National Laboratory of the Rockies

Supply Chain for Photovoltaics in the United States: 2024 in Review

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IEEE Photovoltaics Specialists Conference, New Orleans, LA

June 9, 2026

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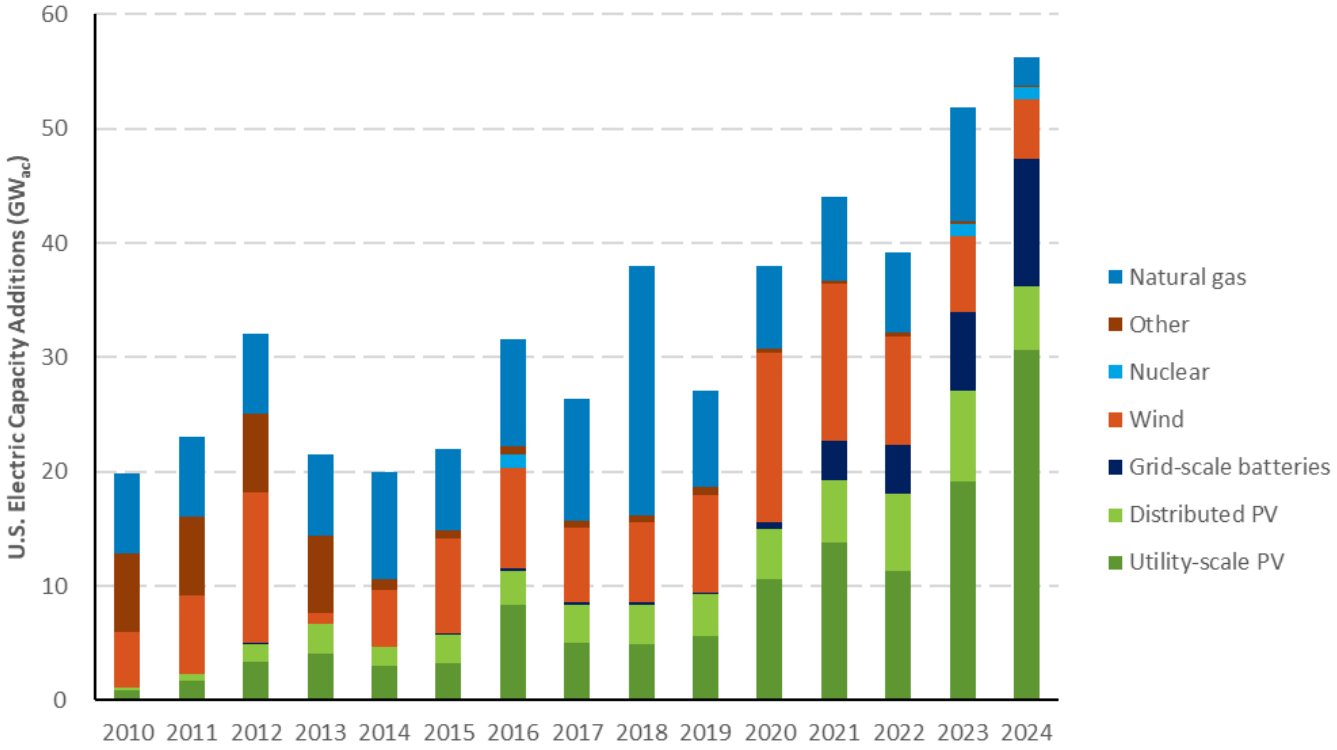
Outline

1. Historical PV Installations and Production in the U.S.
2. U.S. Market and Policy
3. Module Supply Chain and Manufacturing
4. State of U.S. Supply Chain for PV and BESS

Annual U.S. electric capacity additions, 2010–2024

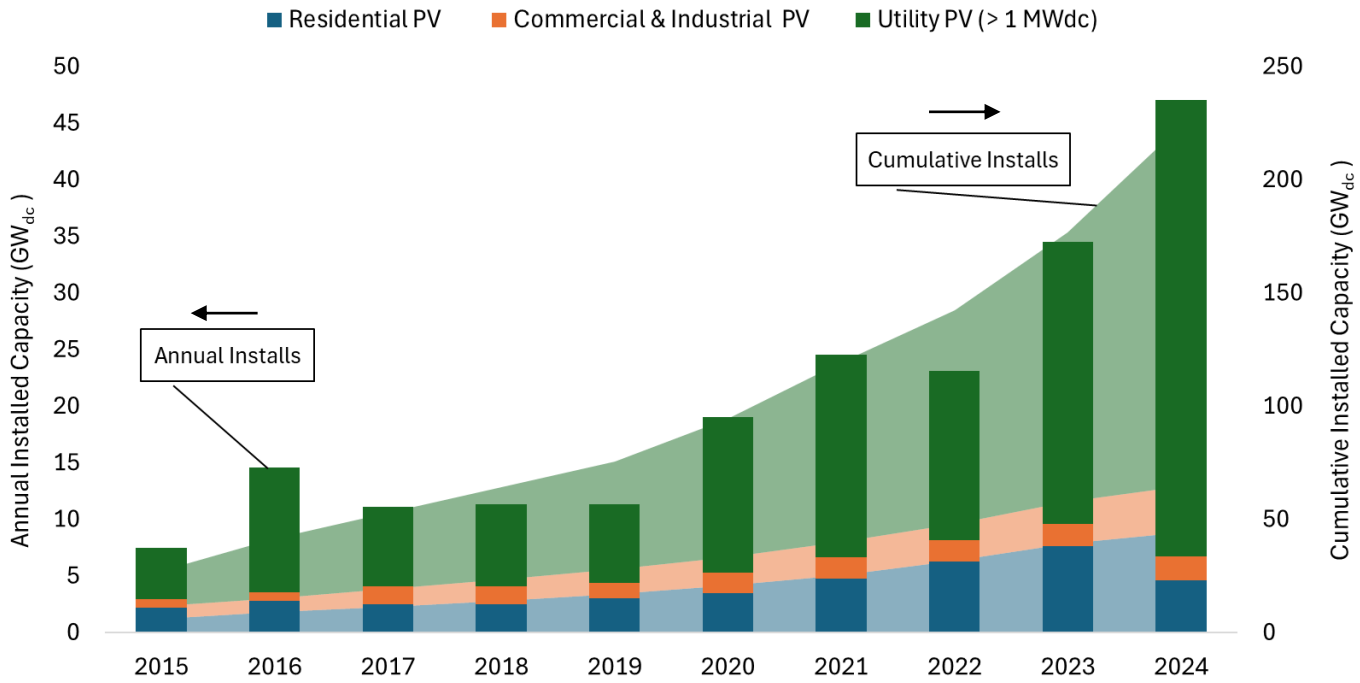


- PV, BESS represented increasing fraction of grid additions (~85%) in 2024
- BESS additions continue to grow dramatically year-on-year
- First significant slowing in distributed PV since 2013 more than compensated by utility PV additions

Note: "Other" includes coal, geothermal, landfill gas, biomass, and petroleum.
Sources: EIA, "Electric Power Monthly" Tables 6.1, 6.2B, 1.1, 1.1A; Form 860M & 861M, April 2025

Smith, *et al*. 2026

Annual and cumulative U.S. installation of residential, commercial, utility-scale PV



- Utility PV continues to dominate U.S. installs and at a growing fraction of total PV
- Residential installs dropped significantly from 2023 to 2024

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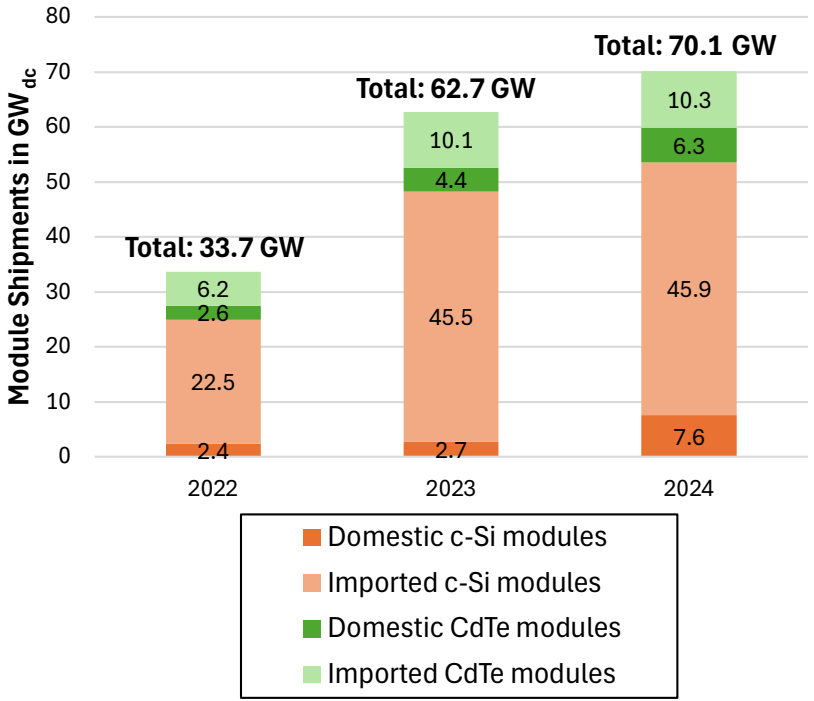
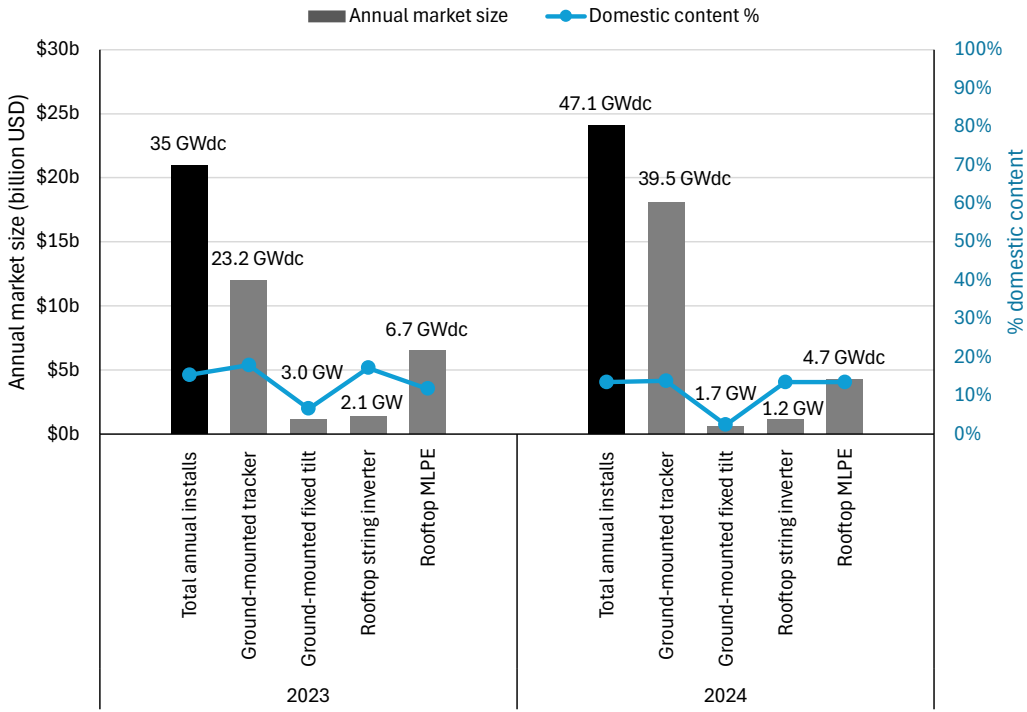
Annual market size and domestic content 2022-2024, by sector

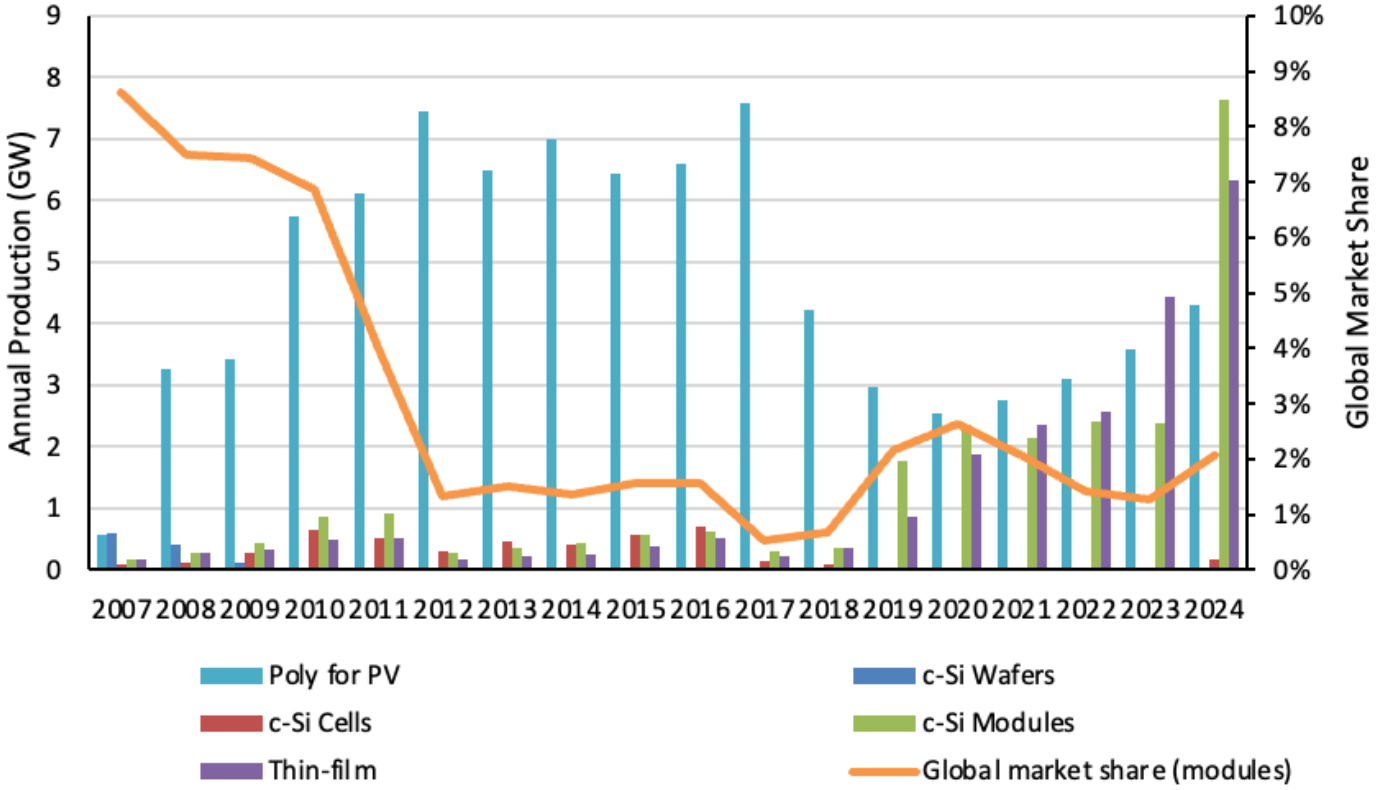




- Domestic modules (Si and CdTe) increased significantly in 2024 but still make up a small fraction of installs
- Domestic content in installed modules decreased slightly despite domestic module shipment growth

Smith, *et al*. 2026

U.S. production for PV, 2007–2024



- U.S. share of module production nearly doubled in 2024 from 1% to 2% (6.5 GW to 14 GW)
- 2024 saw first U.S. cell production since 2018
- Wafer capacity negligible since 2009
- Gradual increase in polysilicon production since lowest production in 2020

Smith, *et al*. 2026

Timeline of U.S. policies and trade actions relevant to PV and BESS, 2011–2024*

*non-exhaustive

AD/CVD = antidumping and countervailing duties

A-SMACC = American Solar Manufacturers Against Chinese Circumvention

BABA = Build America Buy America Act

DCB = domestic content bonus

DOE = U.S. Department of Energy

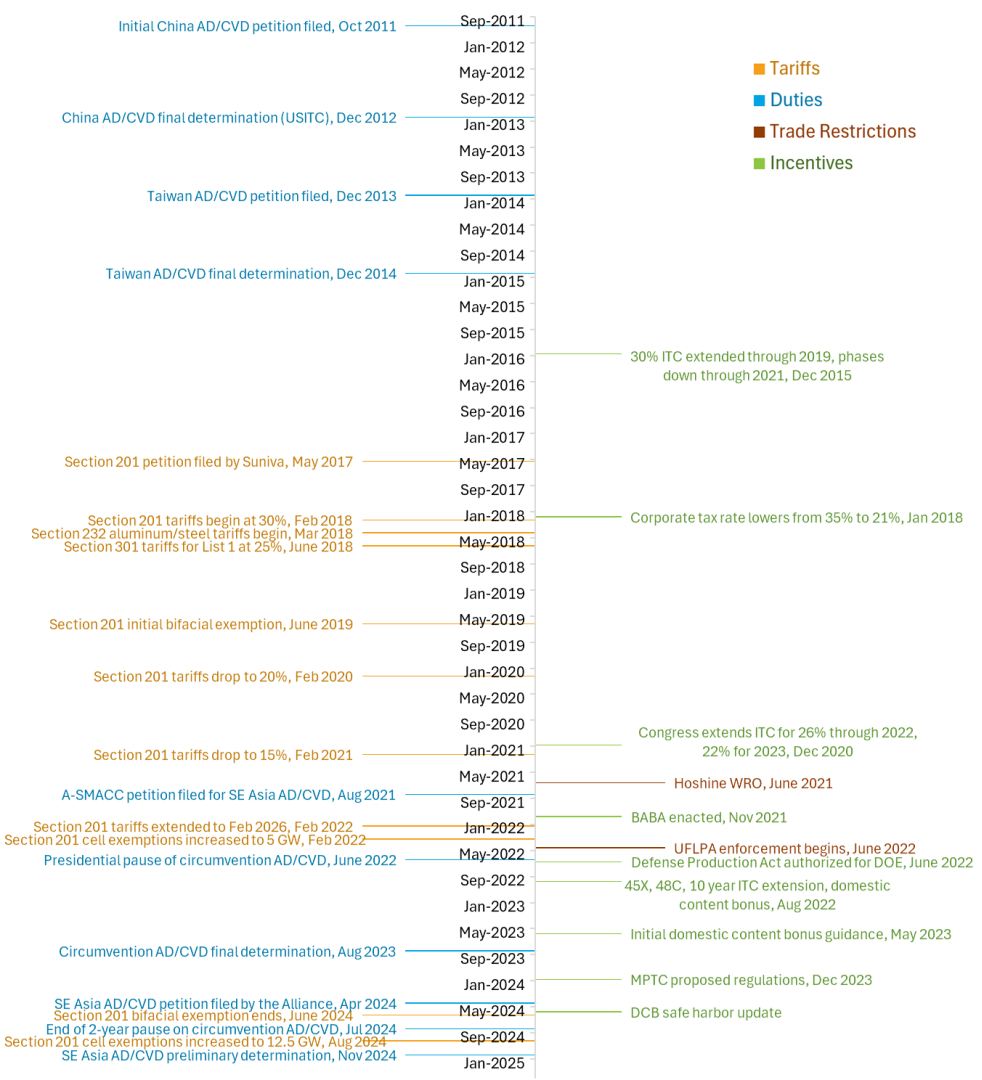
ITC = investment tax credit

MPTC = Advanced Manufacturing Production Tax Credit

UFLPA = Uyghur Forced Labor Prevention Act

USITC = U.S. International Trade Commission

WRO = withhold release order



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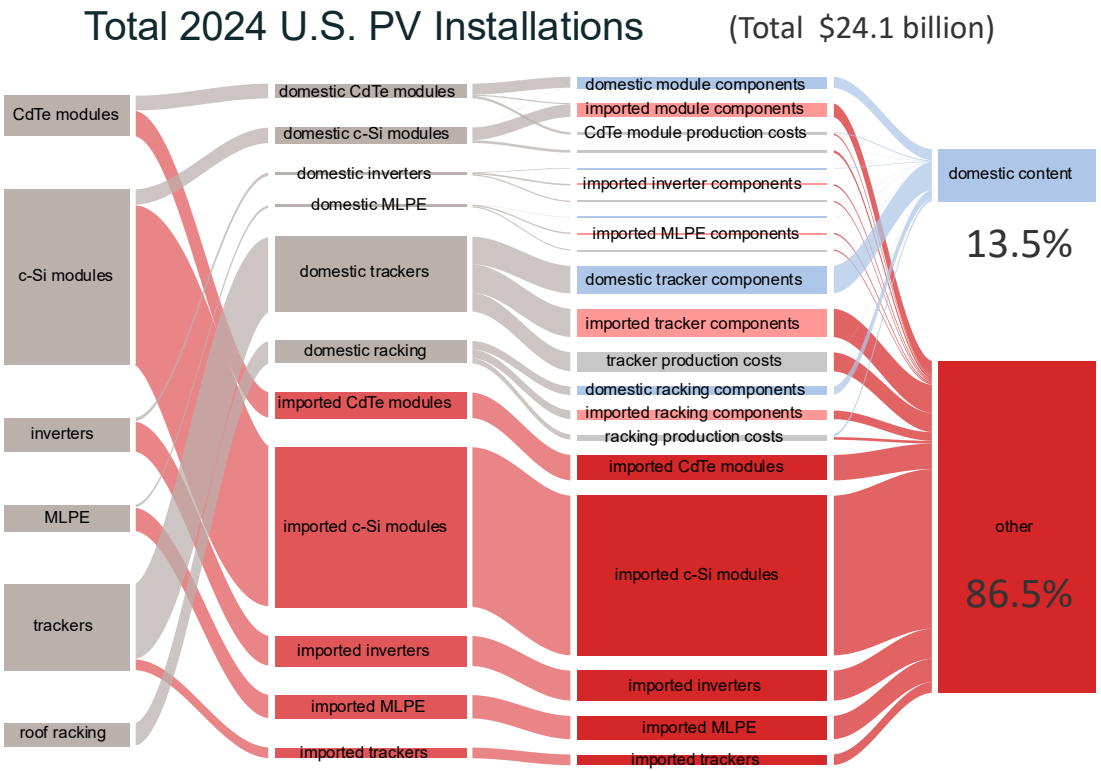
Domestic content of PV systems installed in the United States during 2024



- Not including BESS, domestic content constitutes 13.5% of PV system installations in U.S.
- Despite increased domestic module manufacturing, modules themselves represent largest import fraction
- inverters and module level power electronics (MLPE) have the lowest individual fraction of domestic content in installs
- Racking qualified for 100% domestic content with trackers had a high fraction as well

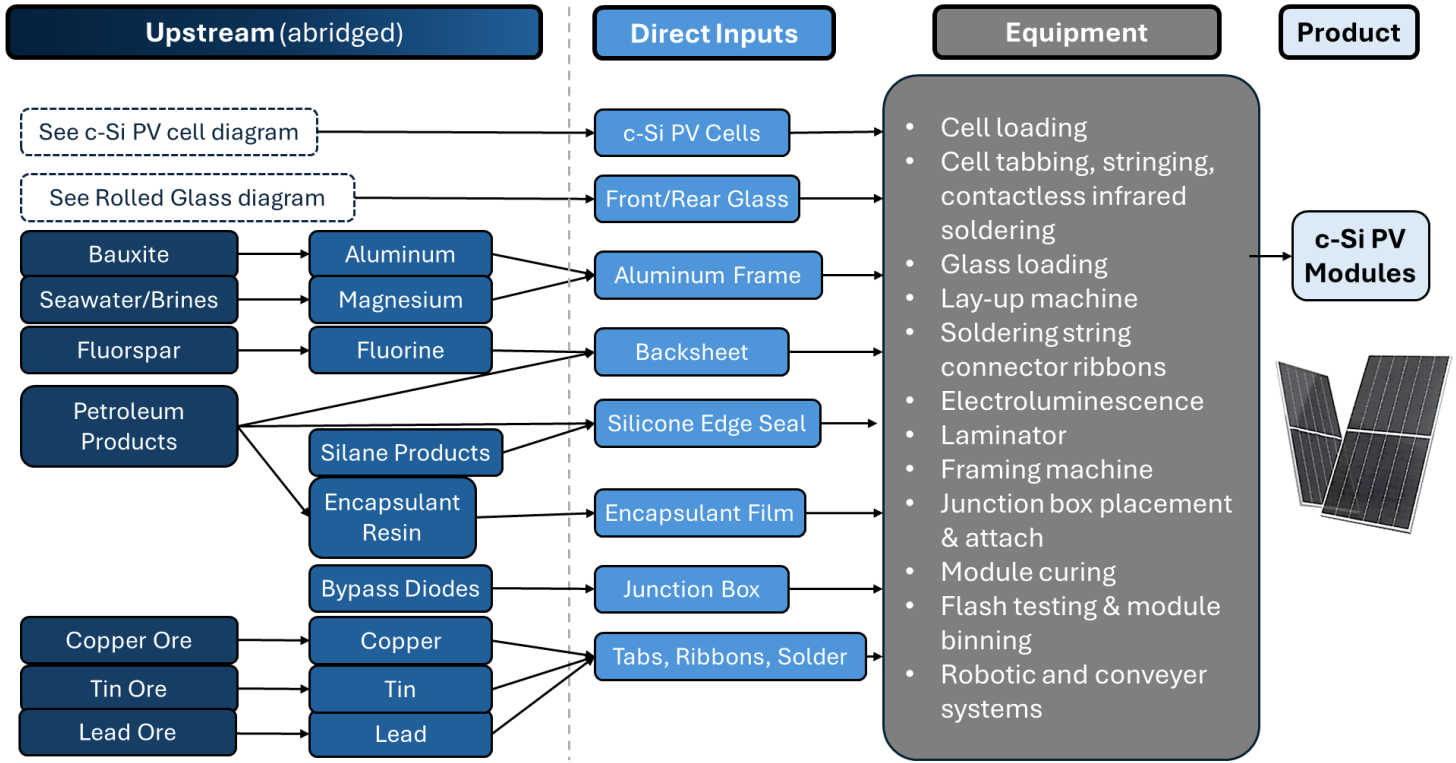
Total U.S. PV systems installed in 2024: 47.1 GWdc

System installs estimated from IEA-PVPS totals using inverter & mounting type % from LBL Tracking the Sun 2024)

Smith, *et al*. 2026

Supply chain diagram for c-Si module assembly

Simplified Supply Chain Diagram for c-Si Module Assembly



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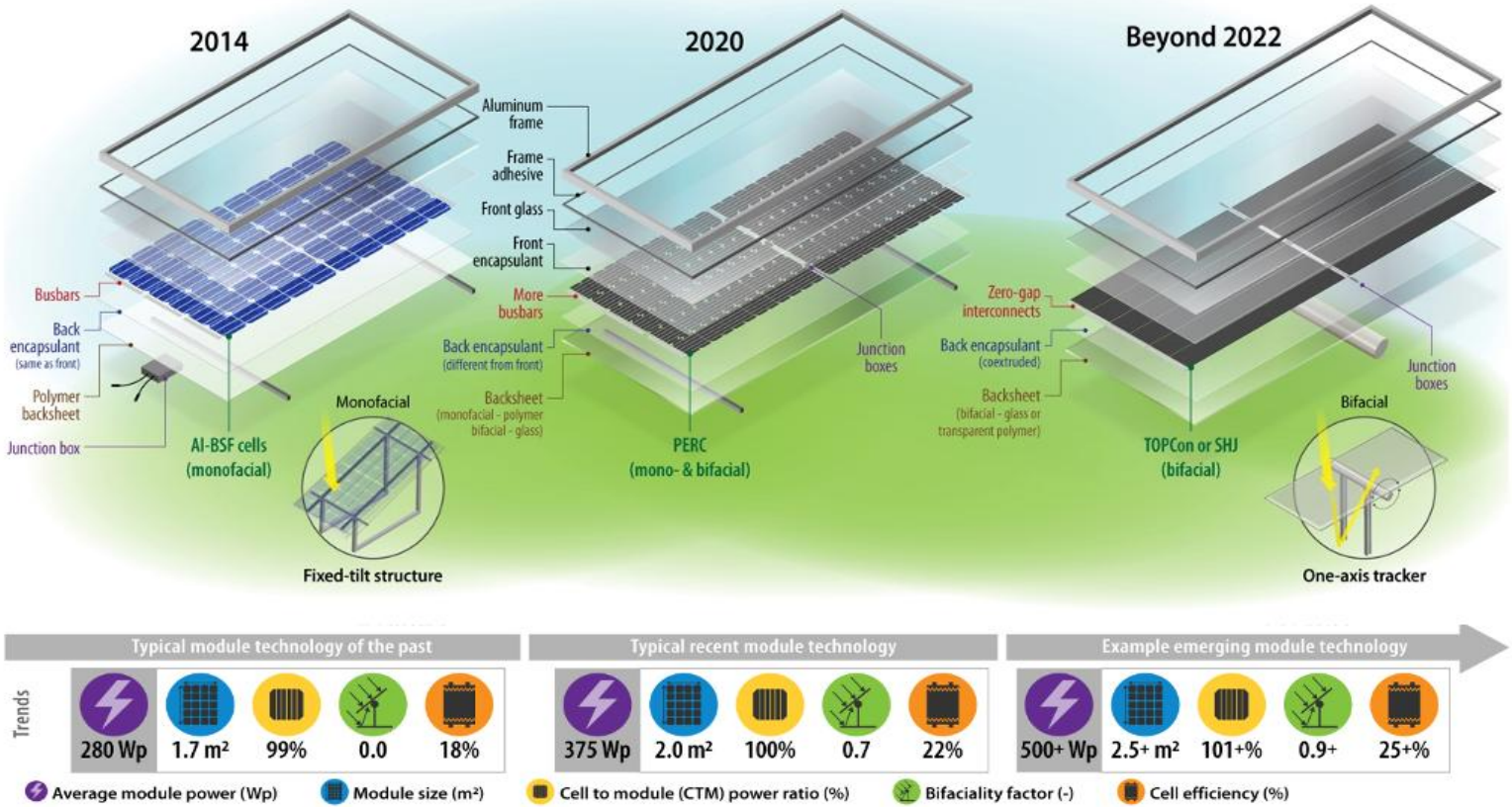
PV module technology trends



- U.S. trending toward larger module sizes for utilities following global trend, including for CdTe modules (FS Series 7)
- Bifacial modules larger fraction than monofacial
- TOPCon manufacturing in U.S. muted relative to rest of world

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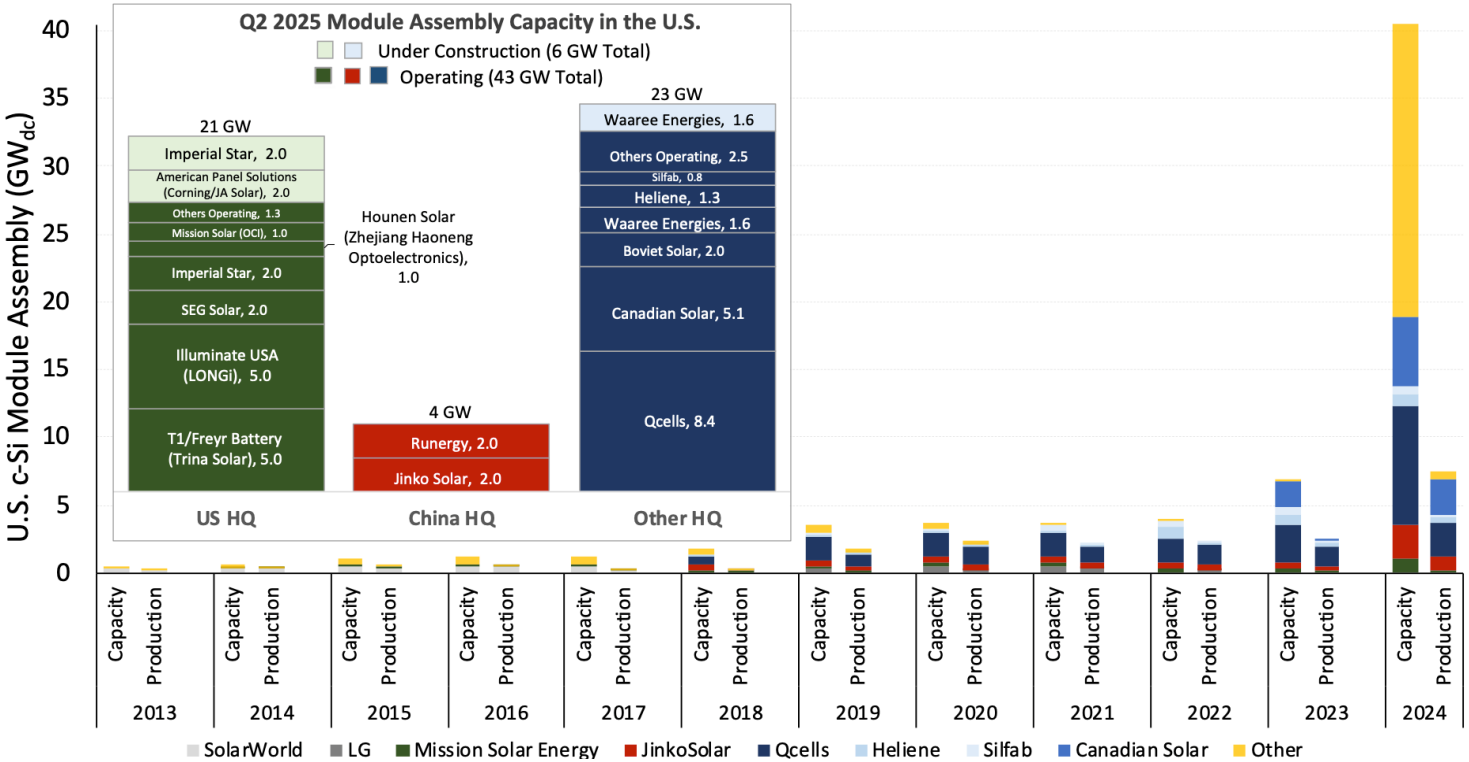
U.S. module assembly capacity, production, and ownership



- Following recent U.S. policies, Chinese firms have moved to reduce share in module manufacturers operating in the U.S.
- China-headquartered companies maintain strong roles in metallurgical grade silicon, battery cells and packs

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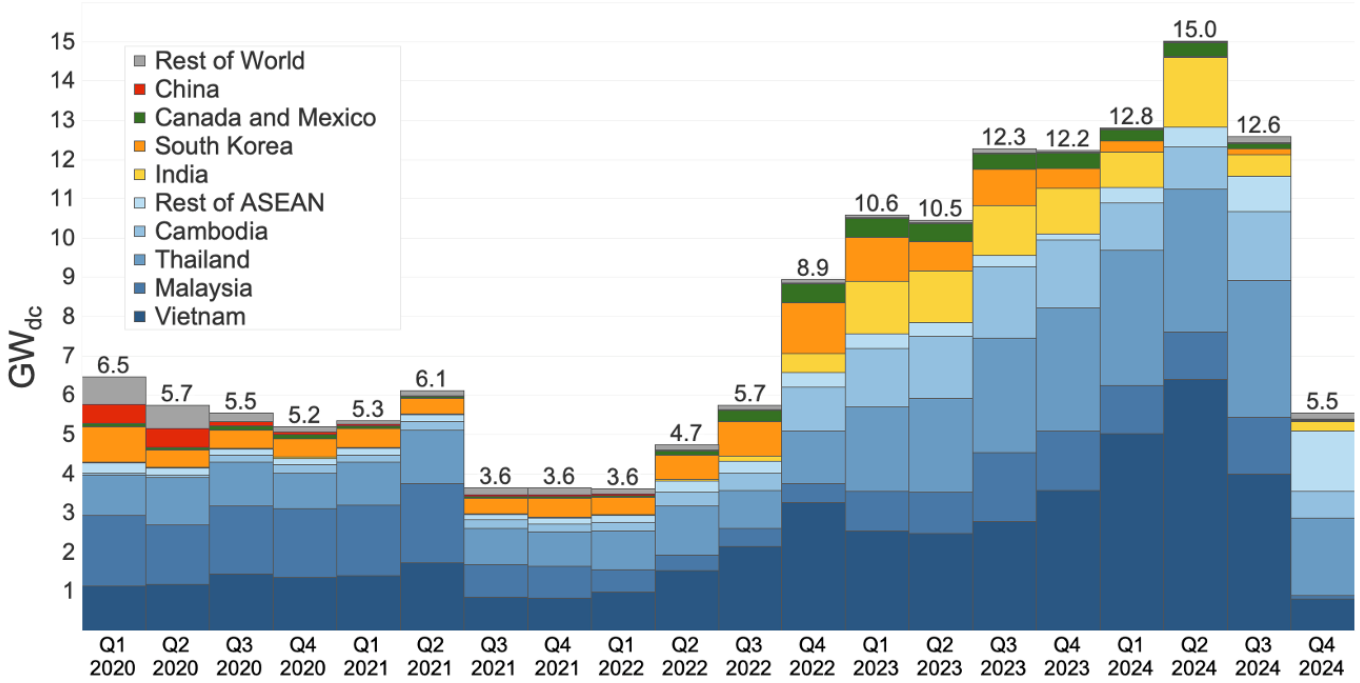
U.S. c-Si module imports by country or region



Source: Feldman, Zuboy, Dummit, Stright, *et al*. 2025

- U.S. module imports increased from Q3 2021 to Q2 2024 before falling dramatically in Q4 2024 likely in part due to AD/CVD preliminary determinations in November 2024 and end of temporary AD/CVD exemption in July 2024

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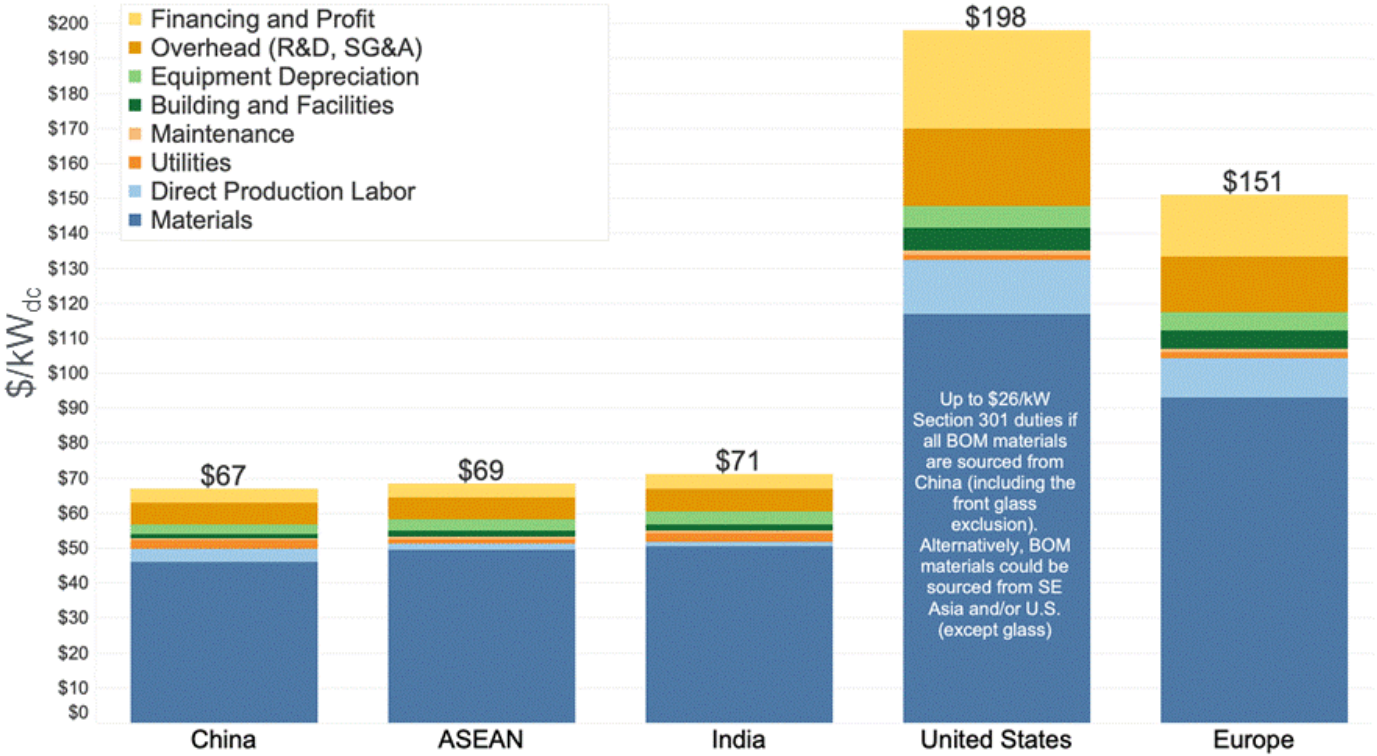
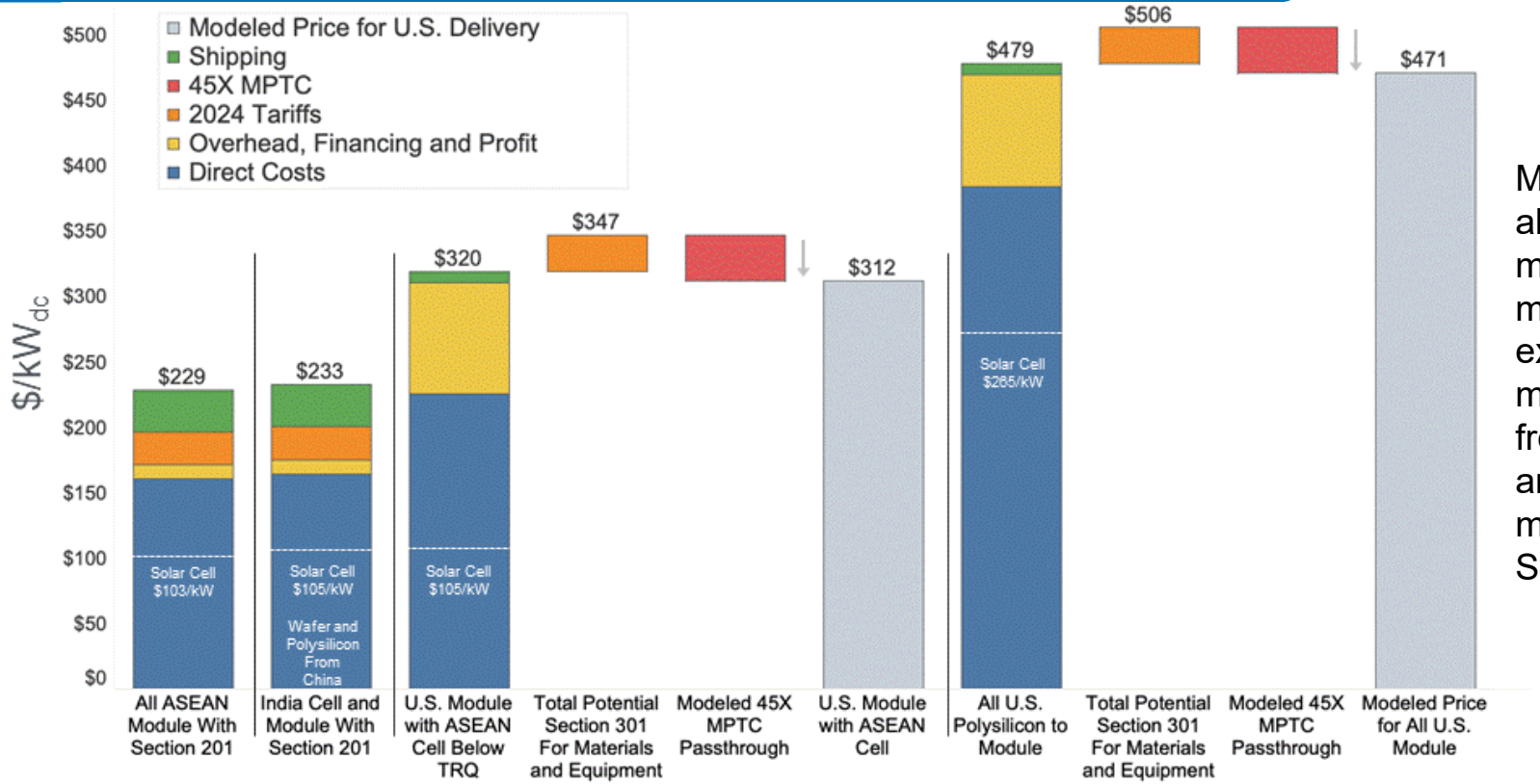
Module assembly costs by point of origin in 2024



- U.S. and European module assembly costs (i.e. not including cell cost) were more than double those of Asian manufacturers in 2024 and continuing through 2025
- Cost contributors include tariffs and embedded costs in materials, financing, labor, and overhead

Smith, *et al*. 2026

Modeled prices of module production and delivery to U.S. utility PV project in 2024



Modeled price for all-U.S. manufacturing module greatly exceeds price for module assembly from imported cells and imported module price from Southeast Asia

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Summary: U.S. Supply Chain Status

Supply chain element	U.S. product demand met domestically	Diversity of product origin	Imports of product segment independent of China	Cost competitive	Secure supply chain of key inputs	Notes
c-Si Modules						
Modules						
Cells						
Ingot/Wafer						
Polysilicon						
Metallurgical-grade Si						
Glass						Dependent on imported equipment
CdTe Modules						
Monolithic Production						
Refined CdTe Powder				NA		Data indicate possible dependence on tellurium from China
Glass		NA		NA		
Structural BOS						
Trackers						Some reliance on electronic components from China
Torque Tubes						Domestic torque tubes receive the 45X credit
Fasteners/Clamps						Some types of fastener heavily imported with from China
Piles & Rebar						
Racking/Rails						
Flashing/Feet						
Electrical BOS						
Inverters						
Transistors						
Med. Voltage Transformers						
Other Components						Vulnerabilities vary by specific product
Energy Storage						
Utility-Scale BESS						
Residential Packs						
Cells						
Inverters & Converters						

	0%–5% of year's production, relative to demand in final product	1 country/trading region	50%+ from China	>50% premium to produce than average price of imports	Dependent on non-market economy
	5%–20%	2–3	25%–50%	15%–50% premium	Reliant on non-market economy
	20%–40%	4–5	15%–25%	0%–15% premium	Potentially vulnerable
	40%–60%	6–7	5%–15%	0%–15% cheaper	Rely only on friendly trade partners
	60%+	8+	<5%	15%+ cheaper	Easy to get domestically

Balance of system (BOS) supply chain remains the "healthiest" compared to module and BESS segments

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NLR/PR-7A40-100052

This work was authored by the National Laboratory of the Rockies for the U.S. Department of Energy (DOE), operated under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Solar Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

Thank You

Questions:

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Full Report:

https://docs.nlr.gov/docs/fy26osti/93857.pdf

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