



Embargoed Until 12:01 AM EST, Thursday December 7th 2023

December 2023

US Solar Market Insight

Executive summary

Q4 2023



About the report

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US Solar Market Insight® is a quarterly publication of Wood Mackenzie and the SEIA®. Each quarter, we collect granular data on the US solar market from nearly 200 utilities, state agencies, installers, and manufacturers. This data provides the backbone of this US Solar Market Insight® report, in which we identify and analyze trends in US solar demand, manufacturing and pricing by state and market segment over the next five to ten years. All forecasts are from Wood Mackenzie, Limited; SEIA does not predict future pricing, bid terms, costs, deployment or supply. The report includes all 50 states, Washington, DC, and Puerto Rico. Detailed data and forecasts are contained within the full version of the report.

References and Contact

- **References, data, charts, and analysis from this executive summary should be attributed to “Wood Mackenzie/SEIA US Solar Market Insight®.”**
- **Media inquiries should be directed to Wood Mackenzie’s PR team (WoodmacPR@woodmac.com) and Jen Bristol (jbristol@seia.org) at SEIA.**
- **All figures are sourced from Wood Mackenzie. For more detail on methodology and sources, access the full report at www.woodmac.com/research/products/power-and-renewables/us-solar-market-insight/.**

Note on US Solar Market Insight report title: The report title is based on the quarter in which the report is released, not the most recent quarter of installation figures.

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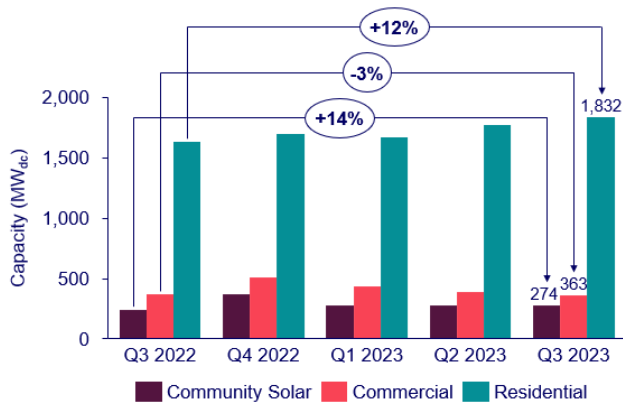
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1. Key figures

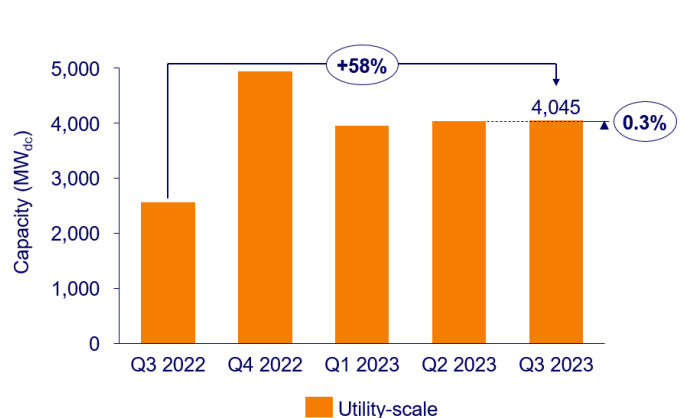
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- In Q3 2023, the US solar market installed 6.5 GW_{dc} of capacity, a 35% increase from Q3 2022 that represented flat growth compared to Q2 2023. This was a record third quarter for the industry, building on the installation momentum of the last few quarters.
- Solar accounted for 48% of all new electricity-generating capacity added to the US grid through the first three quarters of 2023. Cumulative operating solar capacity now stands 161 GW_{dc} and 4.7 million systems.
- The residential segment set another quarterly record at 1.8 GW_{dc} installed across more than 210,000 projects in Q3 2023, reflecting 12% growth over the same quarter last year. California drove this growth, with installations that had already grown 31% year-over-year in the second quarter and grew another 29% in the third quarter. Installations are surging as backlogs of sales made before the switch to net billing in April are interconnected.
- The commercial solar segment installed 363 MW_{dc}, declining 3% compared to Q3 2022 and 6% compared to Q2 2023. There have been slight slowdowns in the Northeast states, which are partially offset by growth in California and emerging state markets.
- The community solar segment installed 274 MW_{dc}, a 14% increase over Q3 2022 and flat compared to last quarter. We continue to see stagnation in some major markets as interconnection, permitting, and siting challenges persist.
- The utility-scale segment installed just over 4 GW_{dc} in Q3 2023, representing 58% growth over Q3 2022, when supply chain constraints were severely suppressing installations, and flat compared to last quarter. This segment has already installed nearly as much capacity through the third quarter as all of 2022, mostly due to abating supply chain constraints.
- Imbalances in global solar module supply and demand have put significant downward pressure on module pricing, with average global pricing falling 30-40% from the first quarter to the third quarter. However, this imbalance is driven by excess capacity in China, which makes up less than 0.1% of US module imports due to a combination of tariffs and enforcement of the Uyghur Forced Labor Prevention Act (UFLPA). Still, the ripple effects caused by this imbalance have pushed US module prices down 10-15% over the same timeframe as supply constraints have alleviated.
- Wood Mackenzie expects the US solar industry to grow 55% this year compared to 2022, a slight upward revision to last quarter's expectations. With nearly 33 GW_{dc} of capacity expected, it will be the nation's largest year of solar installations by far. Unsurprisingly, most of this growth comes from the utility-scale segment, which bore the brunt of the supply chain impacts in 2022.
- Our growth outlook for the US solar industry remains strong, averaging 14% annually over the next five years. However, sustained growth will become more challenging in the longer-term as interconnection bottlenecks and transmission capacity suppress the pace of installations.

US distributed solar quarterly installed capacity Q3 2022 – Q3 2023 (MW)



US utility-scale solar quarterly installed capacity Q3 2022 – Q3 2023 (MW)



Source: Wood Mackenzie

2. Introduction

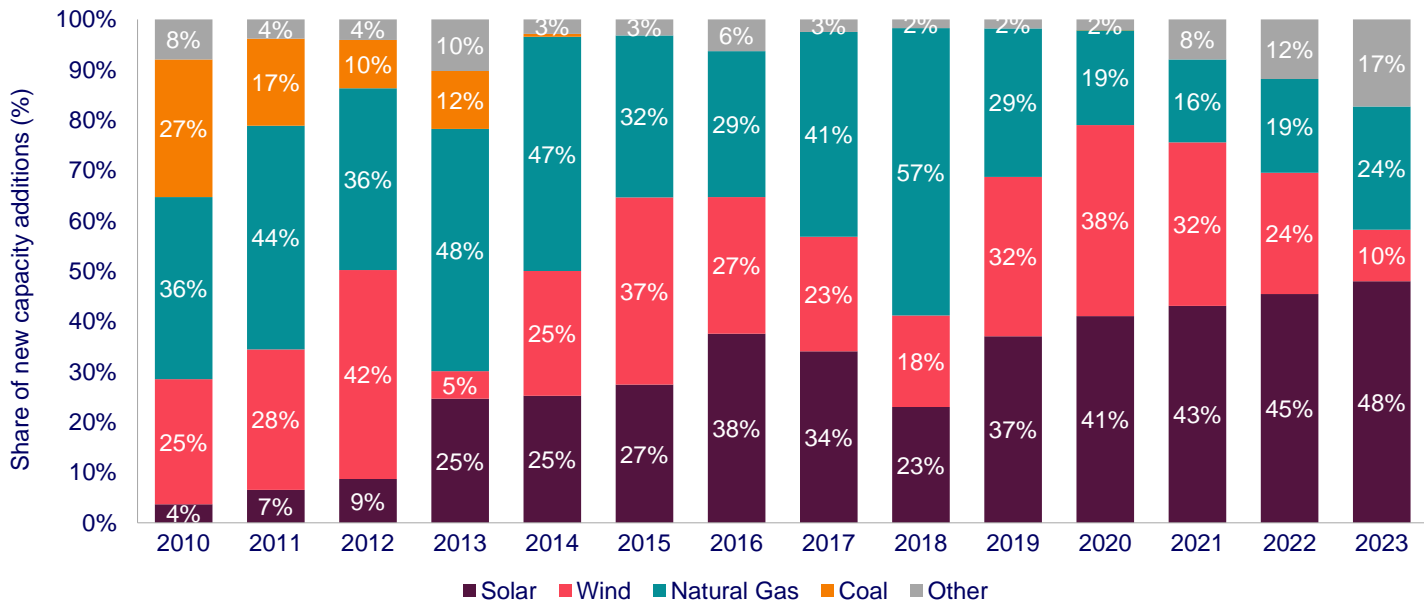
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The US solar industry installed 6.5 gigawatts-direct current (GW_{dc}) of capacity in the third quarter of 2023, a 35% increase from Q3 2022 and a 1% increase from last quarter. While module supply for the utility-scale segment remains moderately tight, increased imports compared to last year have supported installation volume recovery.

The residential segment also contributed to healthy volumes in the third quarter, with 1.8 GW_{dc} installed. California led this growth, with a record 735 MW_{dc} installed, more than 150 MW_{dc} larger than last quarter. Installations in California are surging as backlogs of sales made before the mid-April switch to net billing are interconnected. Commercial and community solar volumes followed a similar pattern as last quarter – declining slightly or remaining flat. For commercial solar, slowdowns in major Northeast markets are being partially offset by growth in California and emerging markets. Community solar has healthy pipelines in most major markets, but interconnection and permitting timelines continue to slow deployment. Utility-scale solar had yet another quarter of solid year-over-year growth, up 58% compared to Q3 2022. We expect utility-scale solar to end the year strong with more than 23 GW_{dc} of installations, which would represent 86% growth over 2022.

Overall, photovoltaic (PV) solar accounted for 48% of all new electricity-generating capacity additions in the first three quarters of 2023.

New US electricity-generating capacity additions, 2010 – Q1-Q3 2023



Source: Wood Mackenzie, US Energy Information Administration (for all other technologies)

As module supply constraints ease, limited availability of other equipment takes the spotlight

With 2023 coming to a close, it's clear that the utility-scale solar industry has recovered significantly after a rough 2022. The segment has already installed 12 GW_{dc}, slightly less than total utility-scale installations last year. As we've reported in the past, supplier diversification and releases of module detentions from Customs and Border Protection (CBP) have resulted in notable increases in solar module imports this year compared to last year. As more equipment has moved through ports and made its way to project sites, installations have ramped up, with average quarterly volumes in Q1-Q3 nearly double that of 2022.

However, it's important to acknowledge the differences in solar module supply dynamics between the US and the rest of the world. Other global regions are currently in a state of module oversupply. As China continues its massive expansion of manufacturing capacity across the entire solar value chain, there has been significant downward pressure on global module pricing. The impacts of this oversupply situation have escalated recently, with reports of spot module prices outside of the US as low as 14-15 cents/watt.

By contrast, the US market is somewhat insulated from these pricing dynamics. Less than 0.1% of US module imports this year have come from China due to a combination of tariffs, anti-dumping and countervailing duties (AD/CVD, Section 201, and Section 301). Almost 80% of modules for the utility-scale market come from Southeast Asia. And while Southeast Asia is generally a low-cost region for module production, manufacturers are still exposed to the restrictions on polysilicon sourcing from China due to the Uyghur Forced Labor Prevention Act (UFLPA).

Consequently, module supply to the US utility-scale sector is still tighter than other global regions. Demand for modules from top tier 1 manufacturers is in high demand. This has kept US module pricing significantly above price points in other countries, even without anticircumvention tariffs. (For more on solar component pricing, see Wood Mackenzie's *PV Pulse*). On balance, availability of modules for the US utility-scale market is still constrained but has improved substantially this year. Of course, module availability will continue to improve as more domestic manufacturing comes online.

As module supply has loosened, supply of other types of electrical equipment has become a greater concern for the utility-scale segment. Transformer availability has become a widespread problem, with wait times extending past 2 years in some cases. High-voltage circuit breaker lead times have nearly doubled in the last year to an average of 100 weeks (see Wood Mackenzie's report *H2 2023 US solar PV system pricing*). This has already increased balance of system (BOS) pricing for utility-scale solar. With no signs of this trend reversing, we expect electrical equipment availability to be one of several factors slowing utility-scale solar growth in the next several years.

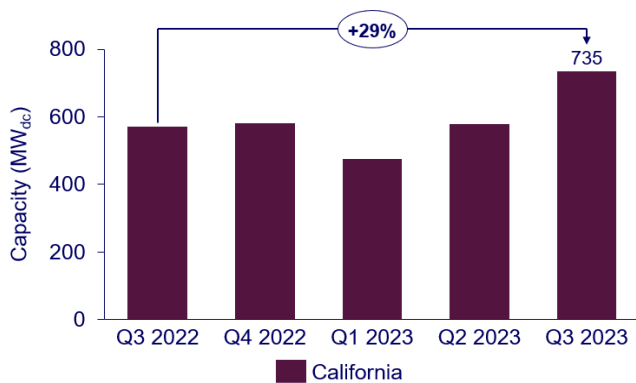
A tale of two residential solar markets

Third-quarter installations for the residential solar market were also robust, setting another quarterly installation record. As a result, we now anticipate 13% growth in residential solar this year. This may come as a surprise to those monitoring the steep declines in residential solar stock prices in recent months. And this is why it's important to understand the dynamics shaping residential solar growth, which point to two different sets of residential solar markets.

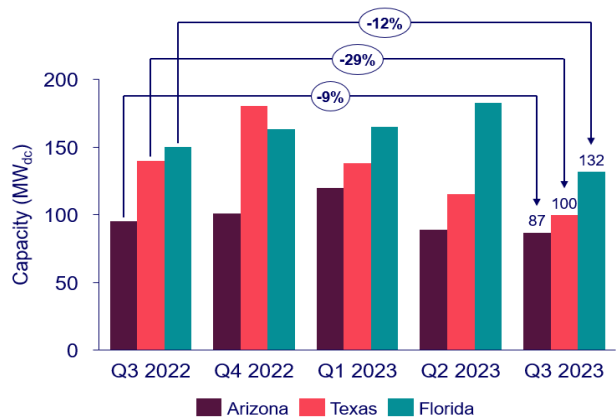
In California and several Northeast states, installation volumes are rising. The switch to net billing in mid-April drove a dramatic increase in residential solar sales in California. That enormous backlog of sales has driven intense installation growth in the last two quarters, and we expect this to last through the first quarter of 2024. Some in the industry have been surprised by this delay, but project-level installation data proves there can easily be a 2-3 quarter lag between sales and interconnection. We expect installation volumes to drop off precipitously once this sales pipeline runs out (likely in early to mid-2024). But California's growth is currently bolstering national residential solar installation volumes.

In the Northeast, retail rate increases that occurred last year are also driving growth. The Northeast generally has high retail rates compared to the rest of the country. And since the Northeast was heavily impacted by high gas prices during the energy crisis, rates rose substantially. Retail rate increases are creating opportunities for significant customer savings. While we do expect rates to decline as more moderate gas prices impact utility costs (and in some cases, they already have), higher retail rates are driving installation volume growth today.

California residential solar (MW_{dc})



Arizona, Florida, and Texas residential solar (MW_{dc})



Source: Wood Mackenzie

This growth is being partially offset by a trend that characterizes the second set of markets: shrinking sales volumes from rising interest rates. Solar loans became much more expensive in 2022 because of federal interest rate increases. In price-sensitive markets such as Texas, Arizona, and Florida, sales volumes, particularly for loan companies, started declining in late 2022 and have continued shrinking since then. This decline began impacting installation volumes in the first half of this year for Arizona and Texas, and Florida by the third quarter (see chart).

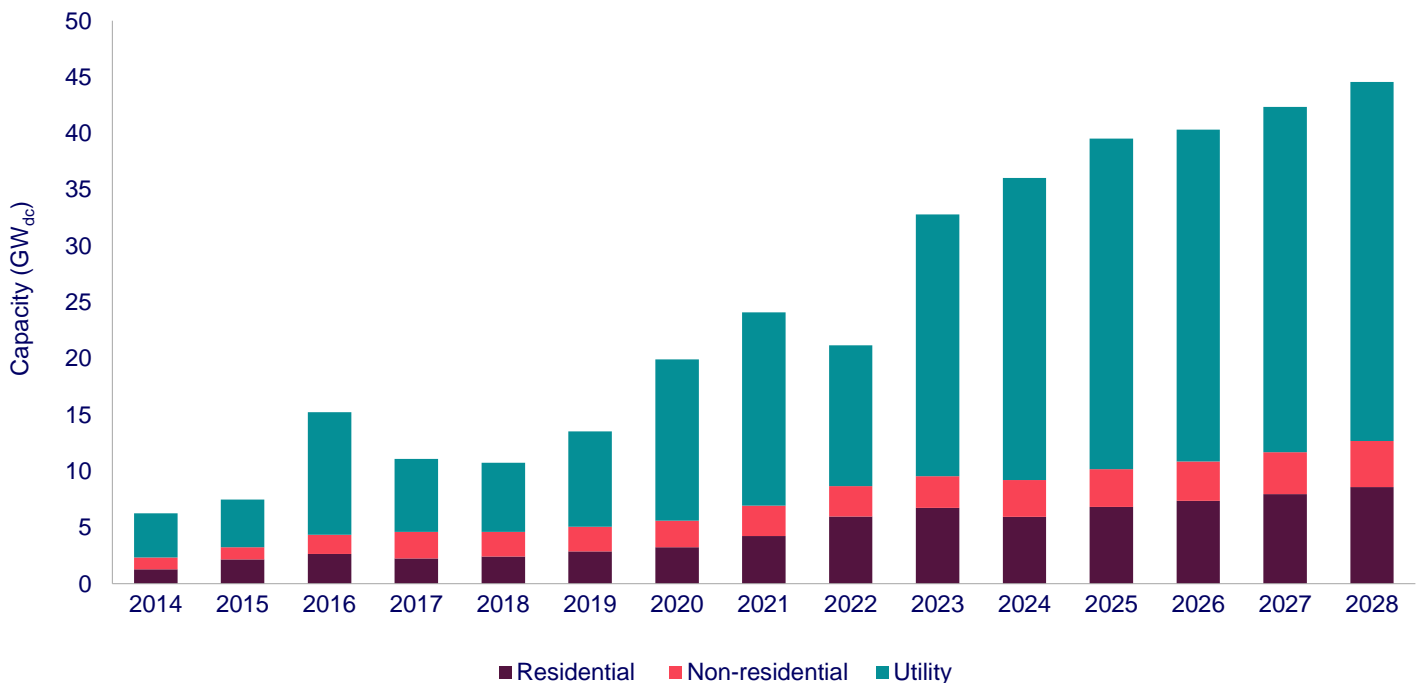
Next year, installation growth in California and the Northeast will no longer offset the impacts of declining residential solar sales volumes, mostly because of the anticipated drop in California. As a result, we expect the residential solar market to decline by 12% in 2024.

Robust near-term growth will give way to more modest long-term expectations

Our outlook for the US solar industry puts average annual growth at 14% between 2023 and 2028. But growth is much stronger in the near-term before falling to the low single-digits starting in 2026. There are differences between each segment, but growth in all solar segments slows down slightly in the next few years. For residential solar, California’s slowdown will impact the broader market and many mature markets will also reach higher levels of penetration. For commercial and community solar, pipelines in major state markets are getting built out faster than they’re being replenished. And for utility-scale solar, despite healthy early-stage pipeline growth, project execution will become increasingly challenging as interconnection timelines lengthen, grid congestion worsens, and labor availability remains limited.

Solar is still the core technology of the US energy transition. Wood Mackenzie expects it will be the largest category of generating capacity on the US grid by 2050. But challenges to this industry’s growth are very real, requiring continued innovation to maximize the value that solar brings to an increasingly complex grid. Interconnection reform, regulatory modernization, and increasing storage attachment rates will be key tools.

US solar PV installations and forecasts by segment, 2014-2028



Source: Wood Mackenzie

State solar PV installation rankings, Q1 – Q3 2023

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State	Rank			Installations (MW _{dc})		
	2021	2022	Q1 – Q3 2023	2021	2022	Q1 – Q3 2023
California	2	1	1	3,648	5,071	3,216
Florida	3	3	2	1,668	1,899	2,764
Texas	1	2	3	6,066	3,660	2,517
Colorado	12	26	4			
Nevada	10	5	5			
New York	9	4	6			
Indiana	7	18	7			
Ohio	18	33	8			
North Carolina	8	16	9			
Georgia	5	6	10			
Virginia	4	9	11			
Arizona	13	7	12			
Illinois	6	8	13			
Michigan	14	20	14			
New Mexico	31	14	15			
Oregon	21	23	16			
New Jersey	17	10	17			
Maine	20	21	18			
Puerto Rico	29	25	19			
Idaho	36	39	20			
Alabama	19	52	21			
Pennsylvania	28	27	22			
Montana	47	45	23			
Hawaii	33	28	24			
Maryland	27	19	25			
Tennessee	44	11	26			
Massachusetts	11	15	27			

Underlying data available in the full report

Source: Wood Mackenzie

State solar PV installation rankings, Q1 – Q3 2023

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State	Rank			Installations (MW _{dc})		
	2021	2022	Q1 – Q3 2023	2021	2022	Q1 – Q3 2023
Utah	16	24	28			
South Carolina	26	12	29			
Minnesota	30	35	30			
Connecticut	22	29	31			
Mississippi	50	30	32			
South Dakota	52	50	33			
Wisconsin	15	13	34			
Missouri	32	31	35			
Rhode Island	25	32	36			
Arkansas	23	38	37			
Washington	35	17	38			
New Hampshire	37	40	39			
Iowa	24	22	40			
Louisiana	41	37	41			
Oklahoma	42	42	42			
Washington DC	34	41	43			
Kansas	40	44	44			
Kentucky	43	34	45			
Alaska	49	49	46			
Delaware	38	36	47			
Vermont	39	43	48			
West Virginia	46	46	49			
Nebraska	45	47	50			
Wyoming	48	48	51			
North Dakota	51	51	52			

Underlying data available in the full report

Source: Wood Mackenzie

3. Market segment outlooks

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3.1. Residential PV

- 1,832 MW_{dc} installed in Q3 2023
- Up 12% from Q3 2022
- Up 3% from Q2 2023

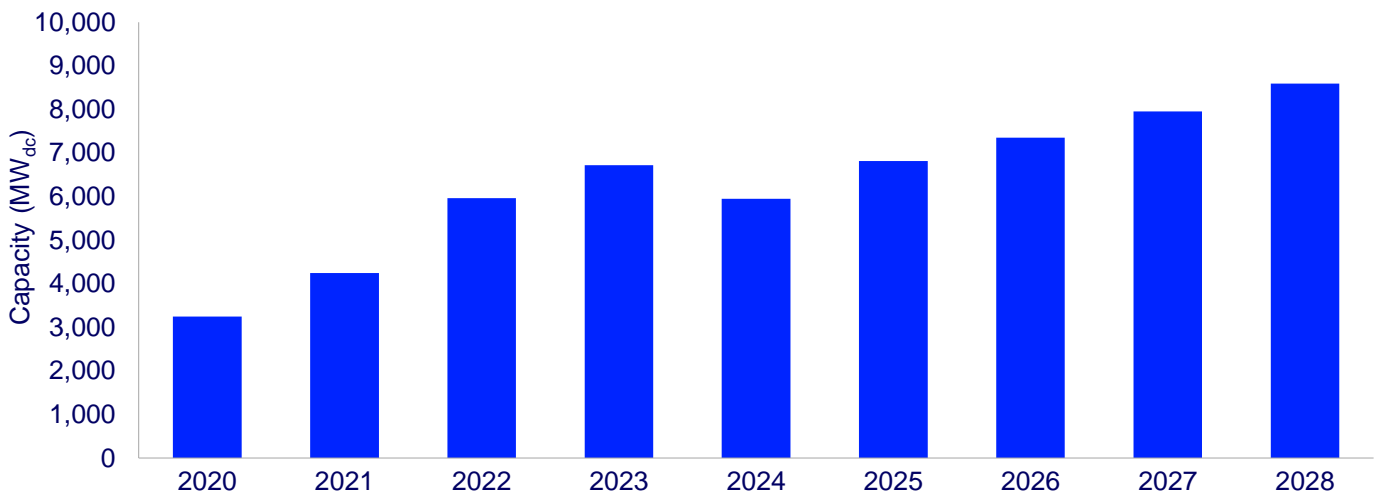
Residential solar sales and installation trends vary

In Q3 2023, the residential solar market installed 1,832 MW_{dc}, growing 12% year-over-year and setting yet another quarterly record. The segment’s total installation volumes for the first three quarters of 2023 increased by 24% year-over-year, with thirty-four states plus Puerto Rico seeing annual growth during this timeframe. While high interest rates persist, the segment has some tailwinds, such as module oversupply resulting in lower pricing. Coupled with increasing retail rates, installers can still provide customers with a compelling value proposition in some states. With third-party ownership (TPO) products less sensitive to interest rate increases than loans, installers also continue to report an increase in TPO installations.

Despite installation growth, installers continue to face challenging market conditions and significant reductions in sales volumes in many states due to high interest rates, illustrating the variance between sales and installation trends in different state markets. However, the sales slowdown has already impacted some states’ installation volumes, as many industry players have decreased their expectations for 2023 and 2024. Notably, Arizona, Florida, and Texas, three of the largest residential solar markets, experienced quarterly and annual declines in installed capacity in the third quarter. Installers are coping with these challenges as best as possible, focusing more on operational efficiencies or experimenting with pricing and product offering tweaks to survive the slowdown.

Wood Mackenzie forecasts 13% growth for the residential solar market in 2023. Although we anticipate a weaker fourth quarter of installations for many states, we increased our outlook for this year by 3%, primarily driven by a boost to California, which added a record-breaking 735 MW_{dc} of installed capacity in Q3 despite continued utility interconnection delays. We now expect that installation backlogs from sales made under NEM 2.0 will last through early 2024, based on installer feedback. Like past quarters, Wood Mackenzie expects the reduction in sales in California under the new net billing regime to lead to a statewide contraction in 2024. Coupled with high interest rates, which will counteract some of the benefits of the IRA in the short-term, we reduced our 2024 forecast by 5%, resulting in a 12% national contraction. The residential solar market will recover in 2025 and grow at an average annual rate of 10% between 2025-2028 as growth picks up in emerging markets.

Residential solar installations and forecast, 2020-2028



Source: Wood Mackenzie

3.2. Commercial PV

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- 363 MW_{dc} installed in Q3 2023
- Down 3% from Q3 2022
- Down 6% from Q2 2023

Note on market segmentation: Commercial solar encompasses distributed solar projects with commercial, industrial, agricultural, school, government, or nonprofit offtakers, including remotely net-metered projects. This excludes community solar (covered in the following section).

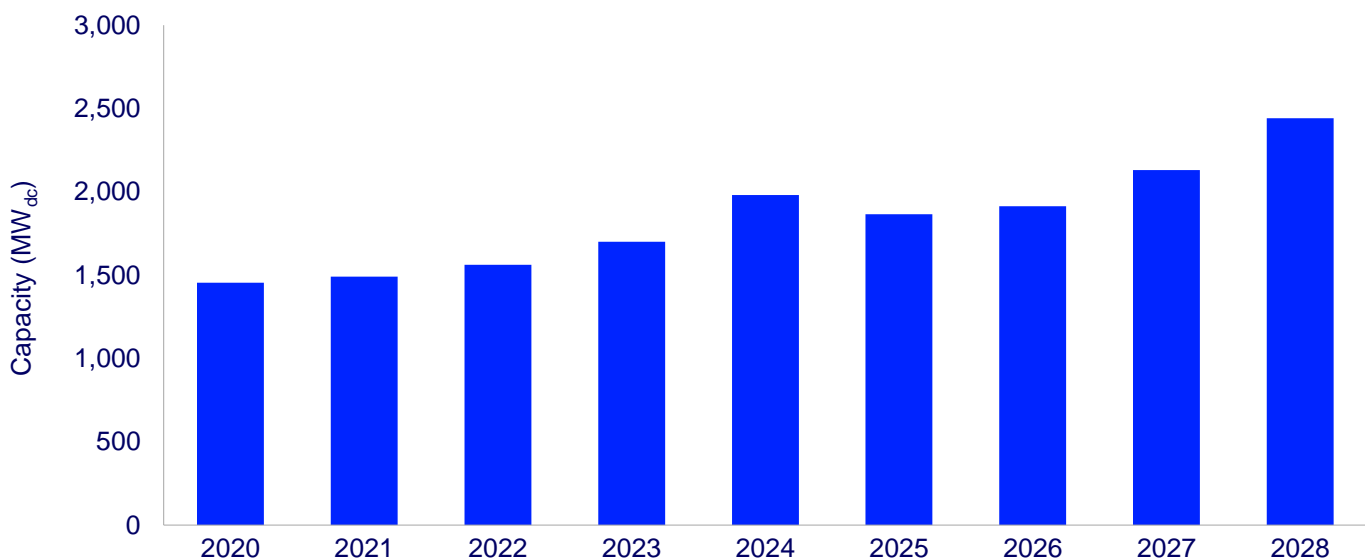
Commercial solar growth slows down slightly while developers continue to explore new states

Quarter-over-quarter, commercial solar installations decreased slightly. But installations through the first three quarters of the year are still driving our expectation for 9% growth in 2023. The commercial solar industry is seeing a slowdown in growth in more mature state markets such as New York, New Jersey, and Massachusetts. As a result, developers are shifting their focus to states with lower development costs, more available land, growing electricity demand, and rising electricity rates. Healthy installation volumes in certain states across the nation signal near-term growth for 2024.

Many nontraditional commercial solar states are seeing growth, even without strong incentives. Due to an increase in energy demand and rising electricity rates, Ohio and Florida are witnessing significant commercial solar growth. At the same time, more mature markets such as New York and Massachusetts are experiencing a decrease in installations quarter-over-quarter. The pipeline of commercial solar projects in Massachusetts' SMART program dropped by roughly 40 MW_{dc} this quarter.

We have lowered our five-year outlook for commercial solar slightly (2%) compared to last quarter due to lower-than-expected installation volumes in the third quarter. However, we expect to see an average of 8% growth over the next five years. Even though growth in some more saturated states is slowing, development in emerging markets will increase. We expect slight demand pull-in next year due to the wage and apprenticeship requirements of the IRA – developers with late-stage projects continue to report that they procured equipment or started construction early enough to avoid the extra administrative burden associated with these requirements. In the long term, growth will gradually increase due to the IRA and higher electricity rates. We expect 1,700 MW_{dc} to come online nationally this year and to grow to 2,442 MW_{dc} by 2028.

Commercial solar installations and forecast, 2020-2028



Source: Wood Mackenzie

3.3. Community solar PV

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- 274 MW_{dc} installed in Q3 2023
- Up 14% from Q3 2022
- Flat from Q2 2023

Note on market segmentation: Community solar projects are part of formal programs where multiple residential and non-residential customers can subscribe to the power produced by a local solar project and receive credits on their utility bills.

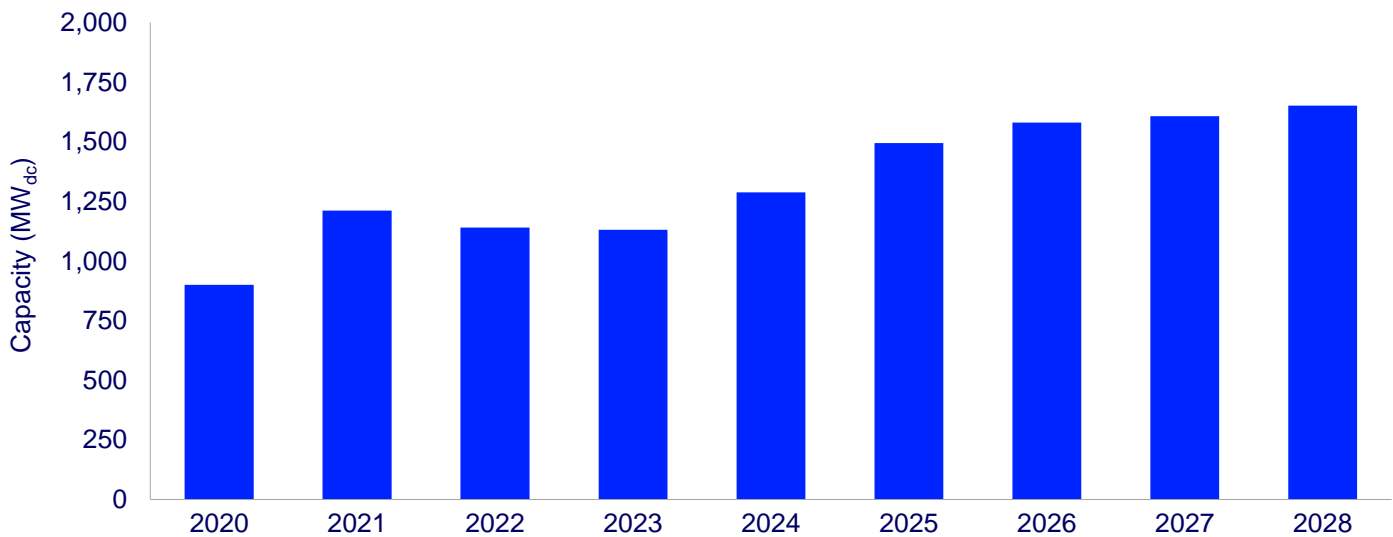
Strong Q3 2023 volumes in key state markets drive 13% increase to 2023 community solar outlook

Community solar installations increased 14% year-over-year in Q3 2023, resulting in 827 MW_{dc} of new installations so far this year – an 8% increase compared to the first three quarters of 2022. Third quarter growth was driven by strong installation volumes in both New York and Maine, totalling 117 MW_{dc} and 74 MW_{dc}, respectively. Maryland is also having a particularly strong year with Q1-Q3 2023 installation volumes up 176% from 2022. As a result, we have increased our 2023 outlook for community solar installations by 13%. Compared to the 6% market contraction in 2023 reported last quarter, we now anticipate flat growth year-over-year, with national installed capacity exceeding 1.1 GW_{dc}.

Despite consistent installations this year, the longer-term outlook for community solar is more uncertain. Interconnection remains by far the greatest hurdle to community solar development, and developers continue to report they will not pursue new development in state markets with poor interconnection or siting conditions, such as Maine and Massachusetts. Additionally, we continue to monitor progress in newer state markets, namely California, New Mexico, Virginia, and Delaware. These states make up a combined 30% of our outlook from 2024 to 2028. While we expect some projects to reach completion in Delaware and Virginia this year, no projects have come online in these newer state programs as of Q3 2023. Additionally, the proposed decision on California’s community solar program has been delayed into at least Q4 2023, the result of which is a key factor in determining the trajectory of the total market.

Overall, our national outlook for community solar remains positive with 8% average annual growth expected from 2024 to 2028. Near-term growth is driven by very robust pipelines in mature markets like New York and Illinois. Longer-term, newer state markets support lasting growth as mature markets become more saturated. Finally, community solar developers will begin to benefit from the incentives within the IRA as soon as next year.

Community solar installations and forecast, 2020-2028



Source: Wood Mackenzie

3.4. Utility PV

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- **4.0 GW_{dc} installed in Q3 2023**
- **Up 58% from Q3 2022**
- **171 GW_{dc} of utility-scale solar will be added between 2023 and 2028**

Utility-scale solar achieves its strongest third quarter on record at 4 GW_{dc}

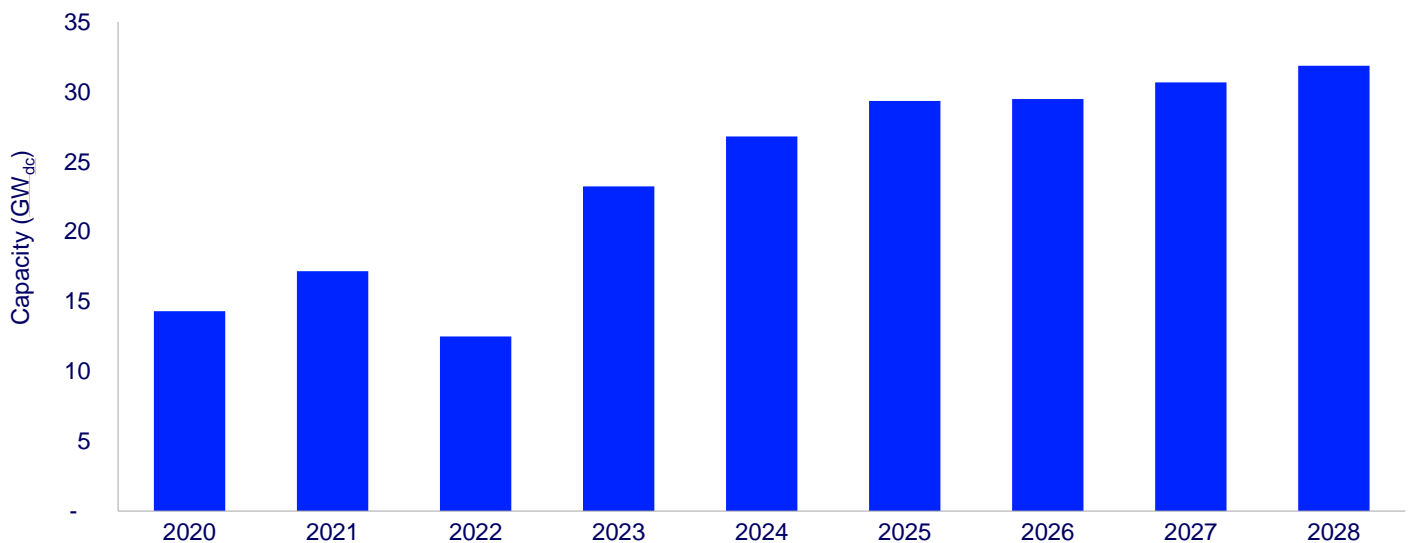
The utility-scale solar sector continued its growth trajectory with 4 GW_{dc} of installations in Q3 2023, its strongest third quarter on record. The sector achieved 58% growth compared to Q3 2022. A cumulative 1.1 GW_{dc} of projects were contracted in Q3 2023, significantly less than past quarters due to high interest rates and tight financing conditions. Combined with quarterly installations, the project pipeline declined slightly to 84.3 GW_{dc}.

The strong deployment growth in Q3 2023 has largely been due to module supply chain stabilization within the past year. Total module imports were 29.6 GW_{dc} in 2022 compared to 24.6 GW_{dc} in the first half of this year, which has eased the procurement challenges seen in previous quarters. However, bottlenecks for equipment procurement have transitioned to transformers and high-voltage circuit breakers. Lead times for these components have increased to an average of 115 to 130 weeks and 60 to 160 weeks, respectively. Higher lead times have significantly impacted project development in the near term, with many developers rushing to secure these components.

Limited EPC availability also continues to impact project timelines, particularly in regions with more stringent environmental permitting regulations and complex topographies. EPC availability has been constrained by a lack of trained personnel, and the administrative complexity related to meeting the prevailing wage requirement is hitting developers harder than originally expected. Many EPCs are also still adapting to the apprenticeship requirements, which has increased their administrative burden.

Wood Mackenzie forecasts that utility-scale solar installations will total 171 GW_{dc} between 2023-2028, a 1% increase compared to our last forecast. The 2023 outlook increased by 484 MW_{dc} (2%) due to strong installations through the first three quarters of 2023. This momentum will continue through 2026, leading to a total increase of 5.3 GW_{dc} in the 2023-2026 period. The lower cost competitiveness of solar and challenged project economics due to increasing renewables penetration have driven a downgrade of 3.7 GW_{dc} in the 2027-2028 period.

Utility-scale installations and forecast 2020-2028

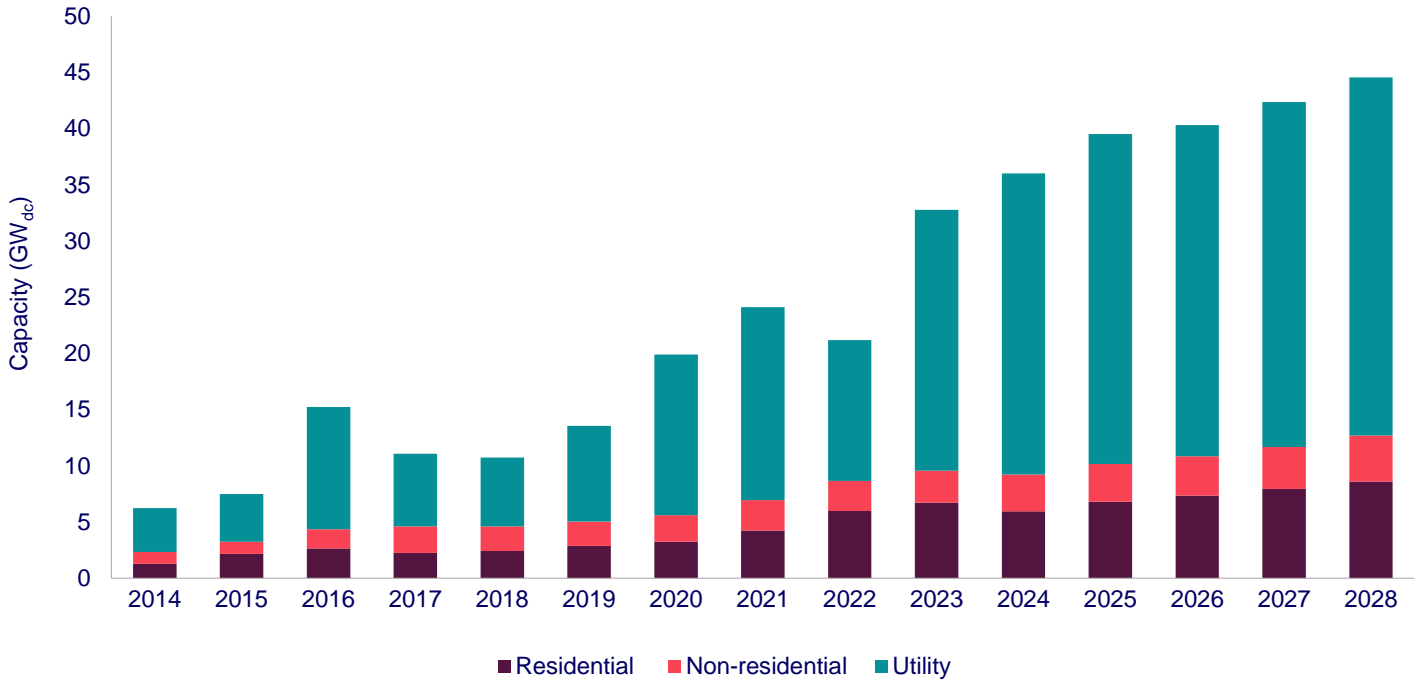


Source: Wood Mackenzie

4. US solar PV forecasts

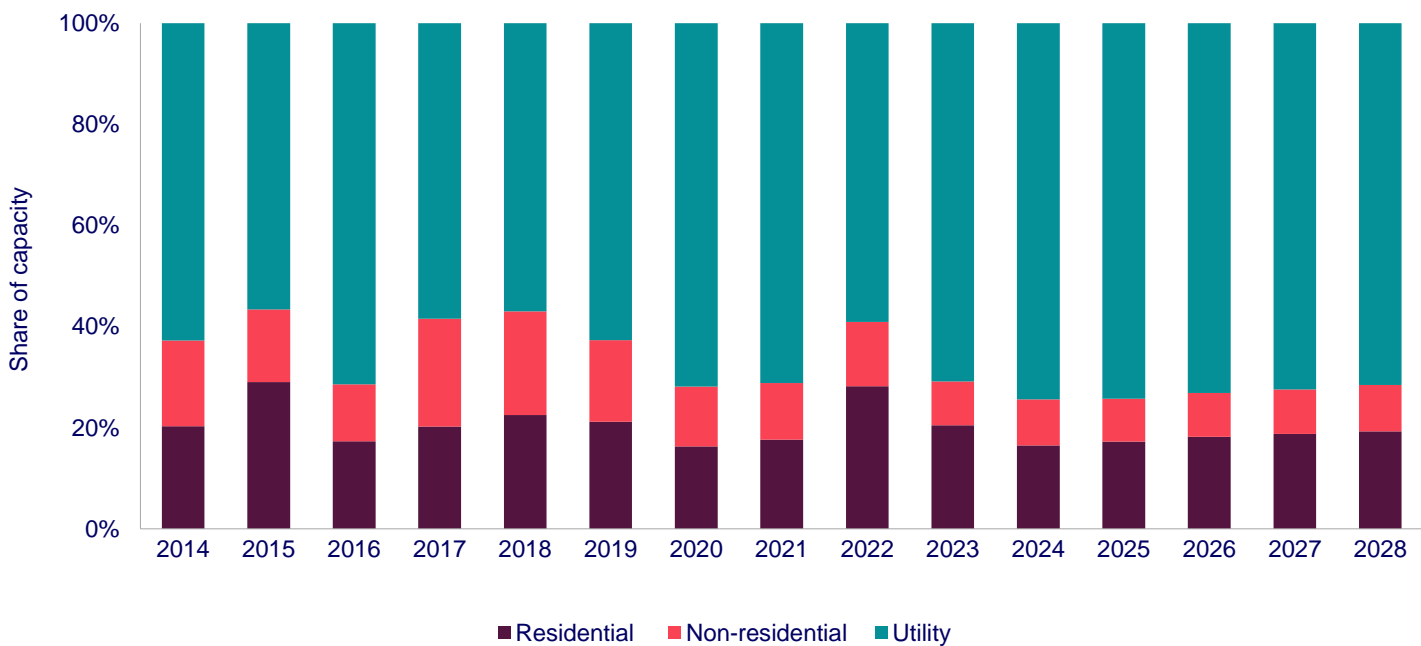
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US PV installation historical data and forecast, 2014-2028



Source: Wood Mackenzie

US PV share of capacity (historical and forecast), 2014-2028



Source: Wood Mackenzie; Note that non-residential solar is broken out into commercial solar and community solar in the full data accompanying the US Solar Market Insight Q4 2023 full report.

5. National solar PV system pricing

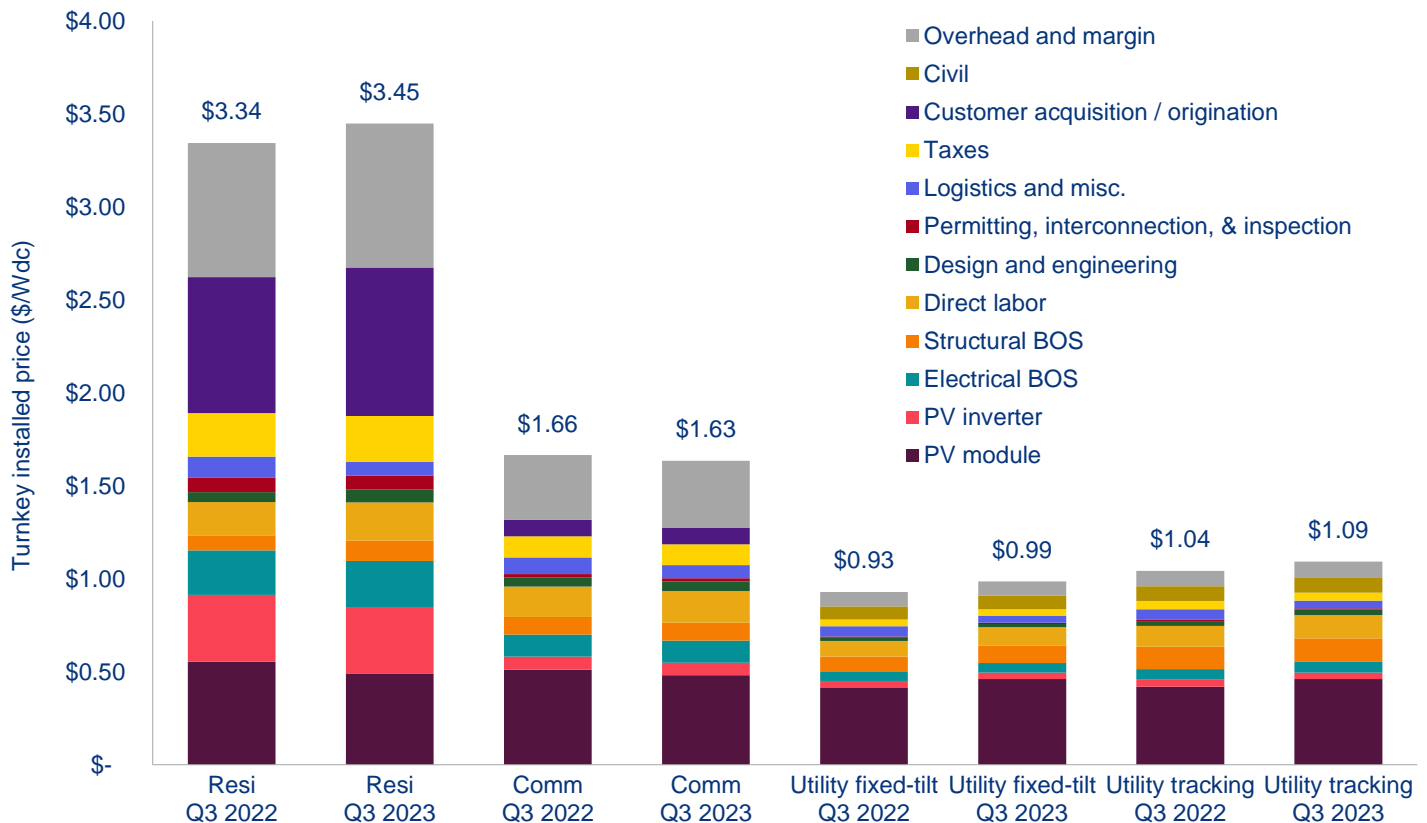
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- Residential system pricing is up 3% year-over-year
- Commercial system pricing is down 2% year-over-year
- Utility segment system pricing is up 6% for fixed-tilt and 5% for single-axis tracking year-over-year

Note: In November 2023, Wood Mackenzie published a refreshed customer acquisition analysis (*US distributed solar customer acquisition cost outlook 2023*). Therefore, there are changes to the modeled residential customer acquisition costs and overall national average turnkey pricing in this report compared to past quarters.

Wood Mackenzie employs a bottom-up modeling methodology to capture, track and report national average PV system pricing by segment for systems installed each quarter. The methodology is based on the tracked wholesale pricing of major solar components and data collected from industry interviews. Wood Mackenzie’s Supply Chain data and models are leveraged to enhance and bolster our pricing outlooks. Wood Mackenzie assumes all product is procured and delivered in the same year as the installation except modules for the utility segment, which are procured one year prior to commercial operation.

Modeled US national average system prices by market segment, Q3 2022 and Q3 2023



Source: Wood Mackenzie.

Module prices declined 12% for the residential and 6% for the commercial segment year-over-year. The utility segment continues to see elevated module pricing due to the one-year lag in module procurement reflected in our pricing data. For distributed solar, the decline in module costs has been offset by an increase in the balance of equipment as well as soft costs. Across the four different market segments, labor and engineering costs have increased anywhere from 5-25%. Equipment component costs have also been increasing over the last few quarters due to the rise in inflation. National PV system prices are up across all segments, except for the commercial segment, which witnessed a drop of 2% year-over-year.

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contactus@woodmac.com

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Installed Price Manufacturing:

- Polysilicon
- Wafers
- Cells
- Modules
- Active U.S. Manufacturing Plants
- Inverters

Component Pricing:

- Polysilicon, Wafers, Cells and Modules
- Inverters
- PV Mounting Structures

Demand Projections:

- By Market Segment
- By State

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