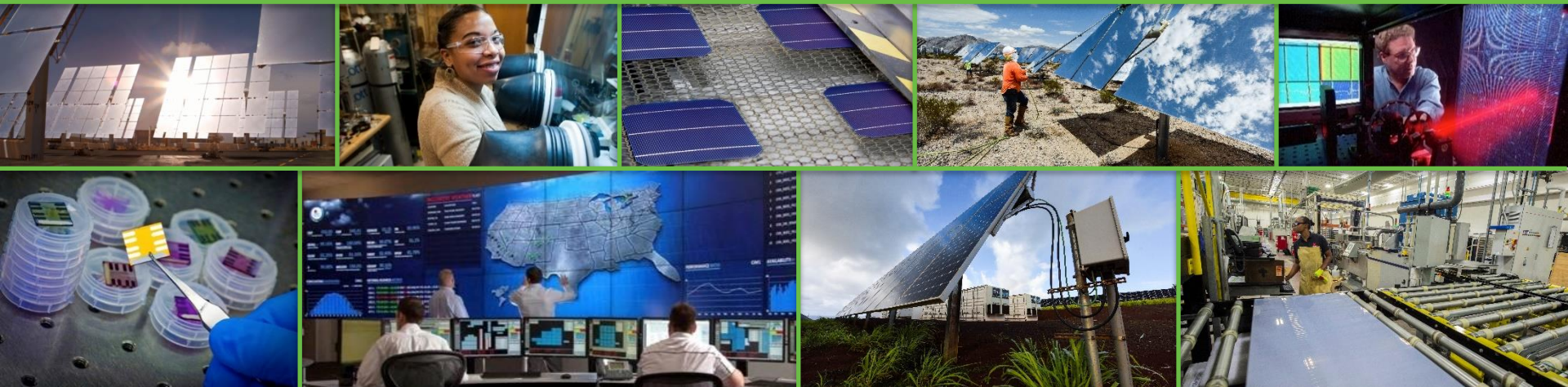


The State of the Solar Industry

Becca Jones-Albertus, Director

Contributors: Krysta Dummit, David Feldman, Shayna Grossman, and Jarett Zuboy

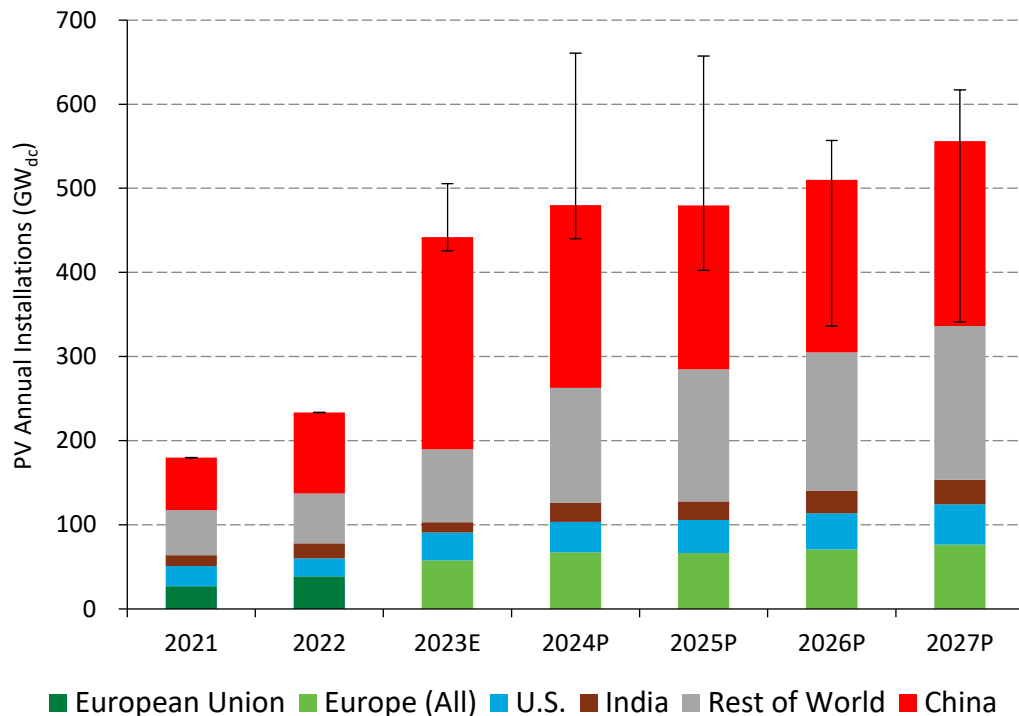
March 2024



Outline

- **PV Deployment Overview**
- **PV Manufacturing Overview**
- **CSP Market Overview**

Global PV Deployment Reaches 1.6 TW_{dc}



- Analysts estimate 2023 global installations reached around 440 GW_{dc}, an 89% increase over 2022 installations, bringing cumulative global capacity to approximately 1.6 TW_{dc}.
- A significant portion of the increase came from China, which deployed around 250 GW_{dc} of solar.
- Overall, analysts expect the industry to continue to grow, however the range of near-term growth projections is substantial.

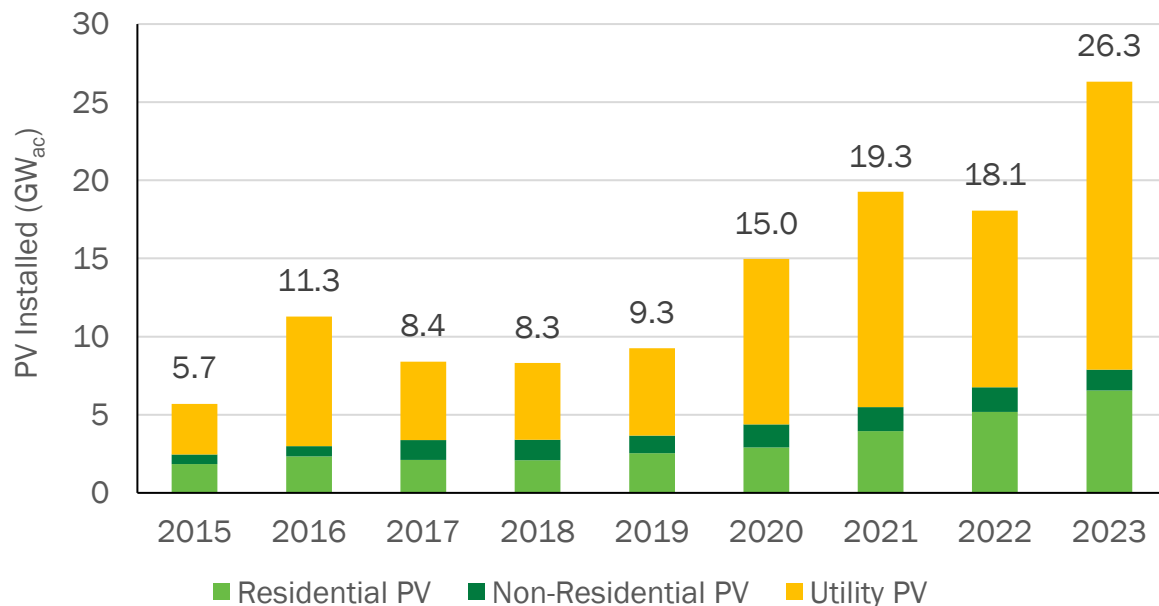
Notes: E = estimate; P = projection. Bar totals represent median global projections across analysts who provide a global projection. Error bars represent high and low global projections. Regional bar segments represent medians of all available regional projections. Where regional medians do not sum to global medians, the differences are reconciled by adjusting the Rest of World segments so the correct global median values are retained.

Sources: BNEF, 4Q 2023/1Q 2024 Global PV Market Outlook; EIA, Annual Energy Outlook 2023, 3/23; Fitch Ratings ([02/07/24](#)); Goldman Sachs Equity Research, America's Clean Technology: Solar, 12/17/23; SolarPower Europe, Global Market Outlook For Solar Power 2023–2027, 6/23; Wood Mackenzie, Three Predictions for Global Solar in 2024, 1/24; Wood Mackenzie, Q1 2024 Solar Executive Briefing, 10/23.

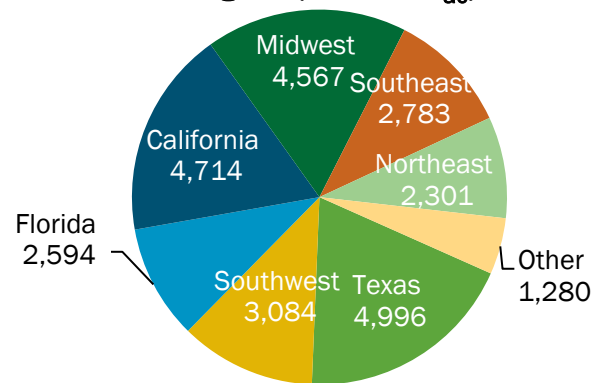
A Historic Level of U.S. Deployment, totaling 177 GW_{dc}/138 GW_{ac}

- The United States installed 26 GW_{ac} (33 GW_{dc}) of PV in 2023—up 46% y/y.

U.S. PV Installations by Market Segment



2023 U.S. PV Installations by Region (26.3 GW_{ac})

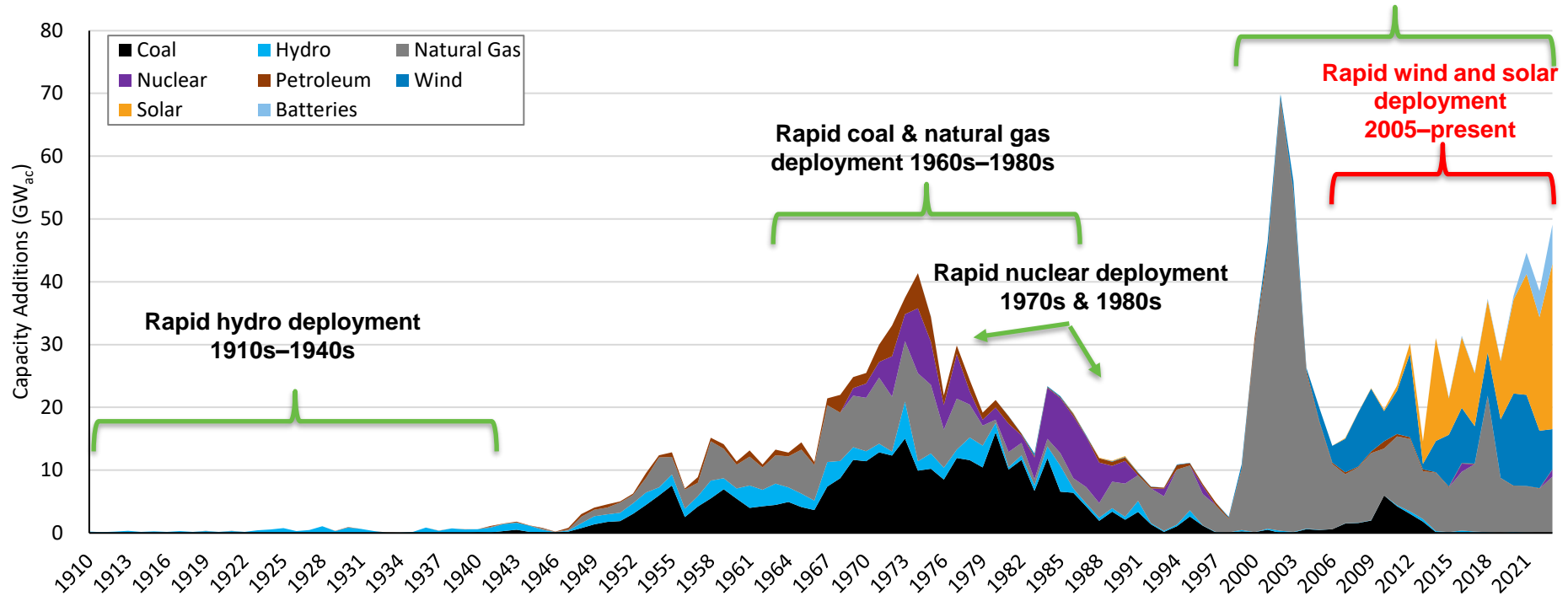


Note: EIA reports values in W_{ac} which is standard for utilities. The solar industry has traditionally reported in W_{dc}.

Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (March 2024, April 2022, February 2021, February 2019).

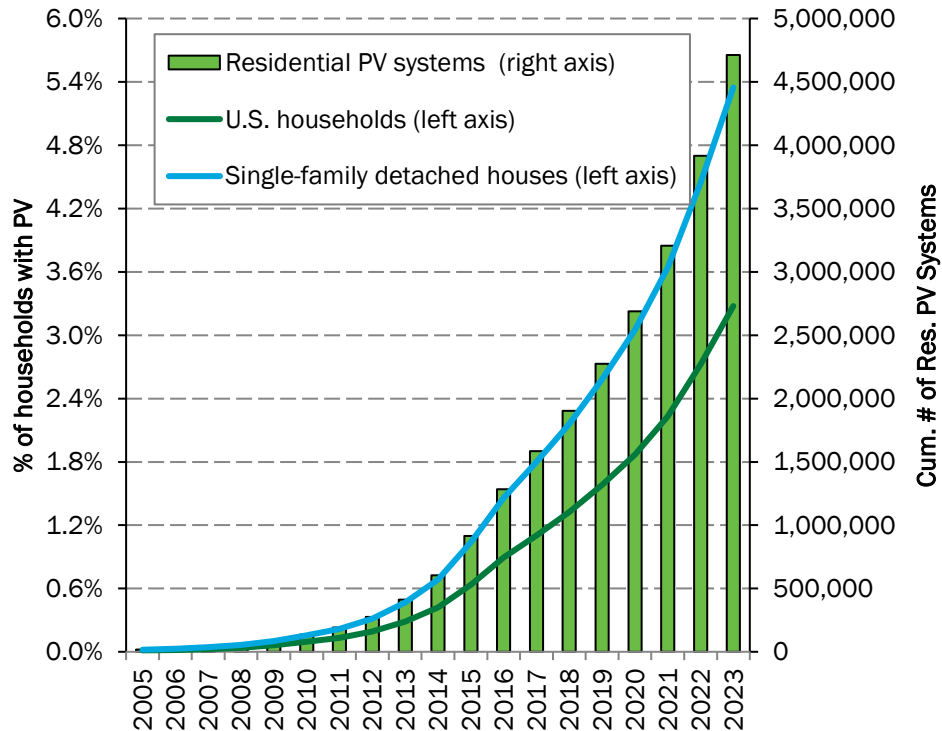
The Era of PV and Wind (and Natural Gas)

Despite the modest percentage of electricity from solar, it represents the largest source of new electricity generation in the U.S., on a scale seen few times before.



Sources: EIA.U.S installed capacity, Form 860. & Electric Power Monthly (March 2024). EIA, [Energy Kids](#).

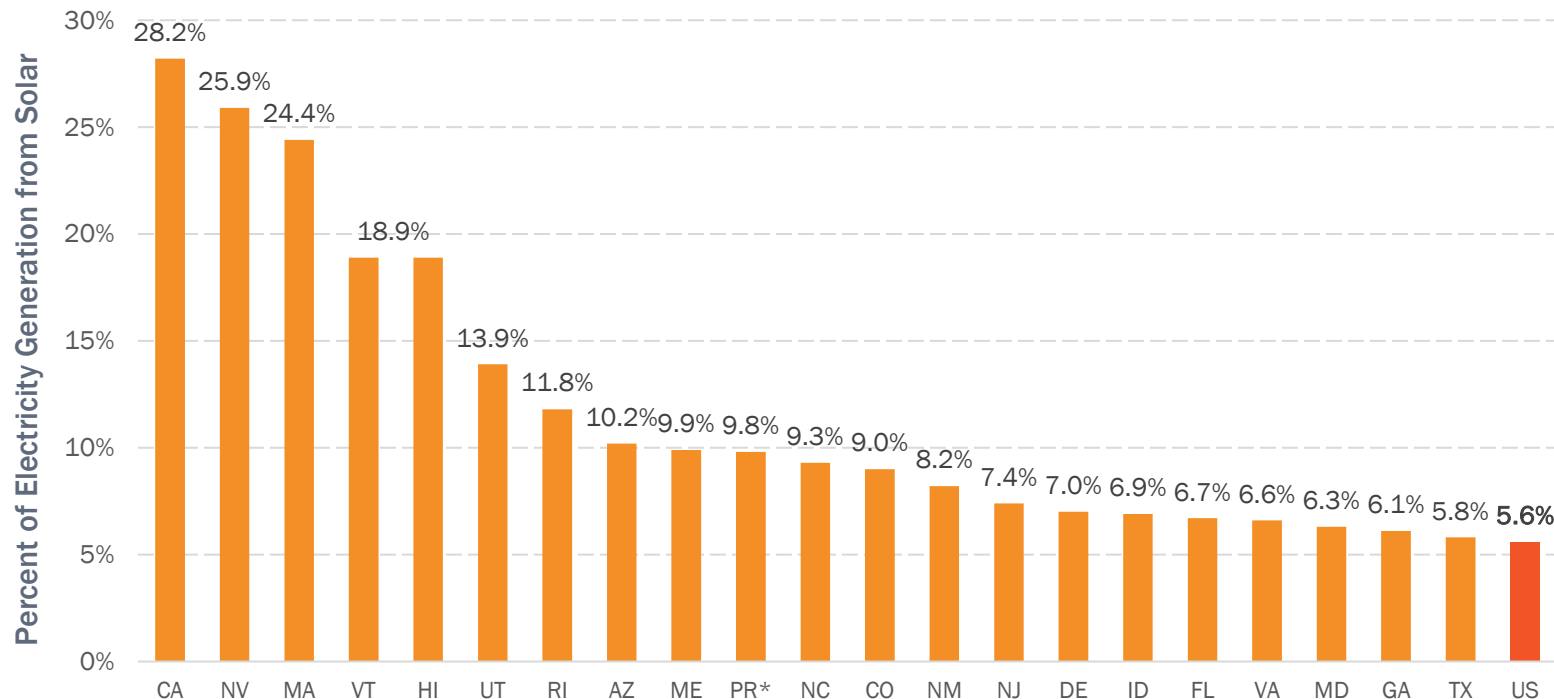
U.S. Residential PV Penetration



- **At the end of 2023, SEIA estimates there were nearly 5 million residential PV systems in the United States.**
 - 3.3% of households own or lease a PV system (or 5.3% of households living in single-family detached structures).
 - Top states for share of solar on single-family detached structures:
 - Hawaii: 35%
 - California: 23%
 - Arizona: 14%

Sources: Res. PV Installations: 2000-2009, IREC 2010 Solar Market Trends Report; 2010-2022, SEIA/Wood Mackenzie [Solar Market Insight 2023 Year-in-Review](#); U.S. Households from [U.S. Census Bureau](#).

State-by-State Electricity from Solar (2023)

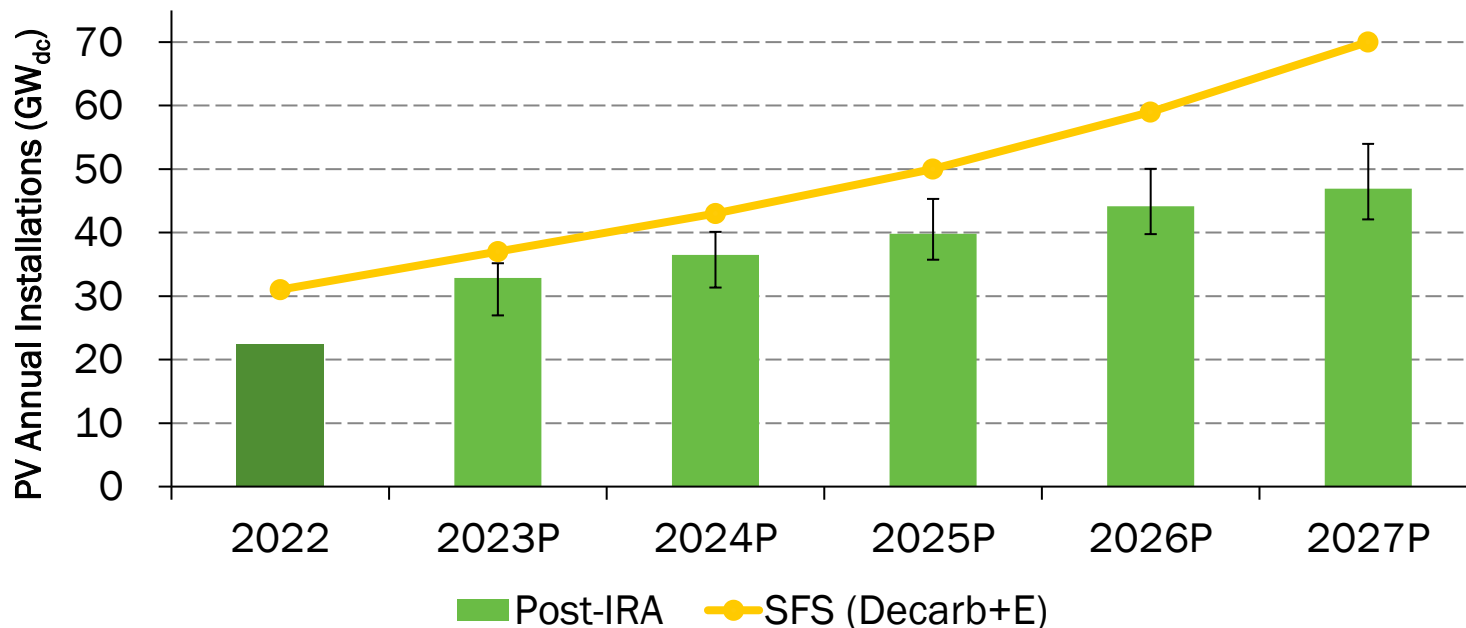


Sources: U.S. Energy Information Administration, “Electric Power Monthly,” forms EIA-023, EIA-826, and EIA-861. U.S. Energy Information Administration, “Electricity Data Browser.” Accessed March 4, 2024. *EIA does not estimate distributed PV production in Puerto Rico; utility-scale values derived from EIA Form 923 and distributed PV values represent estimates based on capacity installations from EIA Form 861 and system production from PVWatts.

Note: EIA monthly data for 2023 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported. “Net Generation” includes DPV generation. Net generation does not take into account imports and exports to and from each state and therefore the percentage of solar consumed in each state may vary from its percentage of net generation.

But, PV Deployment Too Slow to Decarbonize Grid by 2035

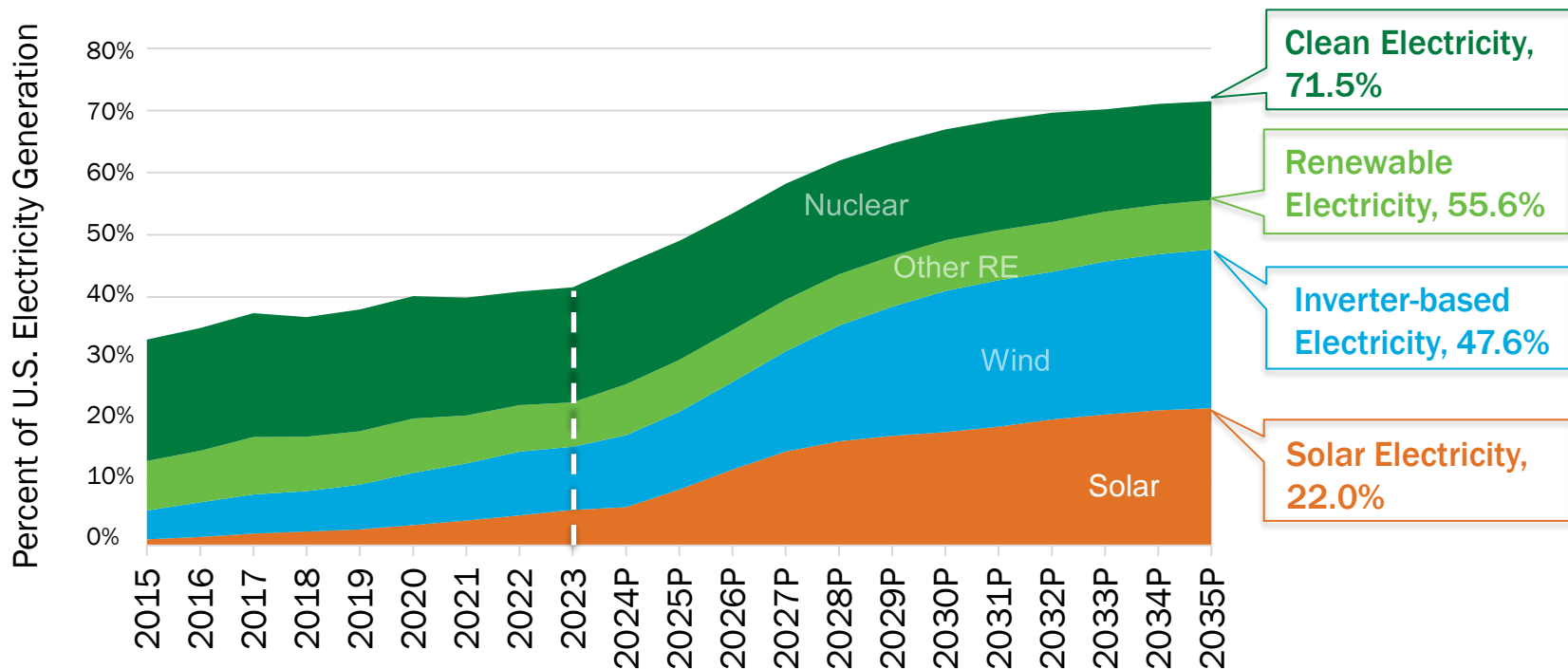
Projected PV deployment (green bars) is growing as a result of the Inflation Reduction Act, but is not on track to reach the levels needed to enable a decarbonized grid by 2035 (yellow line)



Notes: P = projection. Colored bars represent average projections, and error bars represent high and low projections, line represents the Decarb+E scenario from the Solar Futures Study (SFS).

Sources: BNEF, 2Q 2022 Global PV Market Outlook, 5/27/22; BNEF, 2Q 2023 Global PV Market Outlook, 5/22/23; Wood Mackenzie and SEIA, Q2 2022 US Solar Market Insight, 6/22; Wood Mackenzie and SEIA, Q2 2023 US Solar Market Insight, 6/23. Adapted from U.S. Department of Energy, Solar Futures Study, 9/21.

Progress in Decarbonizing the Grid



Solar electricity is driving the decarbonization of the U.S. grid.

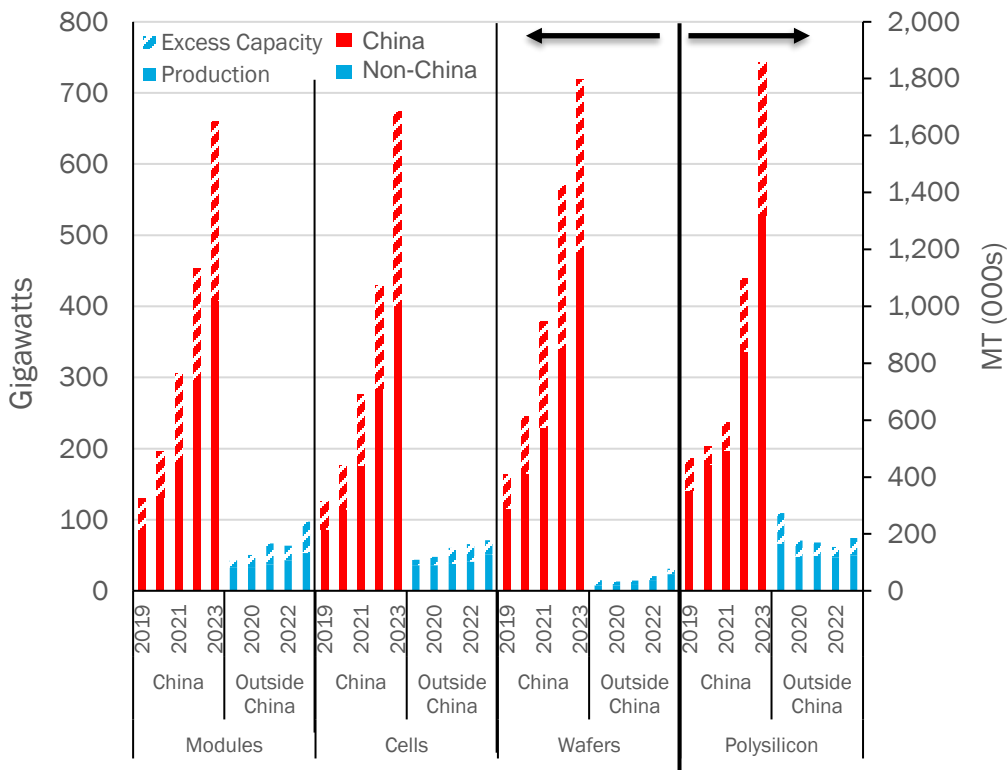
Notes: RE = Renewable Energy (hydroelectric, geothermal, biomass, etc.), P = Projection (EIA's Reference Case)

Sources: U.S. Energy Information Administration (EIA), "Electricity Data Browser." Accessed March 21, 2024 ; EIA "Annual Energy Outlook 2023." Accessed March 21, 2024.

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Growth in Global PV Manufacturing Capacity

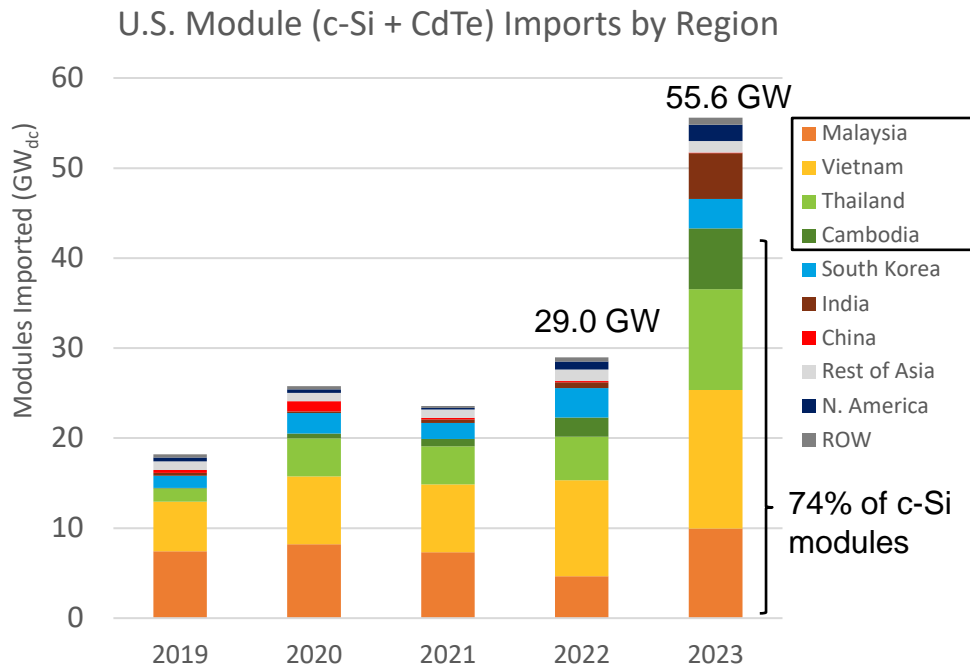


- At the end of 2023, global PV manufacturing capacity was between 650 and 750 GW.
- 30%-40% of polysilicon, cell, and module manufacturing capacity came online in 2023.
- In 2023, global PV production was between 400 and 500 GW.
- While non-Chinese manufacturing has grown, most new capacity continues to come from China.
- Analysts project that it may take years for production to catch up with capacity.
 - However, the amount of current global capacity is what we would need to be installing to meet our climate goals.

Note: Data represent median values from multiple sources.

Sources: Goldman Sachs (12/17/23), PVTech Research, "PV Manufacturing & Technology Quarterly Report - Release 31 - November 2023."

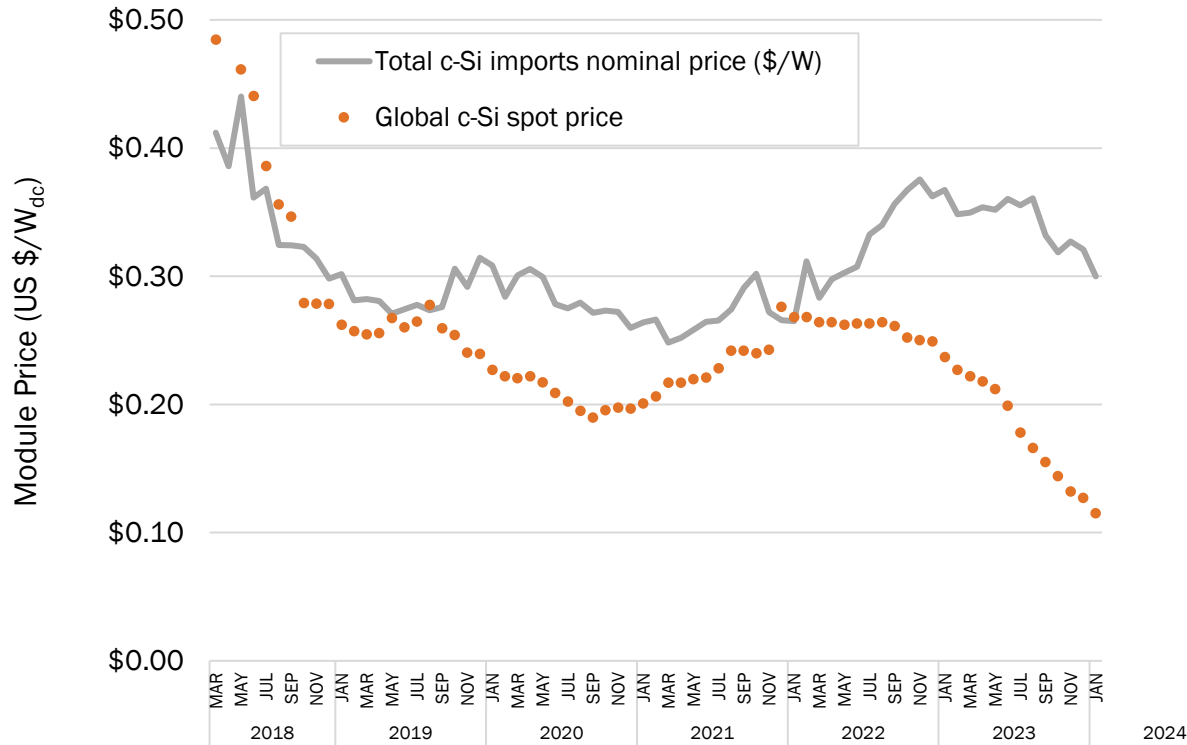
However, the U.S. Relies on Southeast Asia for Wafers, Cells & Modules



Source: U.S. Census Bureau [USA Trade Online tool](#) and [corrections page](#) as of 2/7/24.

- Silicon solar cells and modules for the US market are manufactured outside of China due to AD/CVD
- The recent circumvention decision is also pushing silicon wafers from China to SE Asia
- The polysilicon for U.S. products is sourced from the U.S., Germany and China

c-Si PV Module Prices: The Protected U.S. Market

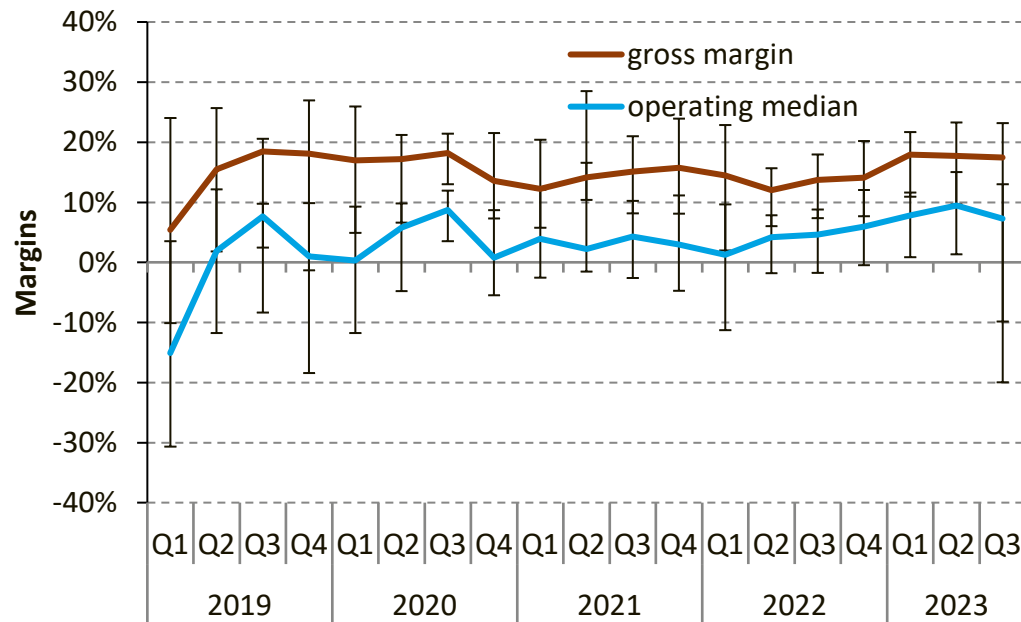


Sources: U.S. Census Bureau [USA Trade Online tool](#) and [corrections page](#) as of 3/12/24. BloombergNEF, Solar Spot Price Index (1/17/24)

*nominal price = the price paid at the time of transaction (i.e., not adjusted for inflation or put another way: the raw data values that anyone could download from public sources)

**real price = the price adjusted for inflation

PV Manufacturer Margins



- Despite global price drops across the PV supply chain, PV manufacturers generally remained profitable through Q3 2023, thanks to increases in sales volumes (particularly for n-type technologies).
- However, pricing has continued to drop, and we may see a drop in margins soon.

Lines represent the median, with error bars representing 80th and 20th percentiles for the following companies in Q3 2023: Canadian Solar, First Solar, JA Solar, Jinko Solar, LONGi, Moxeon, Motech Industries, REC Silicon, Renesola, Risen, Shanghai Aiko, Shanghai Aerospace, Tongwei, Trina Solar, and United Renewable Energy.

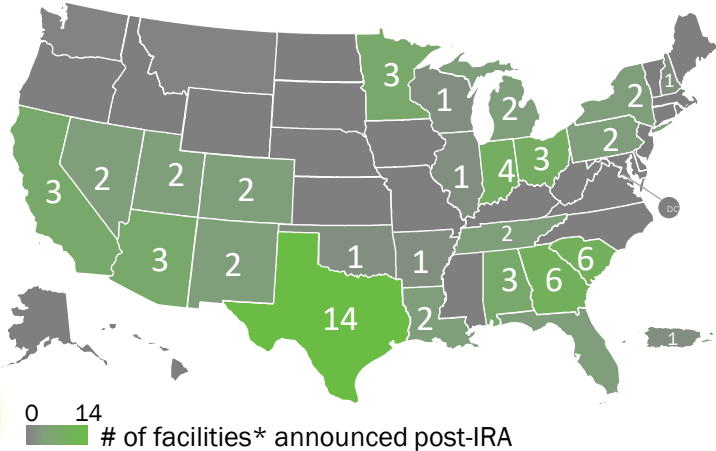
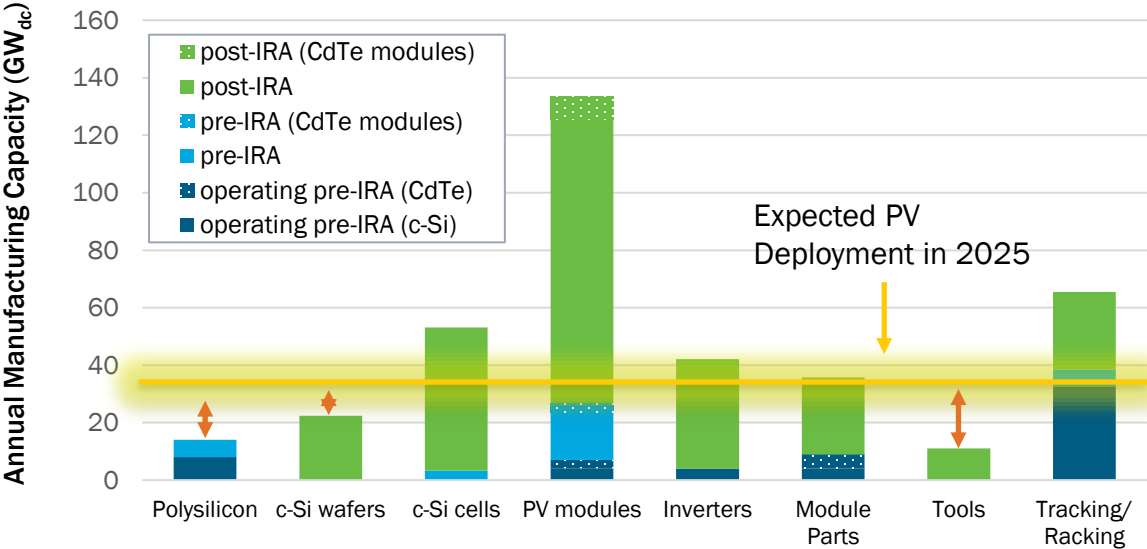
Note: Gross margin = revenue minus cost of goods sold (i.e., the money a company retains after incurring the direct costs associated with producing the goods or services it sells); operating margin = gross margin minus overhead and operating expenses (i.e., the money a company retains before taxes and financing expenses).

Sources: Company figures based on public filings and finance.yahoo.com.

IRA Impacts on U.S. Solar PV Manufacturing Capacity

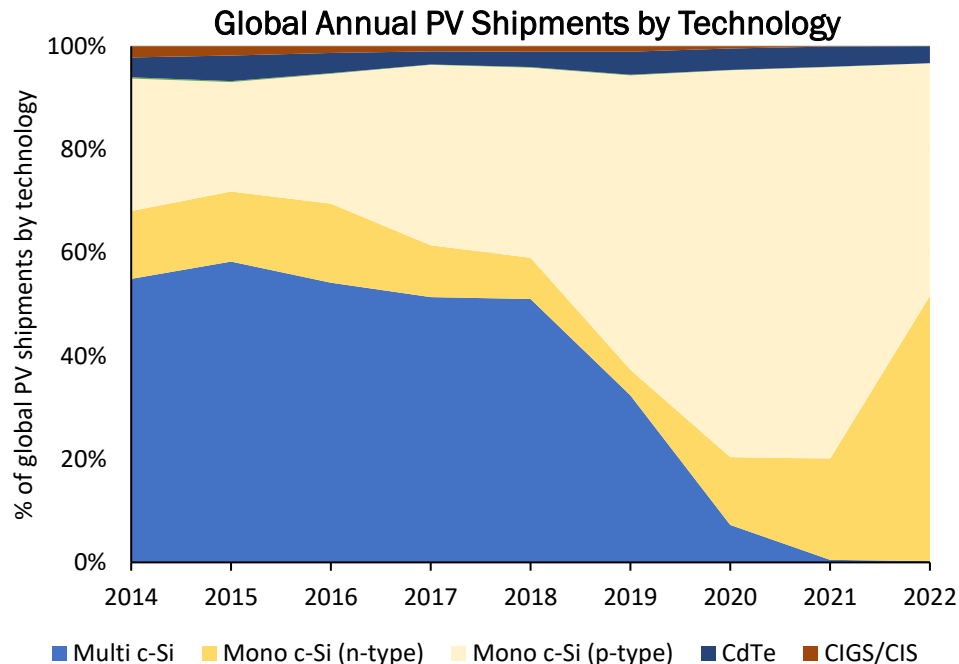
Since IRA's passage, over 280 GW of manufacturing capacity has been announced across the solar supply chain, representing **nearly 28,000 potential jobs** and **more than \$14 billion in announced investments** across **90 new facilities or expansions**.

Manufacturing Announcements by Supply Chain Segment



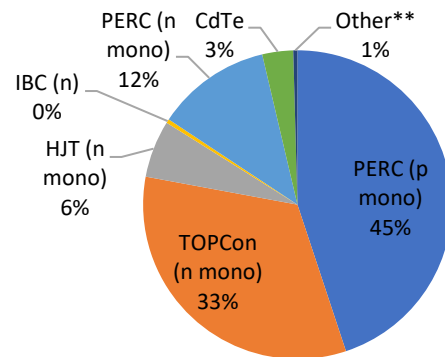
Sources: U.S. Census Bureau USA Trade Online and internal DOE tracking of public announcements. *Not all announcements include facility locations, job, or investment numbers.

Global Annual PV Shipments by Technology*



- In 2022, 96% of PV shipments were mono c-Si technology, compared to 35% in 2015.
- n-type mono c-Si grew to 51% - up from 20% in 2021 (and 5% in 2019).
- Mono p-type PERC was the leading cell type in 2022, followed by TOPCon, mono n-type PERC, and HJT.

2022 Global PV Shipments by Technology



*Notes: excludes inventory sales and outsourcing

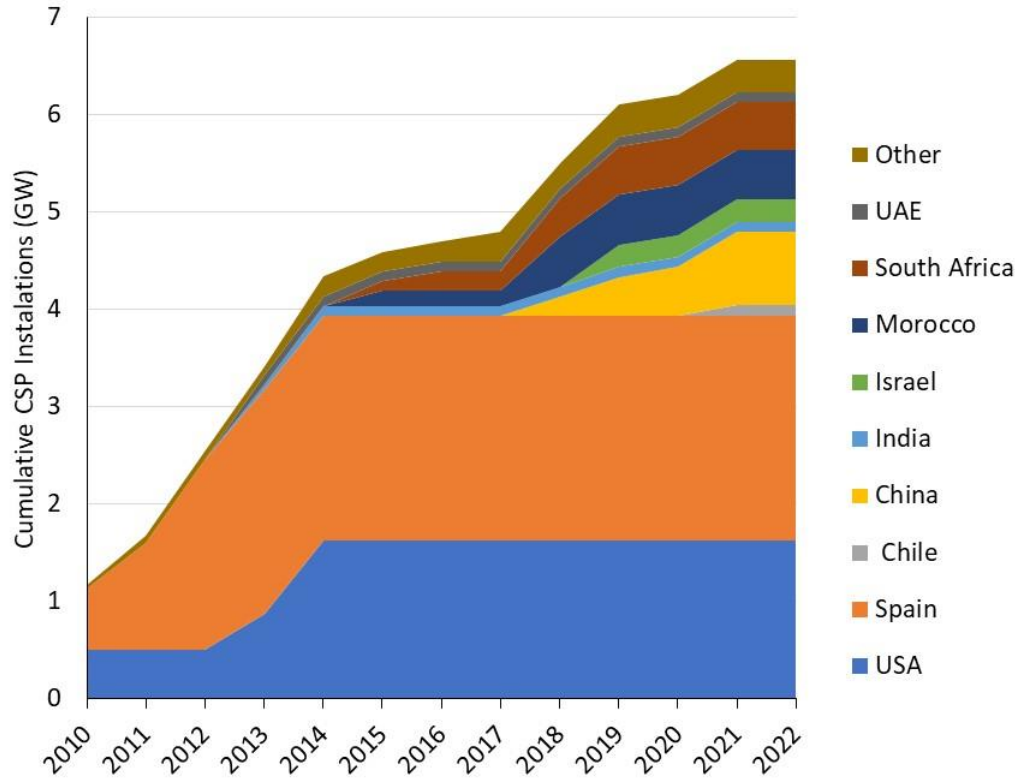
** includes a-Si, CIS/CIGS, TOPCon (p-type Mono), and multi PERC.

Source: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2022/2023." SPV Market Research. Report SPV-Supply11. April 2023.

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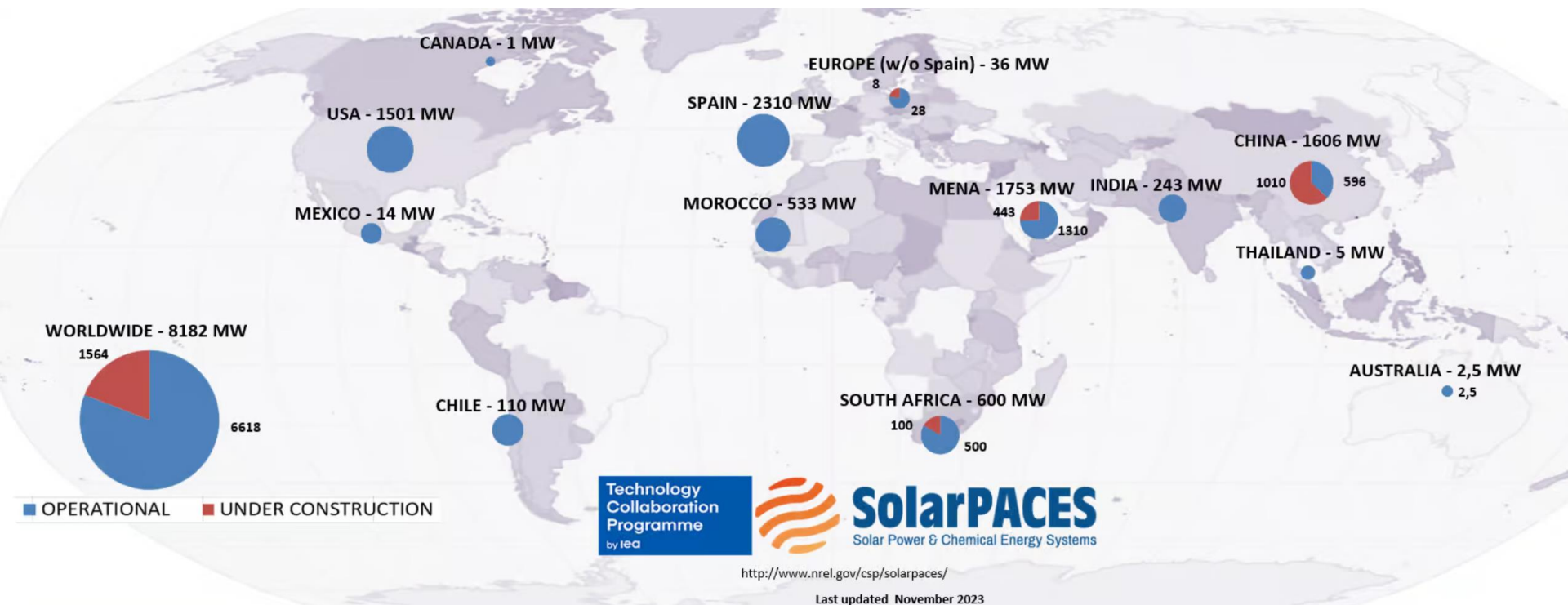
Global CSP Capacity



- At the end of 2022, global CSP capacity reached approximately 6.6 GW.
- Cumulative global CSP installations were almost six times higher in 2022 than in 2010.
 - Initially most of the growth came from Spain (first-largest) and the United States (second-largest).
- From 2015 to 2021, 2.6 GW of CSP was installed in other parts of the world, particularly the Middle East, North Africa, South Africa, and China.
 - There was also development in other parts of the world, such as India and South America.

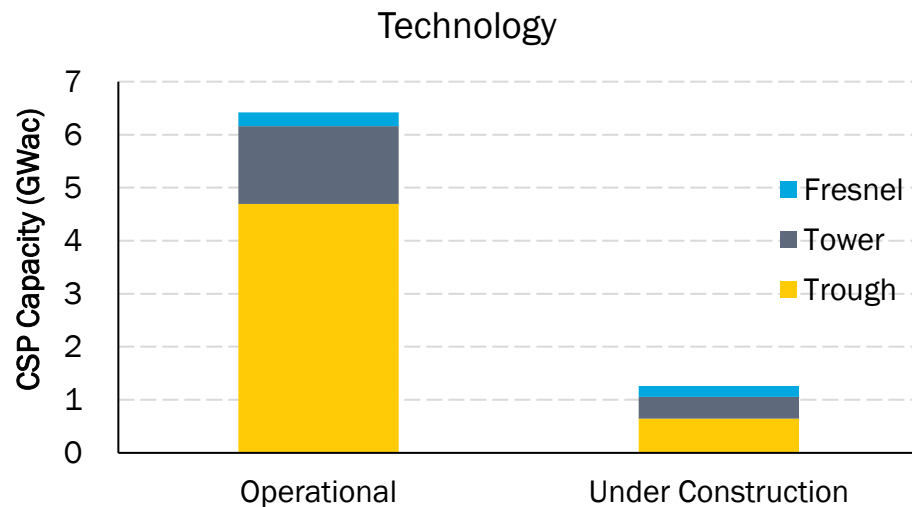
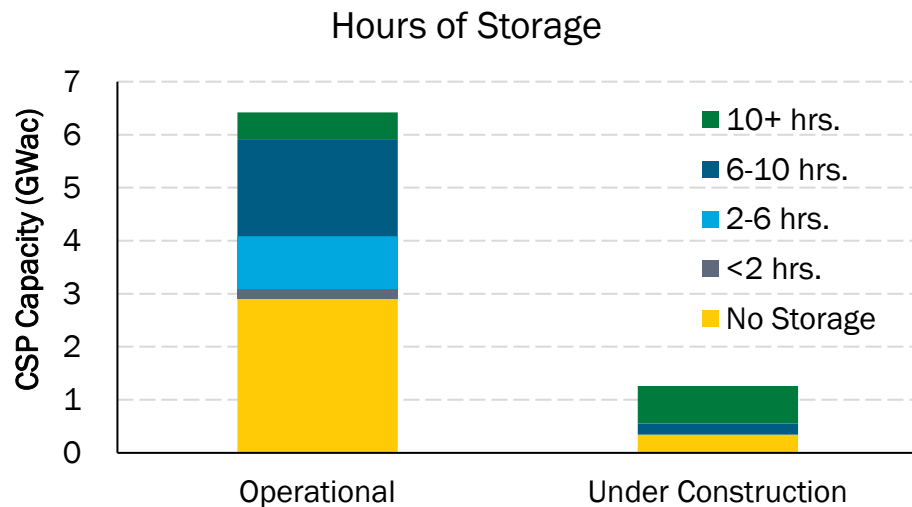
Sources: [The World Bank \(2021\)](#); [Ren21 \(2021\)](#); [NREL](#).

Global CSP Capacity



Global CSP Capacity

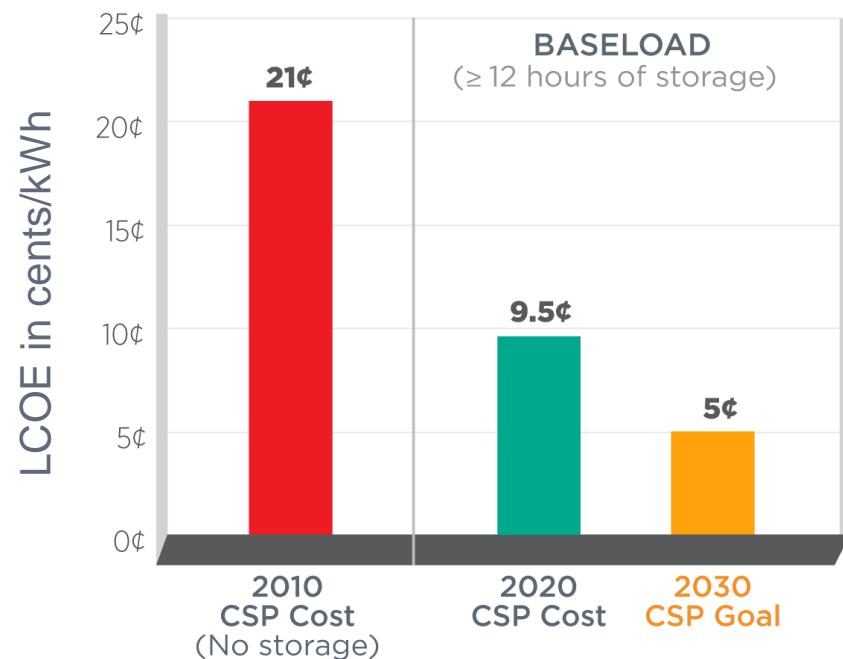
- Over half of CSP projects in operation have storage, with 36% of the capacity having 6 hours or more of storage.
- Projects under construction, on average, have storage, and longer hours of storage, than those currently in operation.
- 73% of current CSP capacity uses parabolic trough technology, compared to 51% of those under construction.



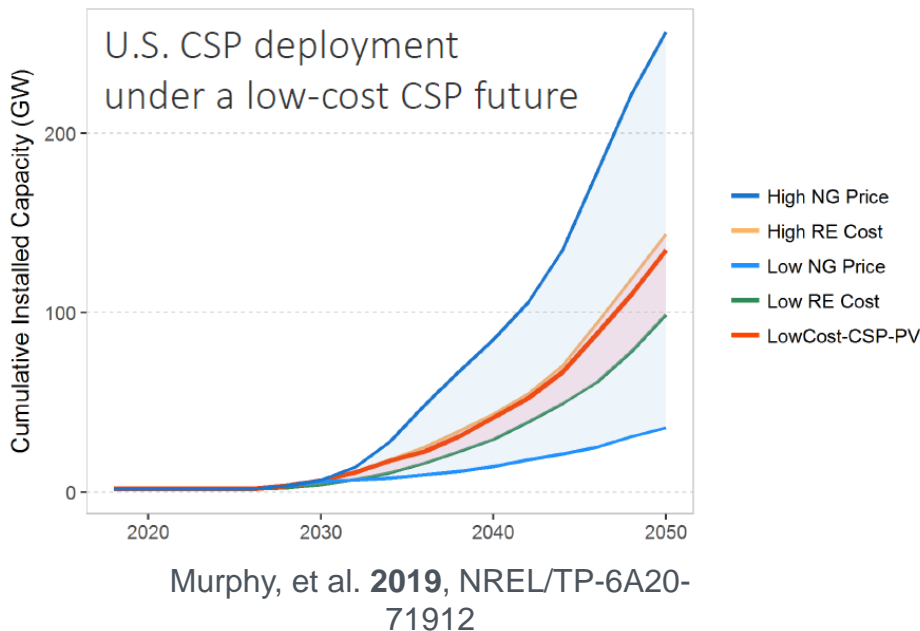
Sources: Richard Thonig, Alina Gilmanova & Johan Lilliestam. (2023). CSP.guru 2023-01-01 [Data set]. Zenodo.<https://doi.org/10.5281/zenodo.1318151>.

2030 CSP Cost Target

The office's 2030 cost targets for CSP baseload (≥ 12 hours of storage) plants will help make CSP competitive with other dispatchable generators.



*Levelized cost of energy (LCOE) progress and targets are calculated based on scenarios without federal tax credit or state/local incentives.



Study prior to passage of the Inflation Reduction Act