2023 | Q1

CLEAN POWER QUARTERLY

Market Report

AMERICAN CLEAN POWER

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Clean Power Definitions & Acronyms

Definitions

Advanced development: Projects not under construction, but with a PPA, firm equipment order, or moving forward with plans to be placed under utility ownership as of the end of the most recent quarter. For offshore wind, advanced development consists of projects that have secured offtake or have had successful bids in response to a state solicitation even if final offtake negotiations have not concluded.

Capacity: Project nameplate capacity. Unless otherwise stated, ACP reports capacity in MW-ac.

Clean power: For the purposes of this report, clean power includes land-based wind, offshore wind, utility-scale solar, and battery storage technology.

Decommissioned: Project is offline and is no longer delivering power to the grid on a permanent basis. Physical removal of equipment is not a requirement.

Duration: The amount of time, in hours, a battery can discharge its power capacity before depleting its energy capacity. For example, a 2 MW battery that has 4 MWh of energy capacity has a duration of 2 hours.

Full repowering: Full decommissioning of a utility-scale project. The original equipment is physically removed from the project site and replaced with new utility-scale equipment.

Inverter Loading Ratio (ILR): The ratio of installed DC capacity to the inverter's AC power rating. Also known as the AC-to-DC ratio.

Online: Project has reached commercial operation and is delivering electricity to the ultimate point of delivery.

Partial repowering, nacelle replacement: Complete replacement of a utility-scale wind turbine's nacelle, rotor, and blades. The tower and foundation are retained.

Partial repowering, major retrofit: Complete replacement of a utility-scale wind turbine's rotor and blades, along with the replacement of at least one major component within the nacelle, typically the gearbox or the generator.

Pipeline: Projects either under construction or in advanced development.

Repowered: Full or partial equipment replacement. Currently only wind repowering activity is tracked, but ACP will expand repowering activity tracked as the market progresses.

Under construction: Construction team has begun work on the ground at the project site. For offshore wind, under construction is defined as in-ocean construction.

Acronyms

AC	Alternating Current
C&I	Commercial & Industrial
CAISO	California ISO
DC	Direct Current
ERCOT	Electric Reliability Council of Texas
GW	Gigawatts
GWh	Gigawatt hours
ILR	Inverter Loading Ratio
IOU	Investor-Owned Utility
ISO	Independent System Operator
MISO	Midcontinent Independent System Operator
MW	Megawatts
MWh	Megawatt hours
NE-ISO	New England ISO
NYISO	New York ISO
OEM	Original Equipment Manufacturer
PJM	Pennsylvania-New Jersey-Maryland Interconnection
PPA	Power Purchase Agreement
RTO	Regional Transmission Organizations
SPP	Southwest Power Pool

Photo credit: Invenergy

2023 Q1 Highlights

2023 Q1 Highlights

Clean Power Project Installations

- 2023 is off to a slow start with 4,079 MW of new clean power capacity installed. This marks the lowest first quarter since 2020 and represents a 36% decline compared to the first quarter of 2022.
- Developers commissioned 95 project phases in the first quarter across 27 states. Florida took the top spot this quarter, installing 947 MW of new solar capacity. Texas ranked second, commissioning 701 MW across wind, solar, and battery storage projects. Florida and Texas were the only states to surpass 500 MW of new installs in the first quarter.
- Solar was the leading technology of the quarter, with 71 new projects coming online totaling 2,200 MW. Wind ranked second, with 7 new plants totaling 1,418 MW. Finally, the industry installed 17 new battery storage projects with a total capacity of 461 MW/1,075 MWh.
- All three technologies experienced significant declines compared to the first quarter of 2022. Wind installations decreased 50%, battery storage fell 32%, and solar dropped 23%.
- Cumulatively, operating clean power capacity in the country is now nearly 232 GW, enough to power 62 million American homes.

Clean Power in Development

- Although it is premature to observe the effects of the Inflation Reduction Act (IRA) on clean power installations, its influence can be observed in the project development pipeline. The 138,808 MW in the pipeline represents an 11% increase from Q1 2022, and a 62% increase from Q1 2021.
- There are 48,957 MW under construction and 89,850 MW in advanced development.
- Year-over-year, the battery storage pipeline experienced the most significant increase at 33%. The solar pipeline also increased, up 16% year-over-year. Bucking the trend, land-based wind capacity in the pipeline fell 14%.
- Solar continues to be the leading technology in the pipeline, accounting for 59% of all clean power capacity in development. Land-based wind accounts for 15% of the pipeline, battery storage represents 14%, and offshore wind claims the remaining 13%.
- Texas will continue as the clean power hub, hosting 17% of the total pipeline with 23,956 MW in development. California follows with 14,760 MW, accounting for 11% of the pipeline. New York has the third largest pipeline with 9,209 MW in development.

Clean Power Procurement Activity

- In the first quarter of the year, clean power buyers announced 3.8 GW of new power purchase agreements (PPAs), down 24% compared to the same period in 2022.
- Corporate buyers signed 63% of all announcements, while utilities accounted for 32% of deals and other non-utility buyers the remaining 5%. Both utilities and corporations announced fewer deals compared to the first quarter of 2022, though the drop in utility announcements was more significant, down 49% compared to just a 5% decline for corporate buyers.
- For the first time in a few years, wind made up the majority of PPA announcements in the first quarter, accounting for 49% of all announcements where the technology is known. Solar announcements were just shy of wind, accounting for another 49% of PPA announcements, while battery storage captured the remaining 2%.
- Wind announcements increased by 61% compared to Q1 2022. Solar announcements, on the other hand, are down by 47%.

Photo credit: Nextracker

Clean Power Capacity Growth

CLEAN POWER CAPACITY GROWTH

Lowest First Quarter Since 2020

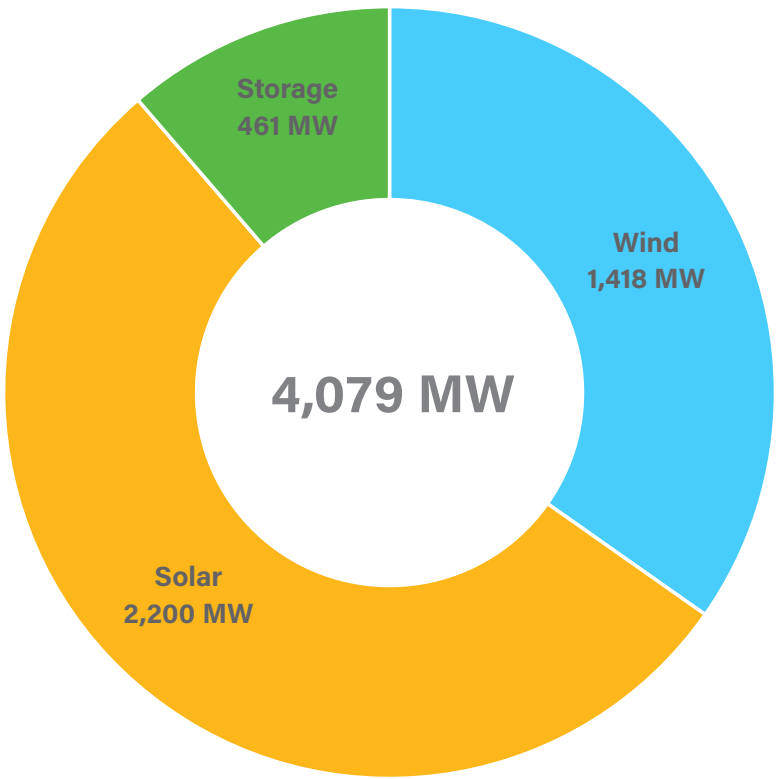
2023 Q1 installs

- The 95 project phases that came online in the first quarter added 4,079 MW of clean power to the grid.
- This is the lowest first quarter the industry has experienced since 2020. Q1 installs are down 36% from Q1 2022, which was a record first quarter.
- Developers commissioned 2,200 MW of new solar capacity in the first quarter, along with 1,418 MW of land-based wind and 461 MW of battery storage.

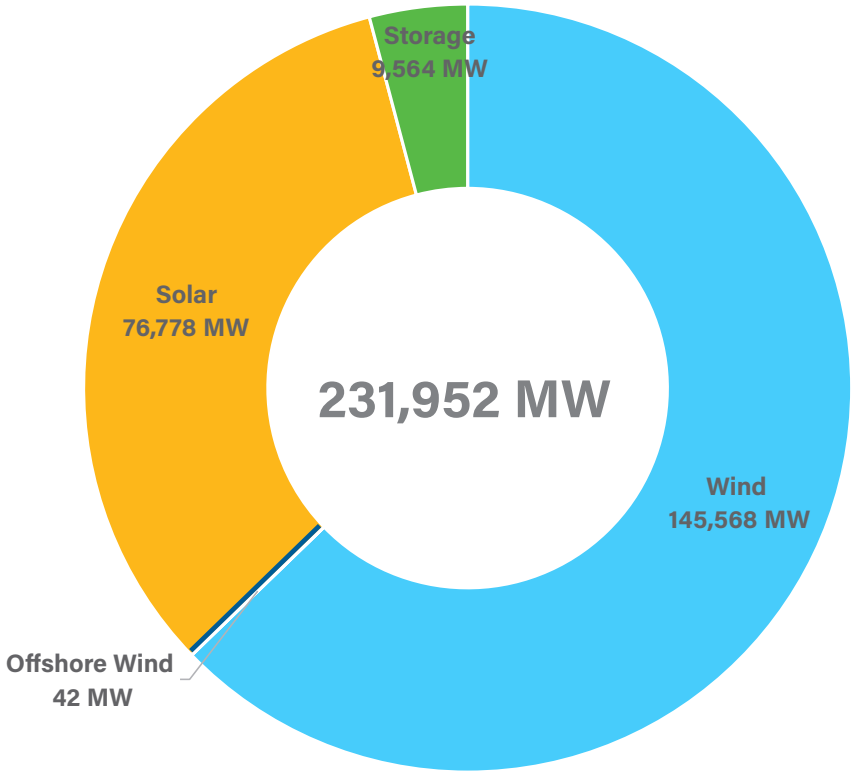
Cumulative operating clean power capacity

- The 231,952 MW of clean power operating in the U.S. is enough to power more than 62 million American homes.
- Broken down by technology, operating clean power capacity is made up of 145,568 MW of land-based wind, 76,778 MW of solar, 9,564 MW/26,276 MWh of battery storage capacity, and 42 MW of offshore wind.

Q1 2023 Clean Power Installs by Technology

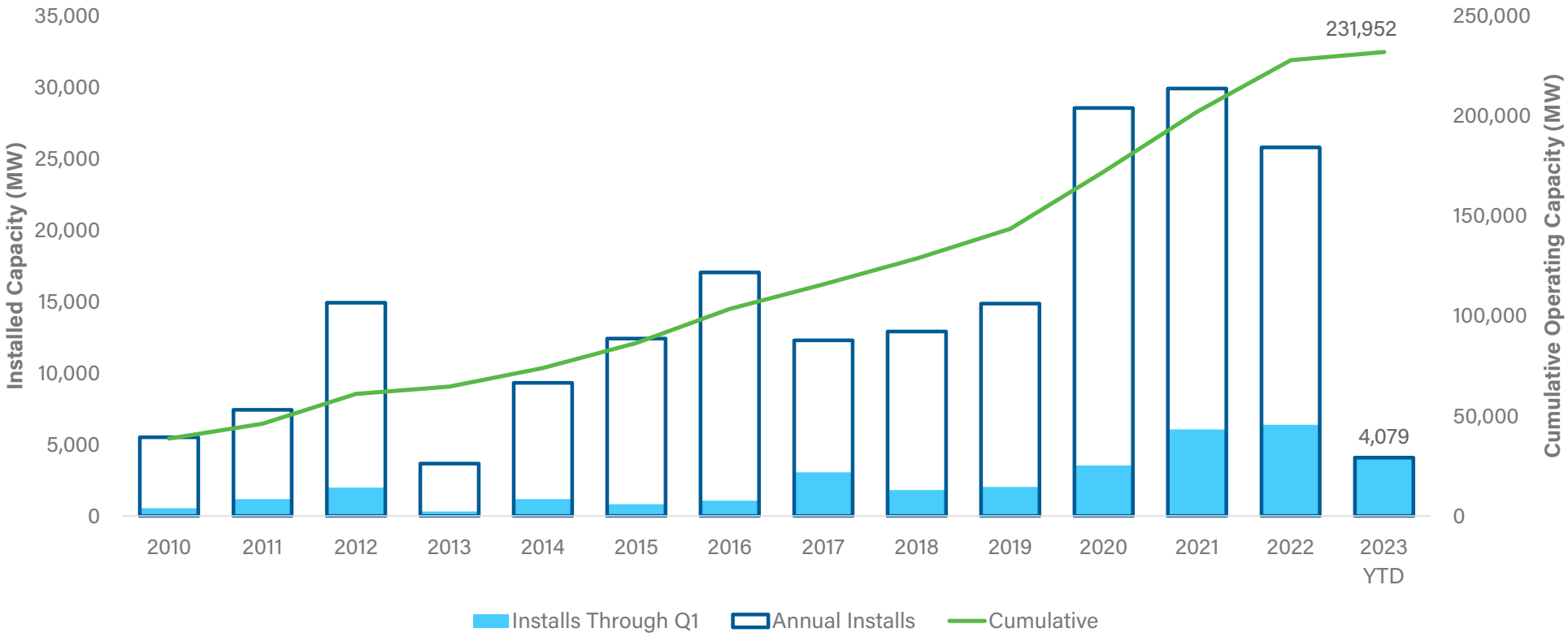


Total Operating Clean Power Capacity by Technology



Lowest First Quarter Since 2020 (continued)

U.S. Annual and Cumulative Clean Power Capacity Growth

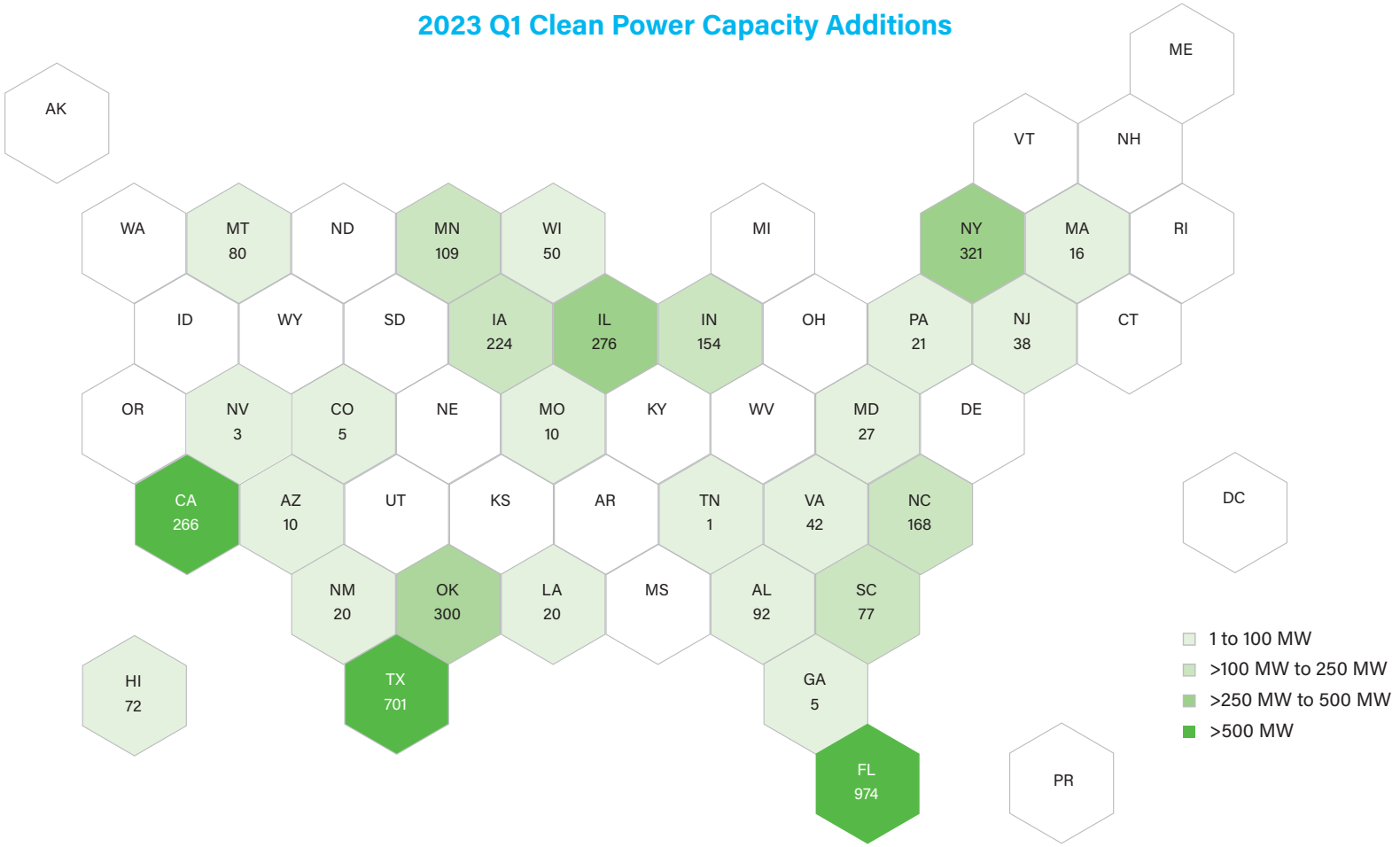


CLEAN POWER CAPACITY GROWTH

Florida Steals Top Spot in Q1

- After consistently ranking first quarter after quarter, Texas dropped to second in terms of quarterly clean power installations. Instead, Florida stole the top spot, commissioning 974 MW of new utility-scale solar projects. Texas installed wind, solar, and storage project this quarter for a total of 701 MW.
- New York ranks third for the quarter, installing 321 MW of wind and solar capacity. Oklahoma, Illinois, California, and Iowa were the only other states to top 200 MW this quarter.
- Of the 27 states that installed new clean power projects in Q1 2023, only two installed more than 500 MW, 10 installed more than 100 MW, and 14 installed more than 50 MW.

2023 Q1 Clean Power Capacity Additions

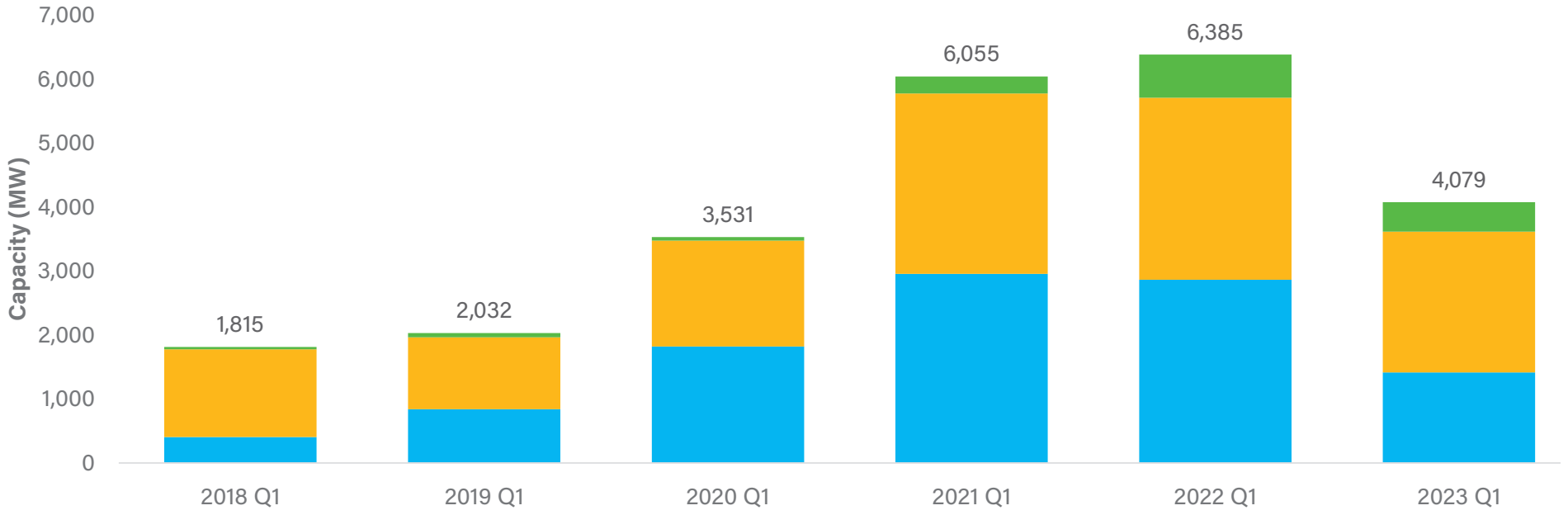


CLEAN POWER CAPACITY GROWTH

Quarterly Clean Power Capacity Growth

- First quarter installations fell 36% compared to Q1 2022, which was the highest first quarter to date. This breaks from the growth in Q1 installs the industry has delivered over the past four years.
- Wind installations fell most significantly, down 50% compared to Q1 2022. The wind industry experienced its lowest quarter since the 2019. Battery storage and solar installations also decreased by 32% and 23%, respectively.
- Seven wind project phases commissioned in 2022 with a total capacity of 1,418 MW. The largest projects include the Inertia Wind Project (301 MW) and Seven Cowboy Wind project (300 MW).
- Developers brought 71 new solar projects online in the first quarter with a total capacity of 2,200 MW. Bellflower Solar Project, owned by Lightsource BP, was the largest solar project to commission in Q1 2023 at 153 MW.
- 17 new storage projects with a total capacity of 461 MW/1,075 MWh came online in Q1. Madero Grid and Ignacio Grid Battery Storage, both owned by Able Grid solutions, tied for the largest battery storage projects online in the first three months of the year. Madero Grid has a storage energy capacity of 100 MW/215 MWh and Ignacio Grid has a storage energy capacity of 100 MW/160 MWh.

Q1 Clean Power Installations, 2018-2023

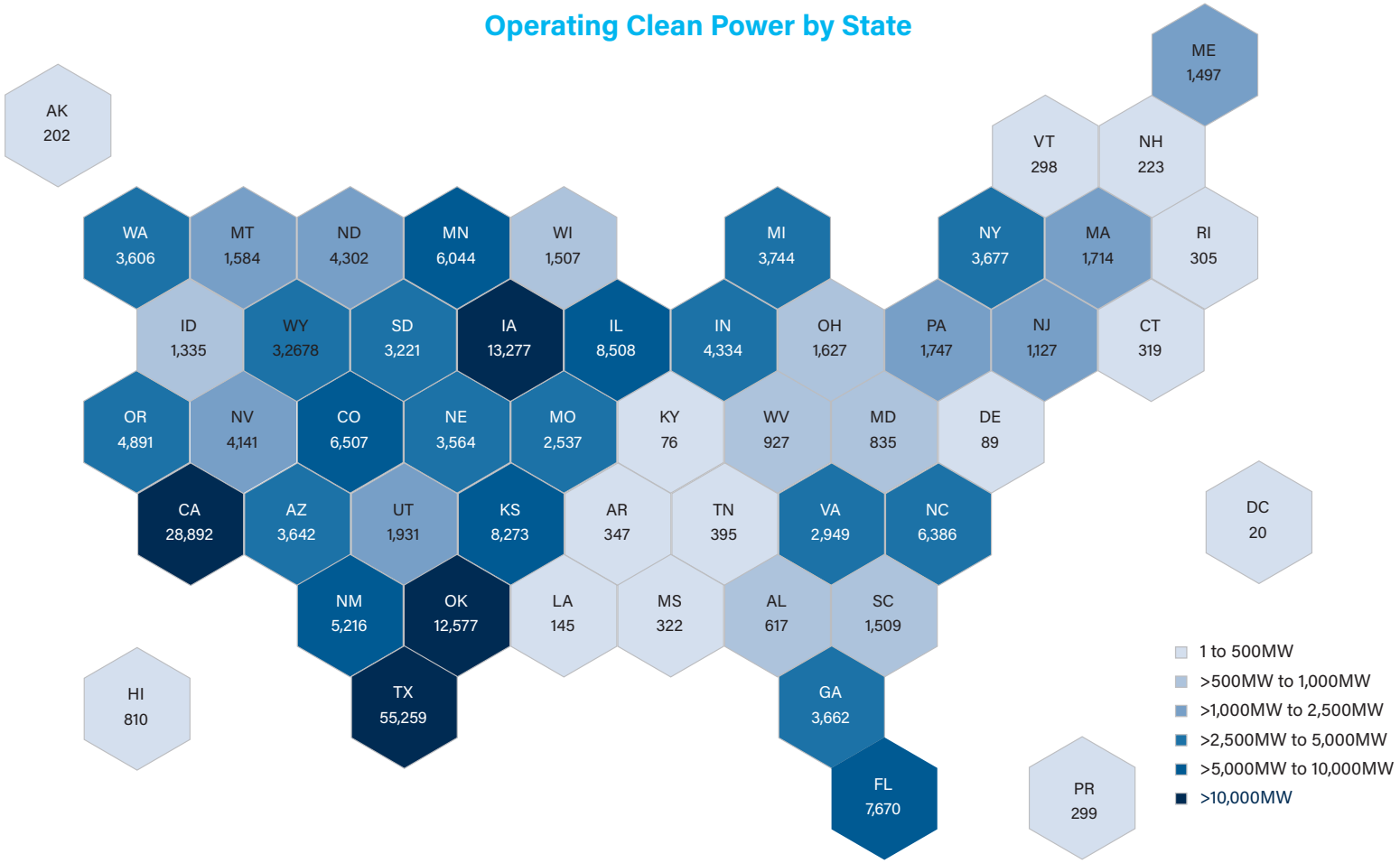


CLEAN POWER CAPACITY GROWTH

Operational Clean Power Capacity

- Clean power is being used to power homes and businesses in all U.S. states, including DC and Puerto Rico.
- There are 231,952 MW of clean power operating, enough to power more than 62 million American homes.
- Texas leads the nation with the most operating clean power capacity (55,259 MW). The Lone Star State also leads in total operating wind capacity and ranks second for solar and battery storage.
- California ranks second for total operating clean power (28,892 MW) and first in solar and battery storage.
- Iowa and Oklahoma, both wind rich states, rank third and fourth with 13,277 MW and 12,577 MW operating, respectively.

Operating Clean Power by State



CLEAN POWER CAPACITY GROWTH

Clean Power Pipeline Growth

Wind

- The land-based wind pipeline is comprised of 93 project phases with a total capacity of 20,176 MW, including 10,018 MW under construction and 10,158 MW in advanced development.
- Compared to the final quarter of 2022, the land-based wind pipeline decreased 3% due to a lack of projects entering the pipeline to replace commissioned projects. Year-over-year, the land-based wind pipeline decreased 14%.
- Wyoming has taken over the top spot in the land-based wind pipeline with 3,927 MW in development, accounting for 19% of the total pipeline. Texas now ranks second with 3,095 MW of wind in development. There are 11 states with more than 500 MW of land-based wind in development.
- With numerous states setting offshore wind targets, the technology now accounts for a significant portion of the clean power pipeline in several states. Based on the state of power delivery, New York is leading the nation with 4,230 MW in development, followed by New Jersey with 3,758 MW in development. Massachusetts is in third with 3,242 MW followed by Virginia with 2,587 MW.

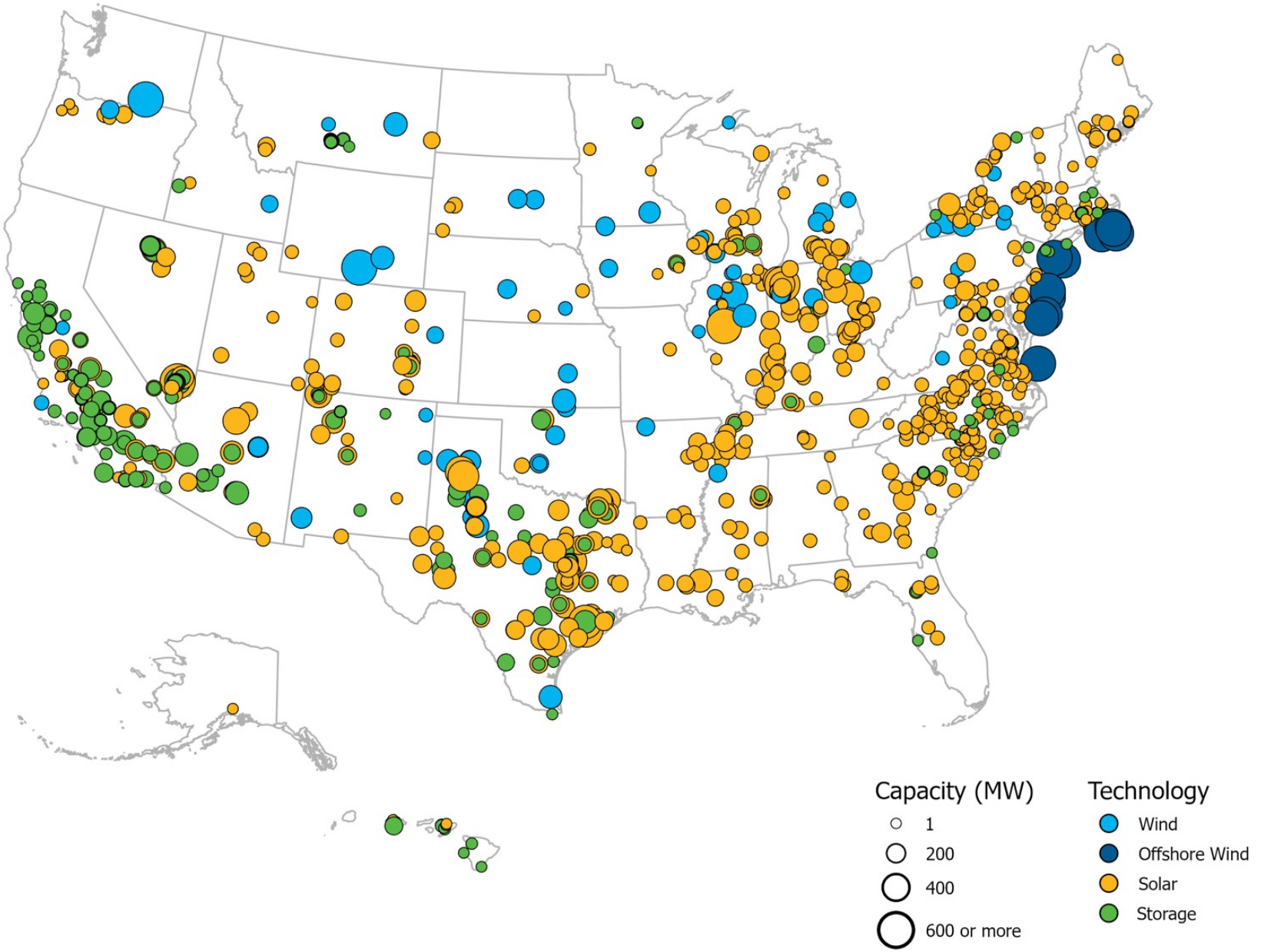
Solar

- The solar pipeline continued steady growth in the first quarter of 2023, with 794 projects totaling 81,509 MW in development.
- The solar pipeline increased 2% compared to the end of 2022 and has grown 16% year-over-year.
- Solar makes up 59% of the total clean power pipeline.
- Every state except Kansas and North Dakota has solar capacity in development. Texas leads the pipeline with 17,316 MW in development, constituting more than a fifth of the pipeline. Indiana maintained second place with 6,251 MW of utility-scale solar in development, followed closely by California with 6,197 MW in development.
- Across the country, 22 states have more than a gigawatt of solar in development.

Battery Storage

- The battery storage pipeline experienced the most significant growth in the first quarter, increasing 17% from the end of 2022 and 33% compared to the first quarter of 2022.
- There are 245 storage projects in development, totaling 19,621 MW/53,184 MWh.
- Hybrid projects account for 61% of storage capacity in development, down from nearly 70% last quarter. Of the 3.4 GW of battery capacity entering the pipeline this quarter, the majority, 61%, was standalone. This is likely due to the availability of the new standalone storage investment tax credit (ITC) included in the IRA.
- California leads the battery storage pipeline with 8,280 MW in development, followed by Texas with 3,545 MW in the pipeline.

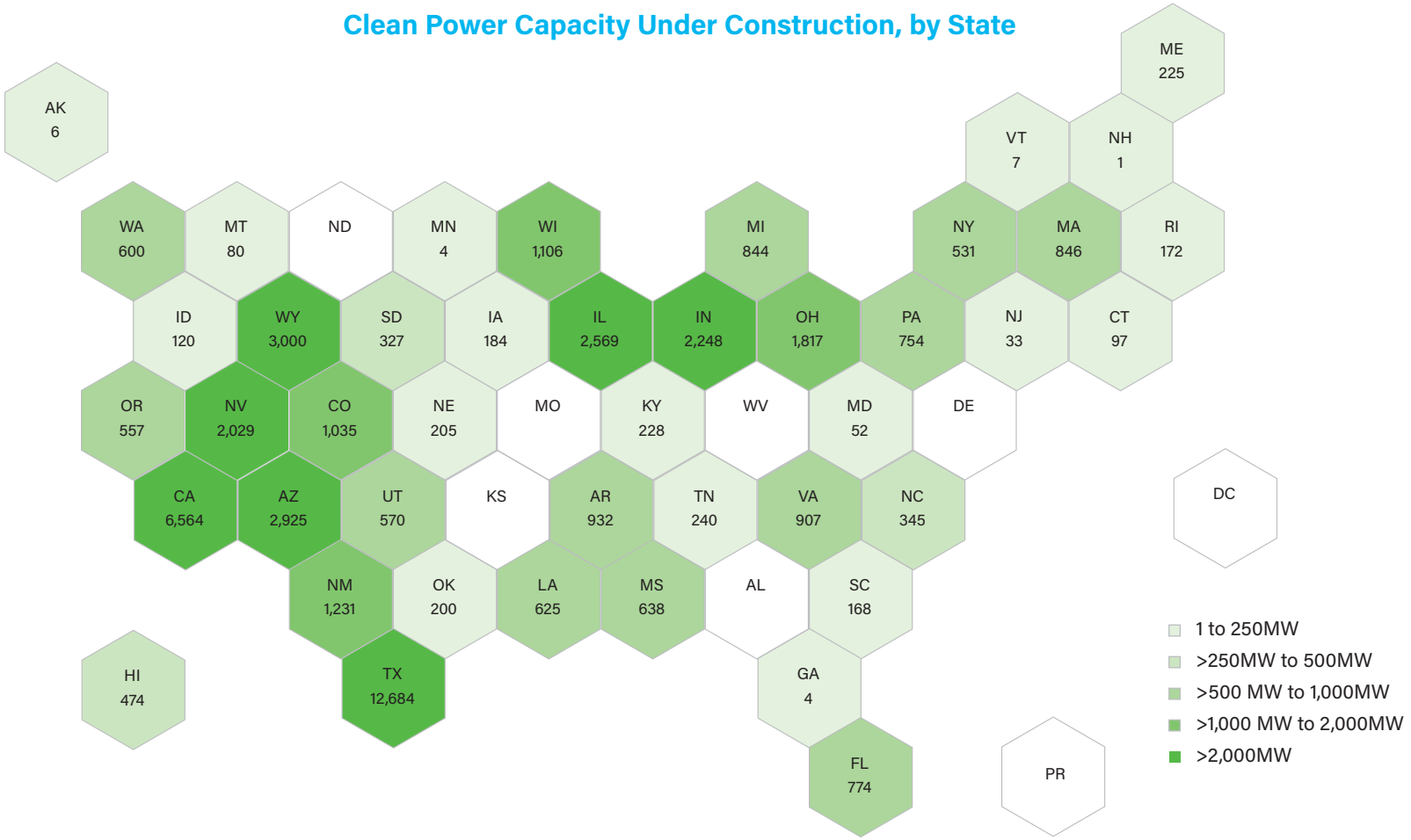
Projects in Pipeline



Clean Power Construction Activity

- There are 406 clean power project phases under construction across 44 states as of the close of the first quarter. These projects total to 48,957 MW.
- By technology, there are 29,309 MW of solar, 10,018 MW of land-based wind, 8,692 MW of battery storage, and 938 MW of offshore wind under construction in the U.S.
- In the fourth quarter, 7,266 MW of clean power projects began construction, more than half of which were solar.
- Texas has the highest amount of clean power capacity under construction, with nearly double the capacity of any other state. California is a distant second, with 6,564 MW under construction.
- On a regional basis, Texas is followed by the Mountain West (10,791 MW) and Midwest (6,955 MW).

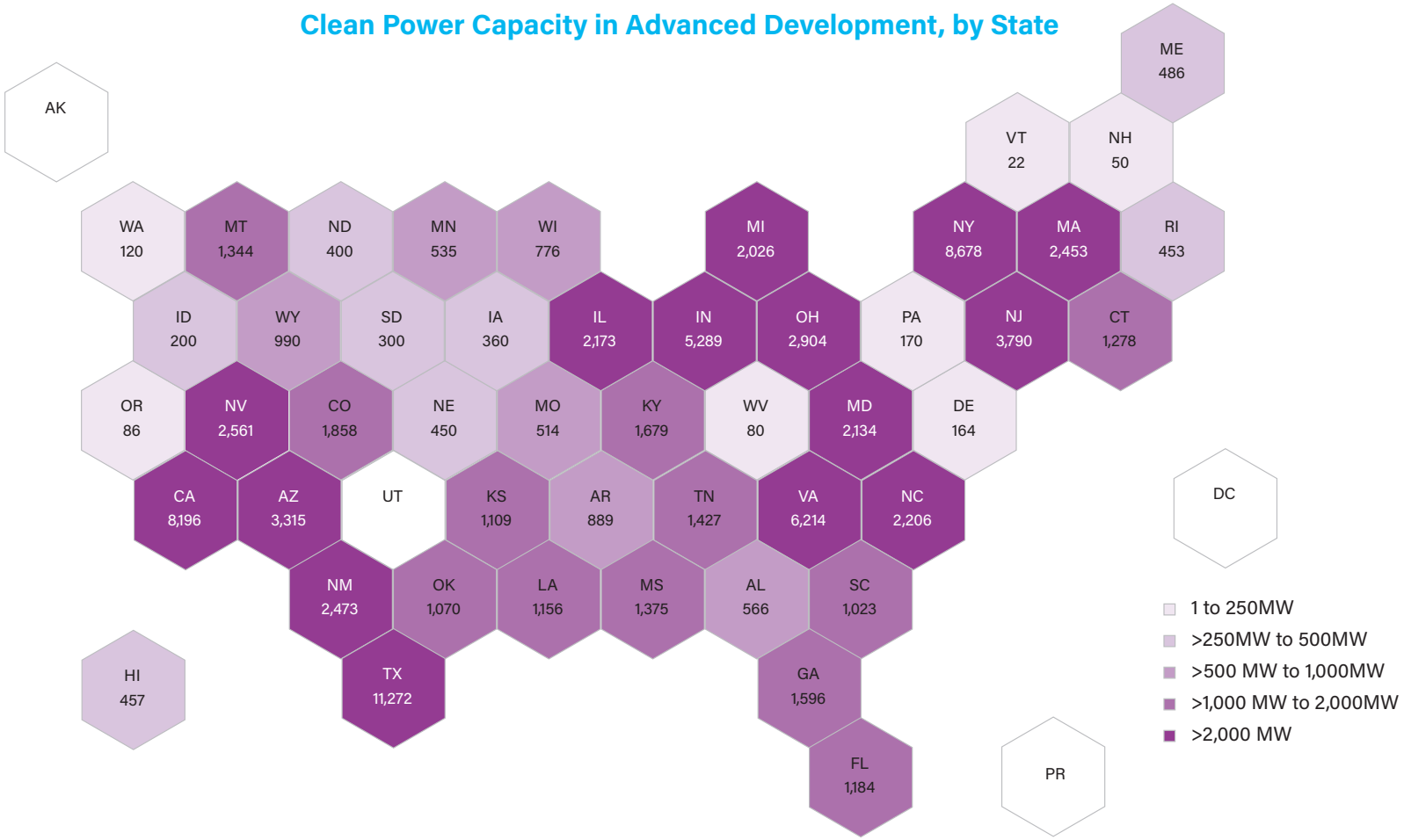
Clean Power Capacity Under Construction, by State



Clean Power Advanced Development Activity

- The advanced development pipeline of 89,850 MW spans 48 states and 744 project phases. Alaska and Utah are the only states without clean power projects in advanced development.
- Texas has the most clean power in advanced development (11,272 MW), followed by New York (8,678 MW) thanks to the states offshore wind projects, and California (8,196 MW).
- Texas leads the solar and land-based wind advanced development pipeline, while California claims the top spot for battery storage and offshore wind is claimed by New York.
- Within the advanced development pipeline, solar comprises 58% while offshore wind represents 18%. Battery storage constitutes 12% of the pipeline while land-based wind accounts for the remaining 11%.

Clean Power Capacity in Advanced Development, by State

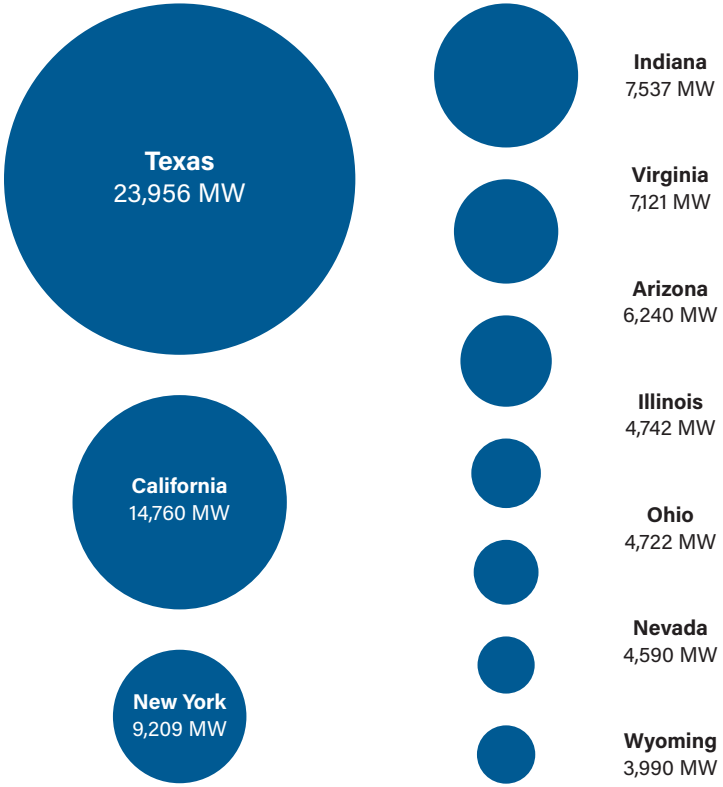


CLEAN POWER CAPACITY GROWTH

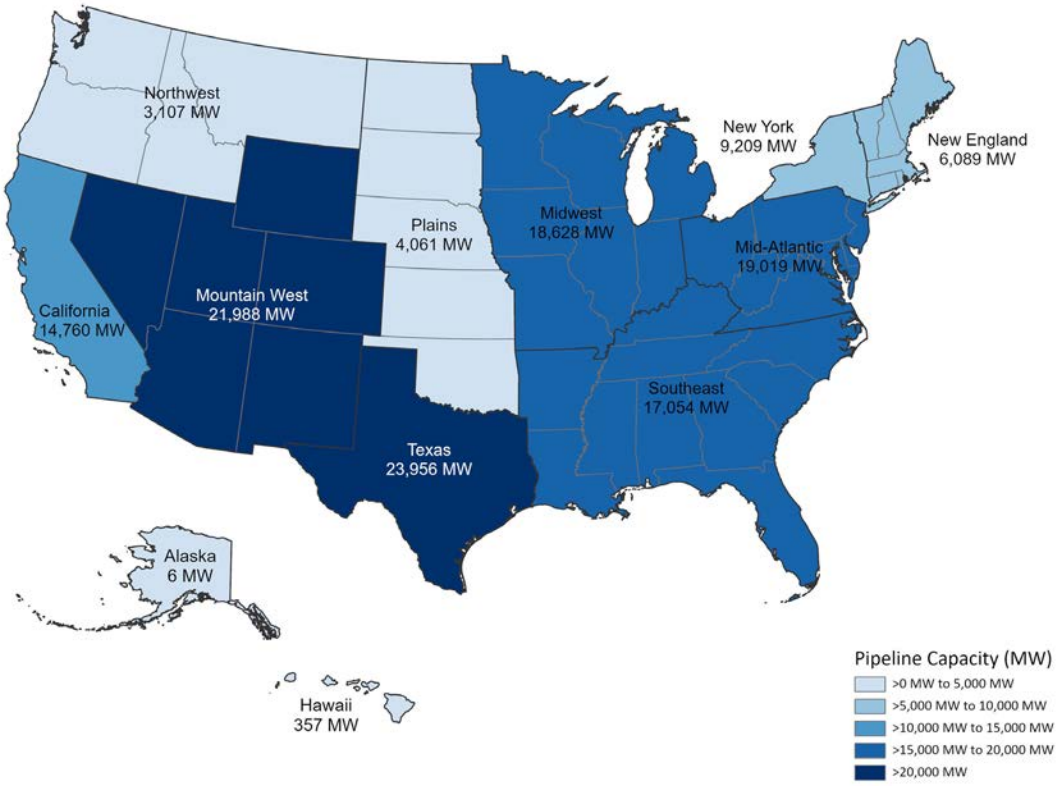
Clean Power Pipeline by State and Region

- There are 138,808 MW in development across all 50 states.
- Texas and California, the nation's leaders in operating clean power capacity, also lead the development pipeline, with 23,956 MW and 14,760 MW in development, respectively.
- New York ranks third with 9,209 MW in development, 46% of which is offshore wind power. New York is followed by Indiana with 7,537 MW in development, the majority of which is solar.
- By region, Texas is followed by the Mountain West and Mid-Atlantic. The Midwest ranks second in terms of operating capacity but fourth in the pipeline.

Top States, Clean Power Development Capacity



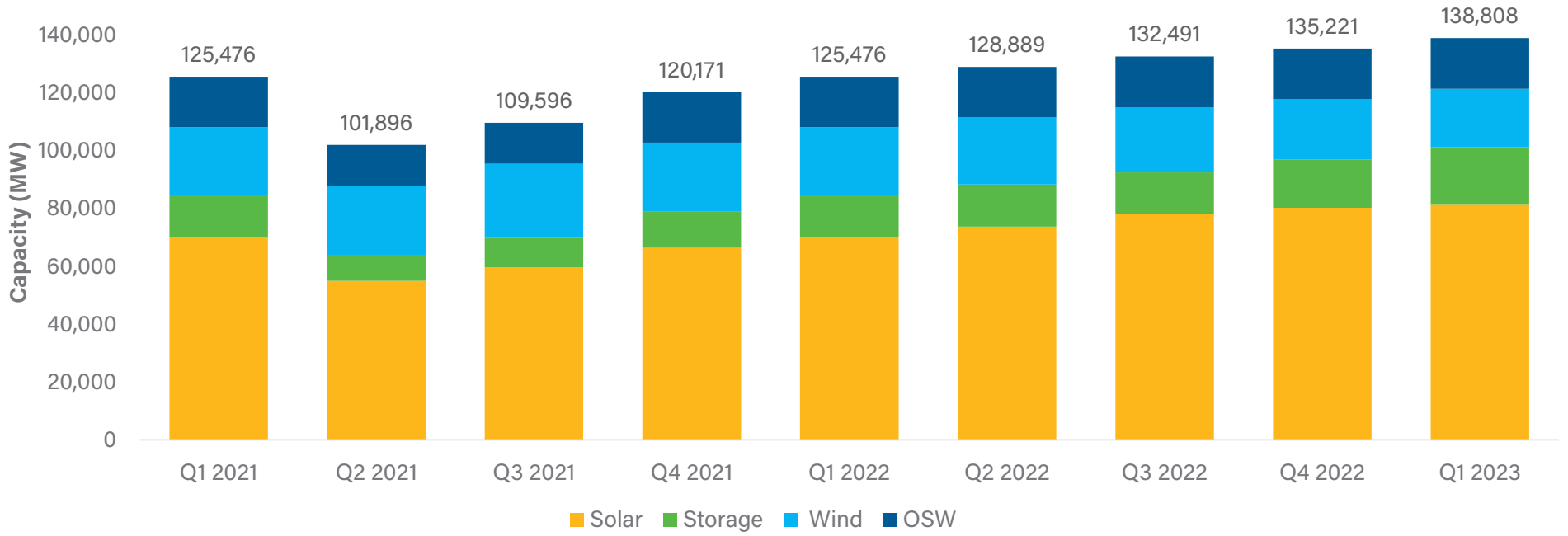
Clean Power Development Capacity by Region



CLEAN POWER CAPACITY GROWTH

Clean Power Pipeline Over Time

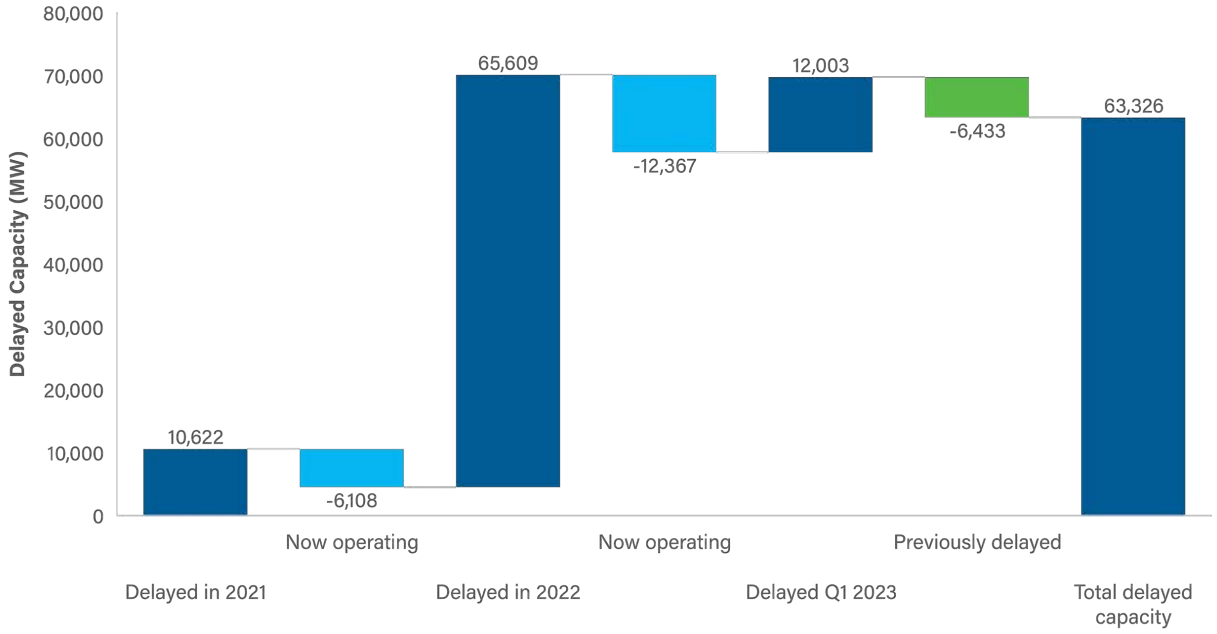
- In Q1 2023, the clean power pipeline reached a record-breaking 138.8 GW. This remarkable figure demonstrates a consistent upward trend, with the exception of a temporary decline between the first and second quarters of 2021.
- Excluding the change Q1 to Q2 in 2021, the pipeline has grown at an average rate of 5% each quarter over this time period. The most significant quarterly growth occurred in the last two quarters of 2021.
- From Q3 2021 to Q1 2023, the storage pipeline experienced the highest average quarterly growth rate at 12%, followed by solar at 6%. The land-based wind pipeline, on the other hand, has decreased by an average of 2% each quarter.
- Over this two-year period, the solar share of the pipeline has increased by 5%.



Clean Power Project Delays

- The 36% decline in Q1 clean power installations compared to Q1 2022 can be attributed, in part, to the large quantity of projects that experienced delays this quarter. More than 12 GW of projects reported delays in the first three months of 2023. Of that, more than 6.4 GW had already experienced previous delays. For comparison, only 6.9 GW of projects reported delays in Q1 2022.
- 7.3 GW of projects initially expected online in Q1 reported delays this quarter. The remaining 4.9 GW that reported delays were initially expected to commission between the second quarter of 2023 and the end of 2025.
- On average, the projects that reported delays in the first quarter were delayed by an average of 6 months.
- Considering the 10.6 GW of projects that experienced delays by the end of 2021, only 58% of them have commenced operations. For the 65.6 GW of projects delayed in 2022, only 19% have been commissioned. Including the projects that recently reported delays, along with the capacity that was delayed in 2021 and 2022 but has not yet started operations, the total delayed capacity amounts to more than 63.3 GW.
- Solar accounts for the majority, 67%, of total delayed capacity.

Clean Power Project Capacity Delayed



Total Clean Power Capacity Delayed, by Technology

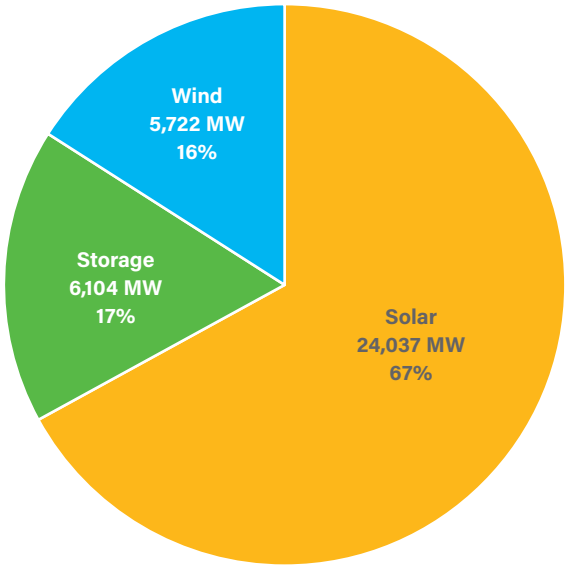


Photo credit: Recurrent Energy

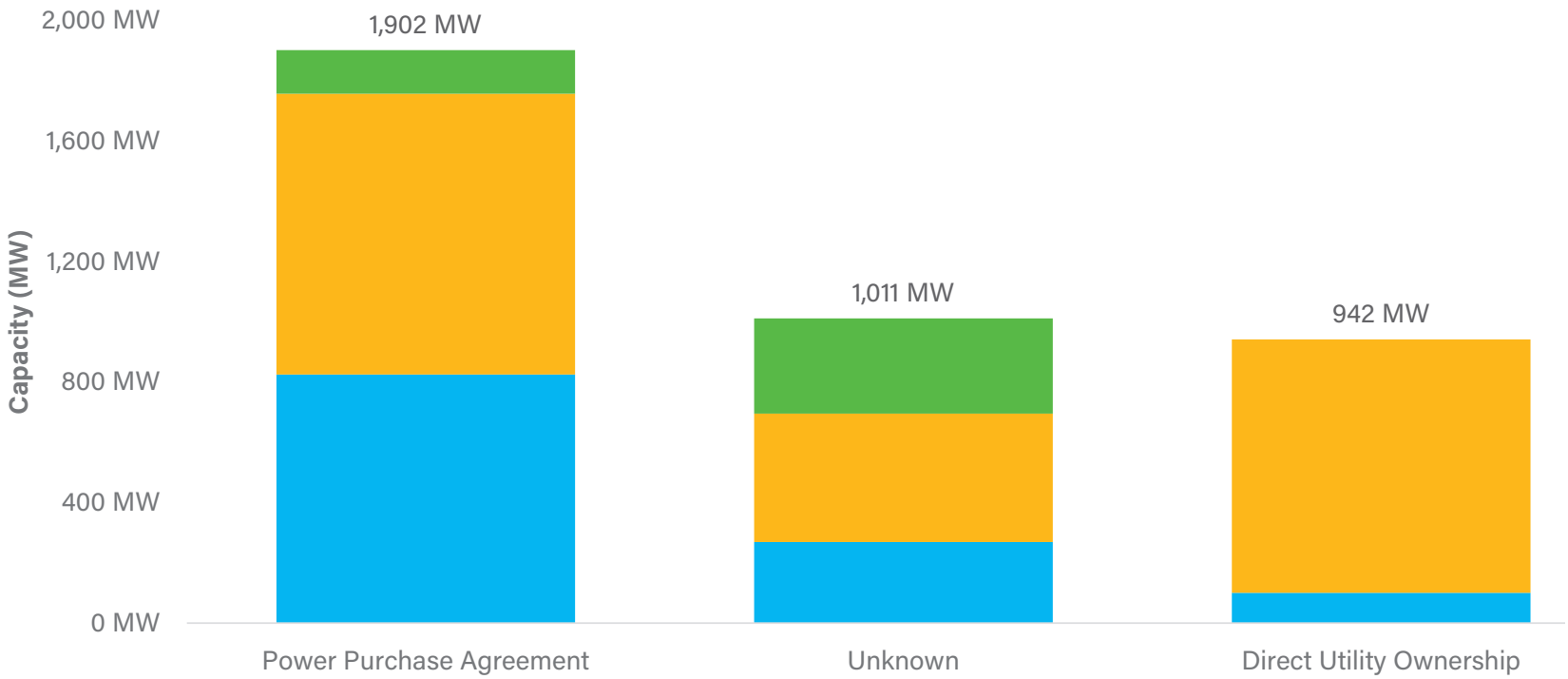
Clean Power Procurement

CLEAN POWER PROCUREMENT

Offtake Mechanisms for Q1 2023 Projects

- Of the 4,079 MW online in the first quarter of 2023, just shy of half, 49%, of operating capacity has a PPA in place.
- ACP is unable to determine the offtake mechanism in place for 26% of capacity brought online this quarter, due in part to the more complicated and often undisclosed offtake structures used for battery storage.
- Utility ownership and use of clean power projects to serve their customers makes up the remaining 24% of capacity online this quarter.
- Utilities also have PPAs in place for 29% of capacity online this quarter. Combined with the capacity owned by utilities, more than half of the capacity online this quarter is being used to serve utility customers.
- Corporate buyers, which reply primarily on PPAs, have PPAs in place for 25% of the clean power capacity added in the first quarter.

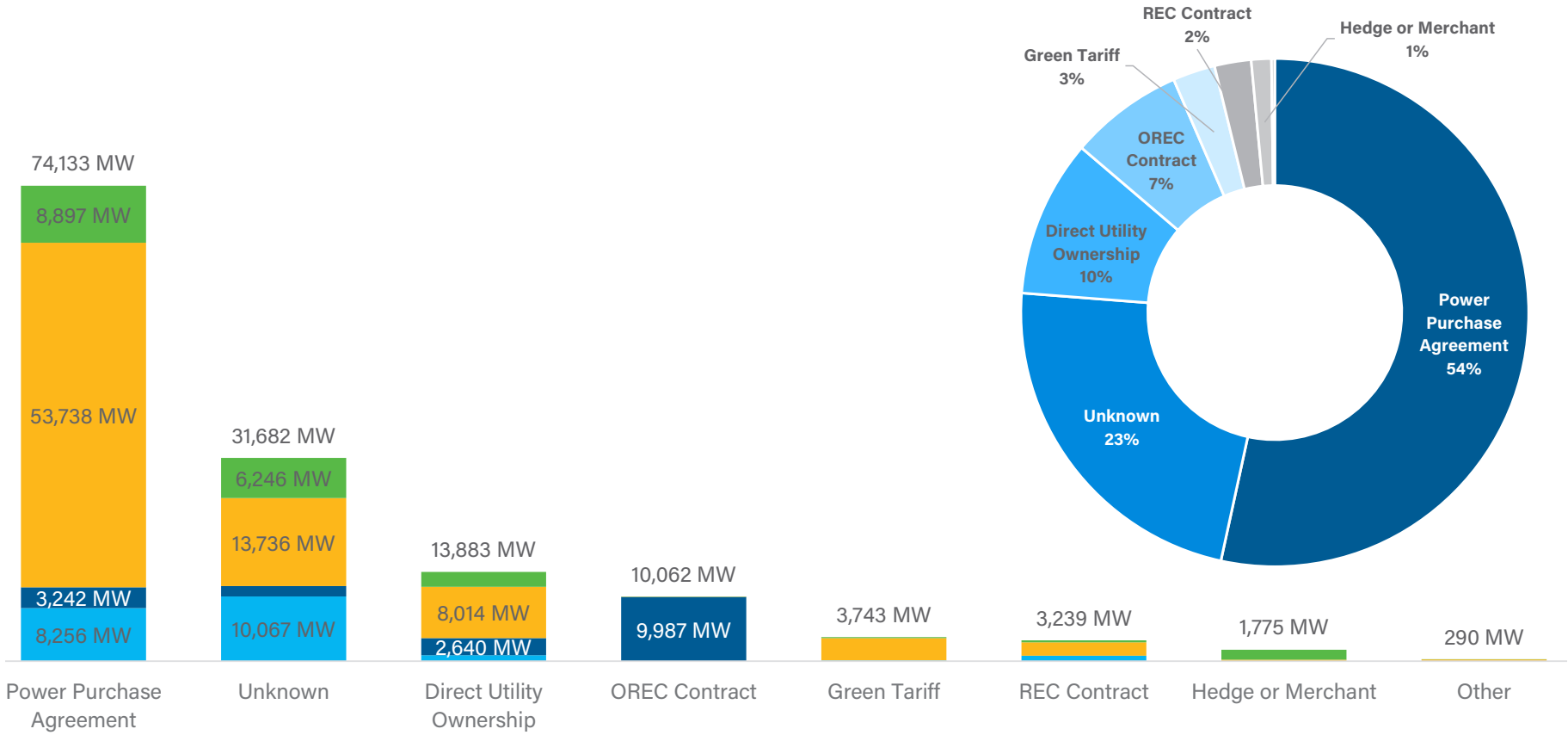
Annual Clean Power Offtake Announcements, By Offtake Mechanism



Offtake Mechanisms for Pipeline Projects

- More than half, 53%, of the clean power capacity in development has a PPA in place. Another 10% of the pipeline is capacity owned by utilities that will be used to serve their customers, and 9% has REC or OREC contracts in place.
- Green tariff contracts make up 10% of the pipeline. Hedge and merchant contracts have become increasingly uncommon, accounting for just 1% of the total pipeline.
- Utilities own or have offtake agreements in place for 45% of the pipeline, with PPAs being the primary offtake mechanism used.
- Corporate purchasers are procuring 20% of the clean power capacity in development. Solar accounts for 85% of pipeline capacity being procured by corporations.

Clean Energy Pipeline Capacity Offtake Status

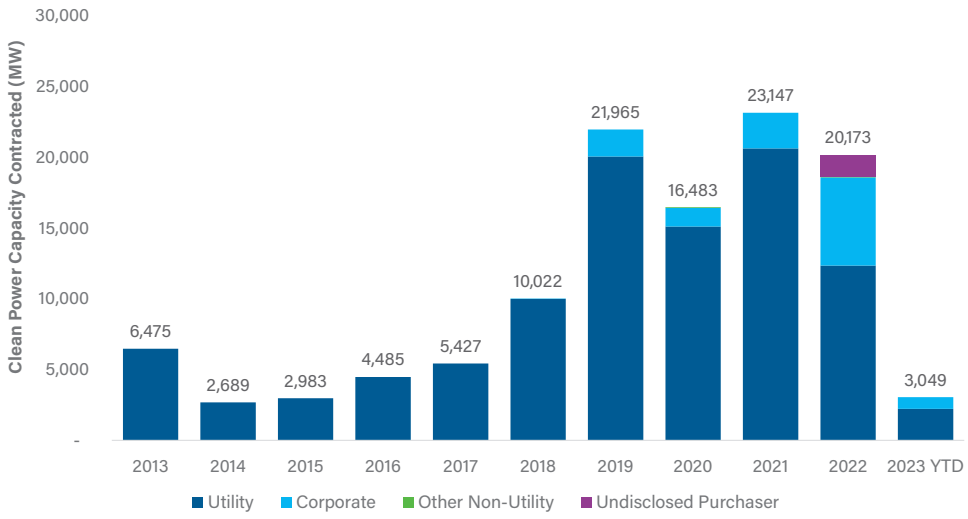


CLEAN POWER PROCUREMENT

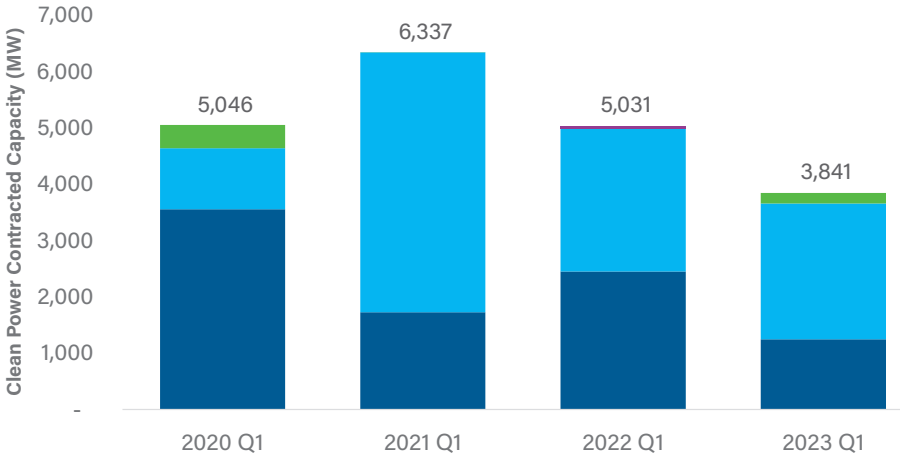
Quarterly PPA Announcements Drop

- In the first three months of 2023, clean power developers and buyers announced 3,841 MW of new PPAs, a 24% decline compared to the first quarter of 2022.
- In comparison to Q1 2022, both utility and corporate buyers announced fewer PPAs, with announcements down 49% and 5%, respectively, for each buyer group.
- Google, Meta, and Verizon led corporate PPA announcements in the first quarter. Google announced nearly 800 MW of new PPAs, including a first-of-its-kind agreement with Sol Systems to build community solar projects in low renewable-penetration areas. Meta announced an addition 435 MW of new PPAs, and Verizon announced 280 MW.
- Within the utility space, Berkshire Hathaway Energy and Southern California Public Power Agency led announcements, having disclosed 451 MW and 176 MW of new PPAs, respectively.

Clean Energy Purchase Agreement Announcements, By Year



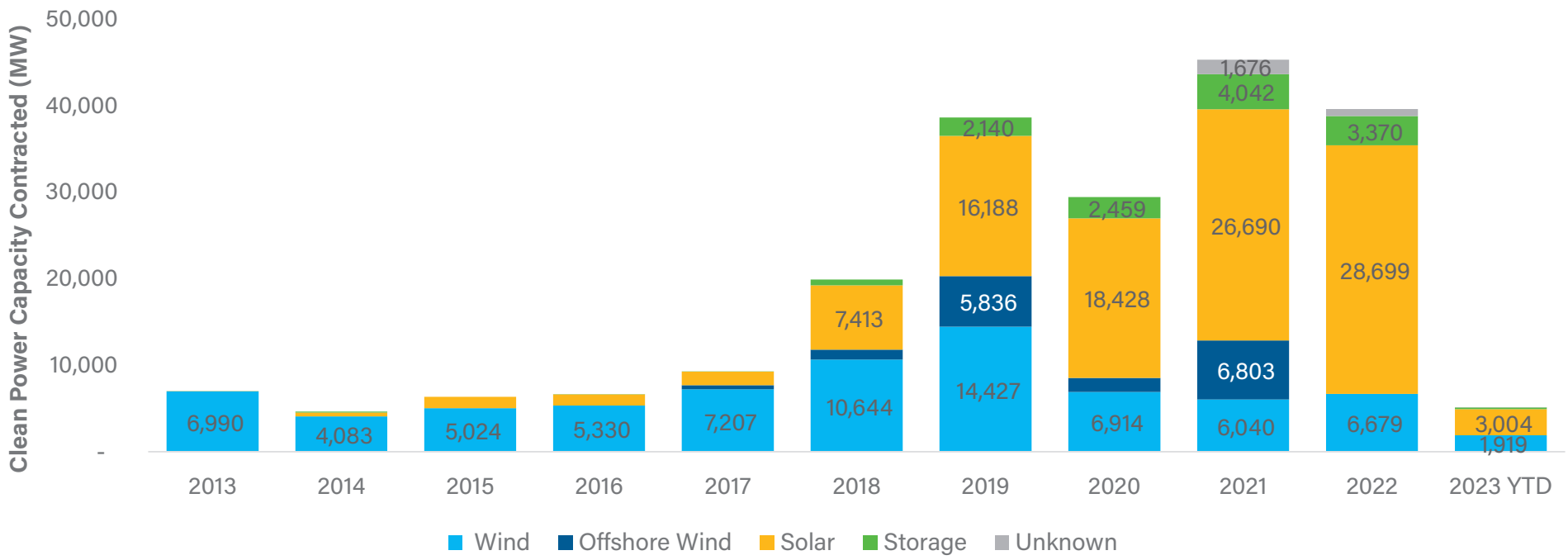
Q1 PPA Announcements, 2020-2023



PPA Announcements Decline Across All Technologies

- In Q1, in a reversal from recent trends, slightly more new wind PPAs were announced than solar PPAs. The industry announced 1,869 MW of new wind PPAs and 1,862 MW of solar PPA. An additional 85 MW of storage PPAs and 25 MW where the technology cannot be determined were announced as well.
- Wind was also the only technology the experience an increased in PPA announcements compared to the same period last year, up 61%.
- Solar PPA announcements, on the other hand, were down by 47% and storage PPA announcements decreased by 77%.
- Falling solar PPA announcements can be partially attributed to seesawing regulations. The U.S. Department of Commerce's (DOC) ongoing anticircumvention investigation delayed or forced changes to solar module delivery plans and introduced significant risk regarding project delivery timelines. This likely pushed some buyers to the sidelines to await resolution and firmer delivery commitments.

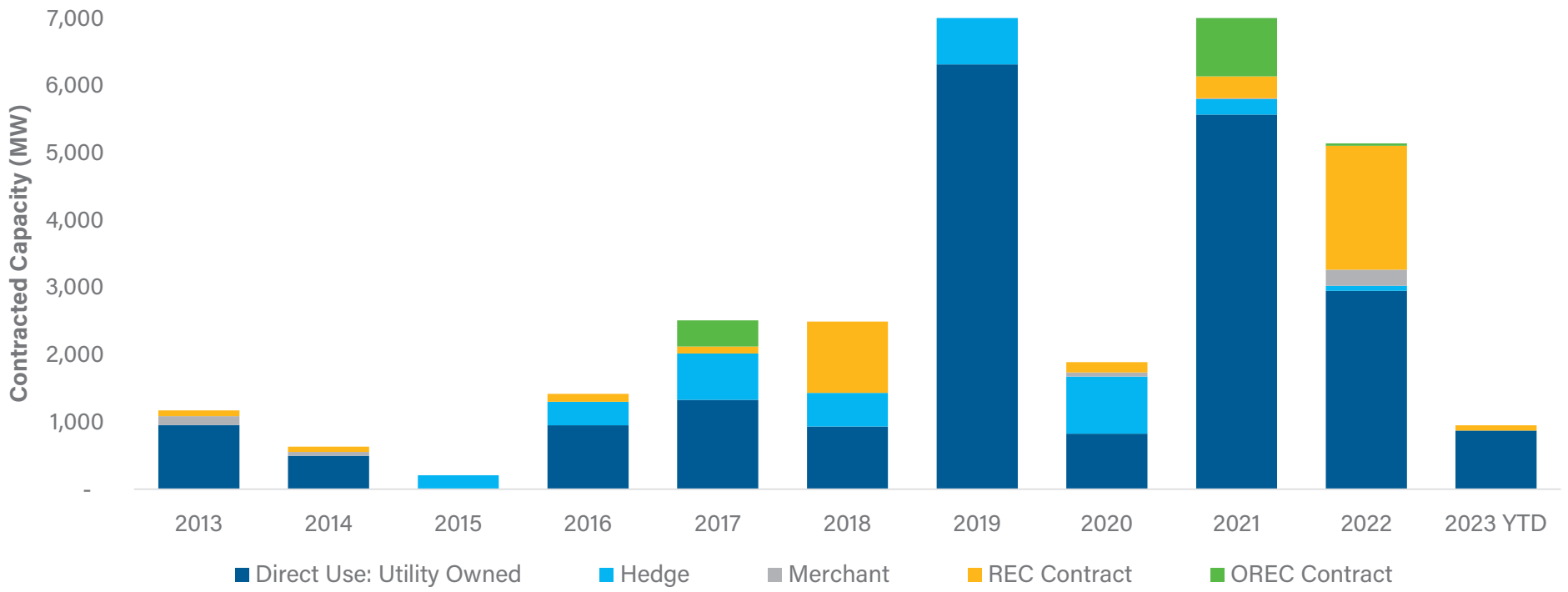
Annual Clean Power Purchase Agreements, By Technology



Other Offtake Announcements Also Decline

- While PPAs are the dominant offtake mechanism, ACP also tracks announcements for other types of clean power procurement.
- In the first quarter of 2023, direct use was the primary offtake mechanism announced besides PPAs at 871 MW. REC contracts made up an additional 78 MW of offtake announcements.
- Other offtake type announcements were up by more than 40% compared to the first quarter of 2021, but it should be noted that public announcements of these other offtake mechanisms is not as common or consistent as PPA announcements.

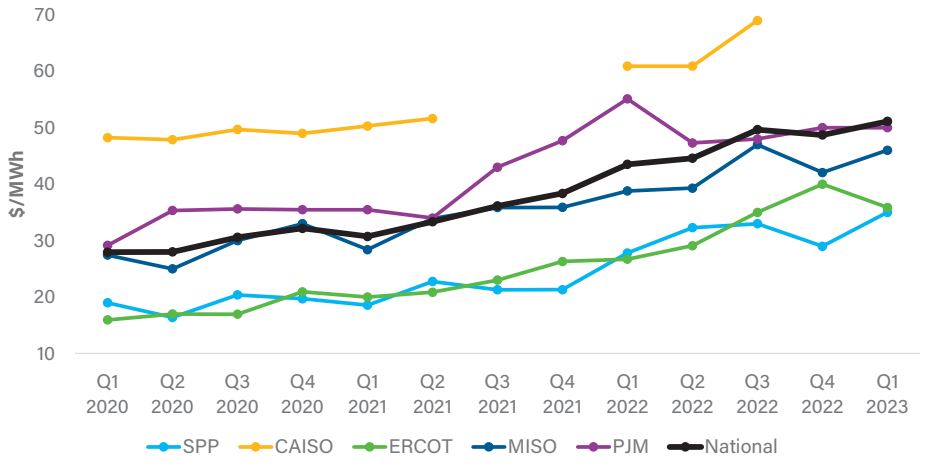
Annual Clean Power Purchase Agreements, By Technology



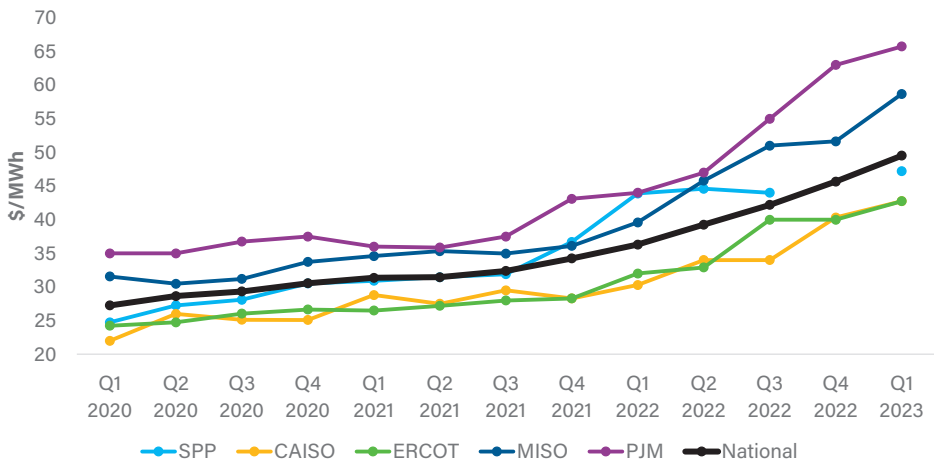
Continued Rise in PPA Prices

- Year-over-year, the blended national corporate PPA price index has increased by 26% to $50.32/MWh. For comparison, between Q1 2020 and Q1 2021, the price index rose by 29%.
- Wind PPA prices have climbed by 27% compared to Q1 2022 and 66% compared to Q1 2021, although they have dropped by 2% from Q4.
- Among all regions, PPA prices for wind projects in ERCOT have seen the largest increase, rising by 34% year-over-year. However, the prices in ERCOT have cooled from $40/MWh in Q4 2022 to $35.88/MWh in Q1 2023.
- The rise in solar PPA prices has been more pronounced, with a 36% increase year-over-year. PJM and MISO have experienced a 49% and 48% increase in prices, respectively, while SPP has had the smallest increase in solar PPA prices, rising only 8% compared to Q1 2022.

Wind PPA Prices, Q1 2021 – Q1 2023



Solar PPA Prices, Q1 2021 – Q1 2023



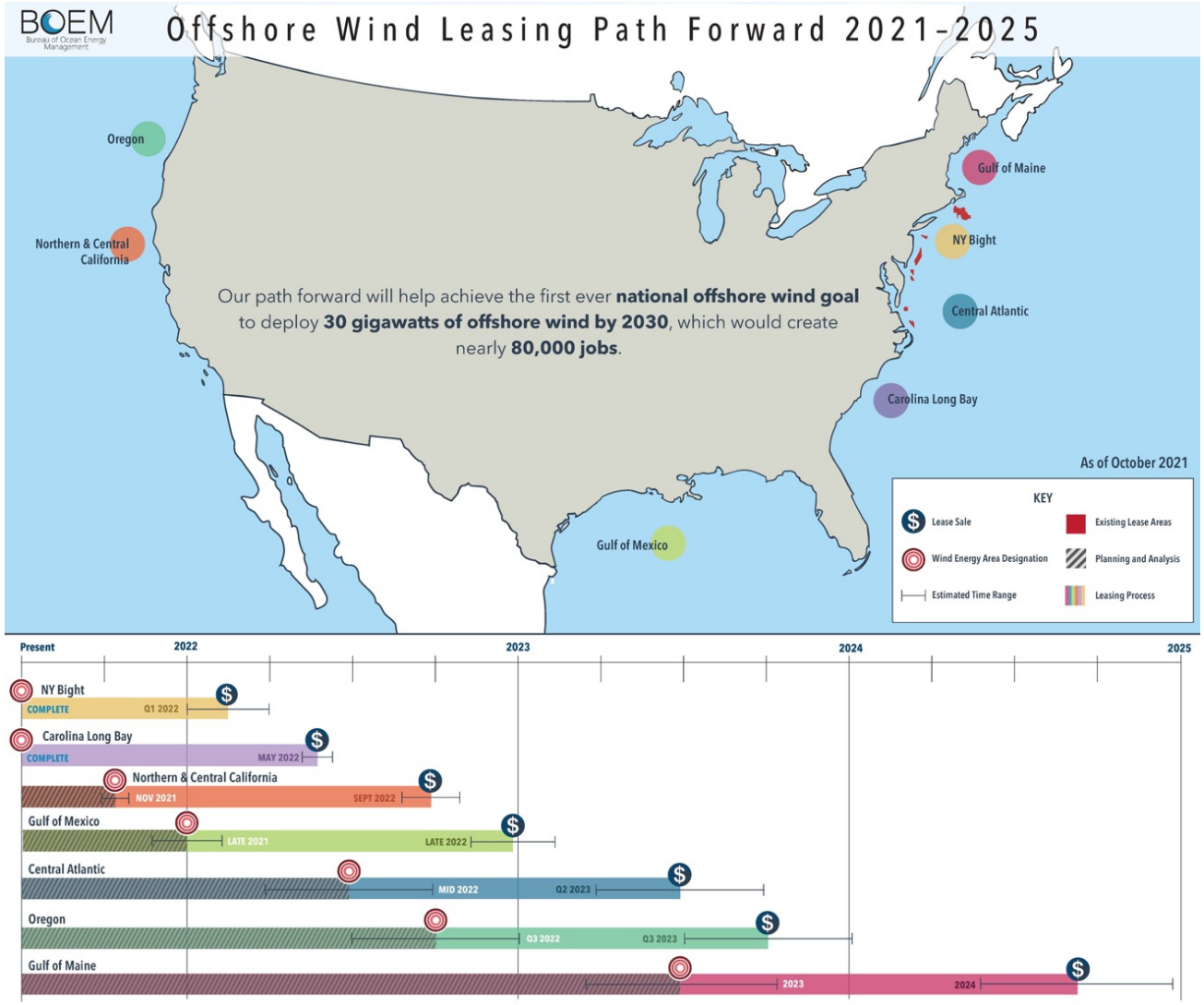
Source: LevenTen Energy

Photo credit: Ørsted

Offshore Wind Activity

Federal Activity

- In February 2023, BOEM announced a proposed offshore wind lease sale for three proposed lease areas in the Gulf of Mexico. Lease OCS-G 37334, off Lake Charles, LA contains 102,480 acres. Lease OCS-G 37335, off Galveston, TX also contains 102,480 acres. Finally, lease OCS-G 37336, also off Galveston, contains 96,786 acres. A final sale notice and a lease auction is expected in 2023.
- In the Gulf of Maine, BOEM published a draft Call for Information and Nominations Area (Call) in January 2023. In the second quarter of the year, BOEM announced the publication of a Call to invite public comment on, and assess interest in, possible commercial wind energy development in areas offshore Massachusetts, New Hampshire, and Maine.

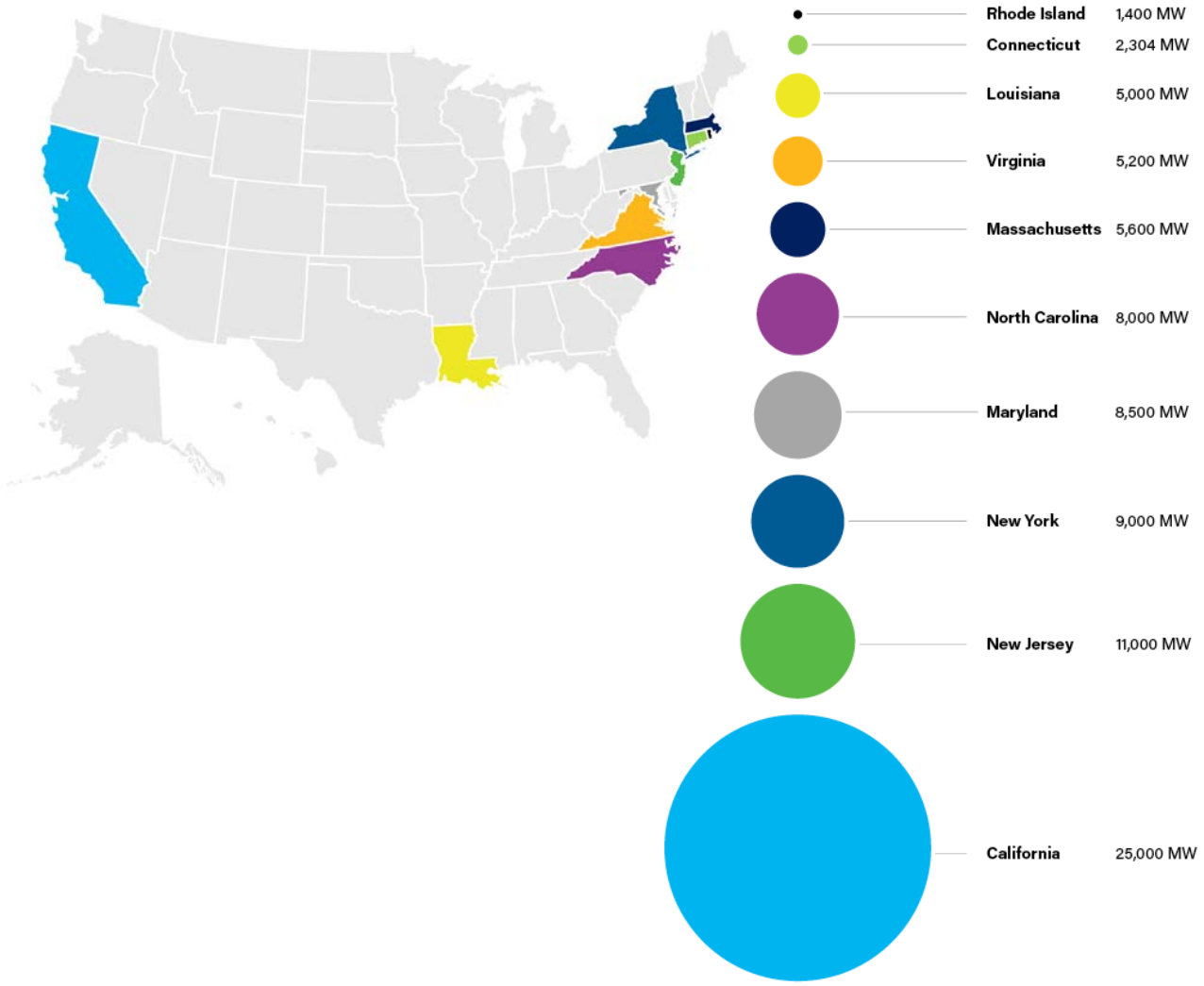


OFFSHORE WIND ACTIVITY

State Activity

- Proposals in response to New York's third offshore wind solicitation, seeking to procure at least 2 GW, were due at the end of January 2023. The state received proposals from six developers. Winners are set to be announced in the second quarter.
- Similarly, proposals in response to Rhode Island's latest RFP, seeking at least 600 MW and up to 1 GW of new offshore wind capacity were due in March 2023. The state received proposals from just one developer. The winner is set to be announced in June.
- In the second quarter, Maryland lawmakers passed a bill setting the state's offshore wind target to 8.5 GW by 2031 that was signed by the Governor.
- Ten states have set offshore wind targets totaling more than 81,000 MW.

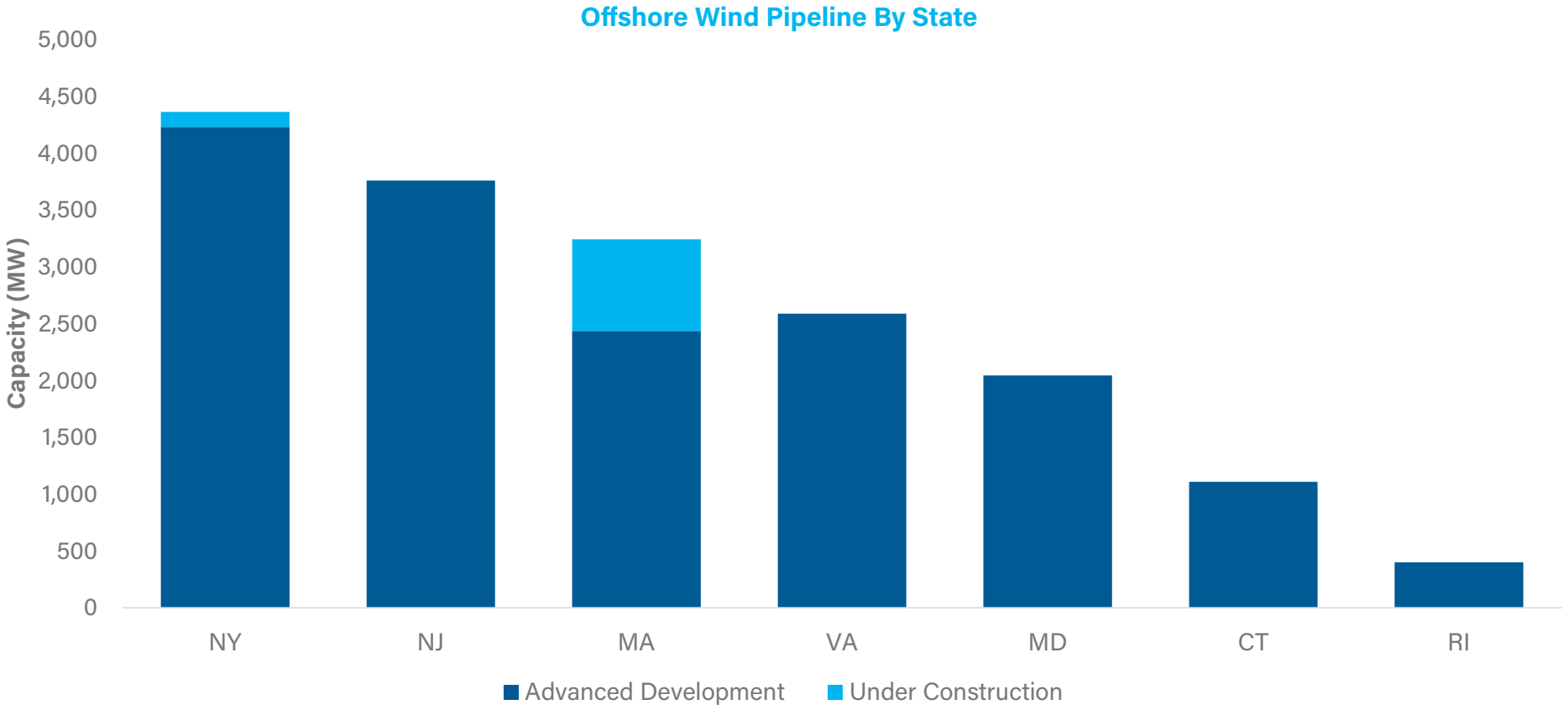
State Offshore Wind Targets



OFFSHORE WIND ACTIVITY

Project Updates

- Offshore construction on Ørsted & Eversource's 132 MW South Fork Wind project began in March 2023 with cable laying activities. South Fork Wind Farm has a PPA with the Long Island Power Authority in New York. The project is expected to be completed in 2023.
- The only other project currently under construction is Avangrid and Copenhagen Infrastructure Partner's 806 MW Vineyard Wind project, destined to serve customers in Massachusetts.
- In total, there is 17.5 GW of offshore wind capacity under construction or in advanced development on the East Coast. New York leads with nearly 4.4 GW of capacity in the pipeline, followed by New Jersey (3.8 GW) and Massachusetts (3.2 GW).



OFFSHORE WIND ACTIVITY

Vessel and Supply Chain Announcements

- In January, CREST Wind, a joint venture between U.S.-based Crowley and Danish maritime leader ESVAGT, announced that they will build and operate an SOV under a long-term charter with Siemens Gamesa Renewable Energy to support service operations at Dominion Energy's Coastal Virginia Offshore Wind project. Shipbuilding group Fincantieri will construct the vessel at their Sturgeon Bay, WI shipyard.
- In the first quarter, GE announced that it would construct a nacelle facility and a blade facility in New York if it wins a sufficient volume of orders from the State's third solicitation. Similarly, Siemens Gamesa announced its intention to build a nacelle manufacturing facility in New York, subject to the company's wind turbines being selected by the New York authorities in their third offshore wind solicitation.

Photo credit: Crowley

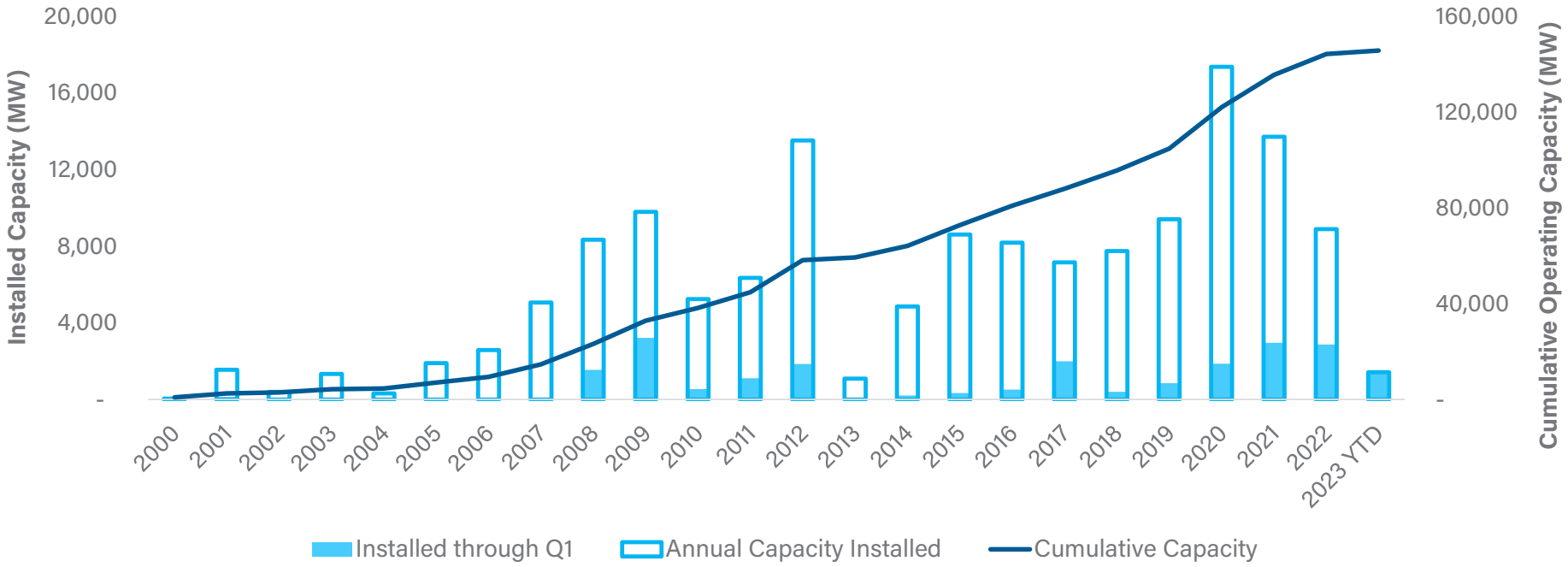
Land-Based Wind Activity

LAND-BASED WIND ACTIVITY

Over 1.4 GW of Land-Based Wind Capacity Added to the Grid

- During the first quarter of 2023, 7 new land-based wind project phases with a combined capacity of 1,418 MW started commercial operations.
- First quarter installations decreased by 50% compared to the first quarter of 2022, when 2,863 MW were added. This was the slowest first quarter the wind industry has experienced since 2019. Additionally, land-based wind installations dropped by 59% compared to the fourth quarter of 2022, when 3,459 MW of wind capacity was added.
- The capacity-weighted average size of projects added in the first quarter of 2023 was 236 MW, a decrease from the capacity-weighted averages of 360 MW in 2022 and 310 MW in 2021.
- The largest projects that came online were the Inertia Wind Project in Texas with a capacity of 301 MW and the Seven Cowboy Project in Oklahoma with a capacity of 300 MW. The Inertia Wind Project and Seven Cowboy Project are owned and developed by NextEra Energy Resources and Enel Green Power, respectively.

U.S. Annual and Cumulative Land-based Wind Capacity Growth

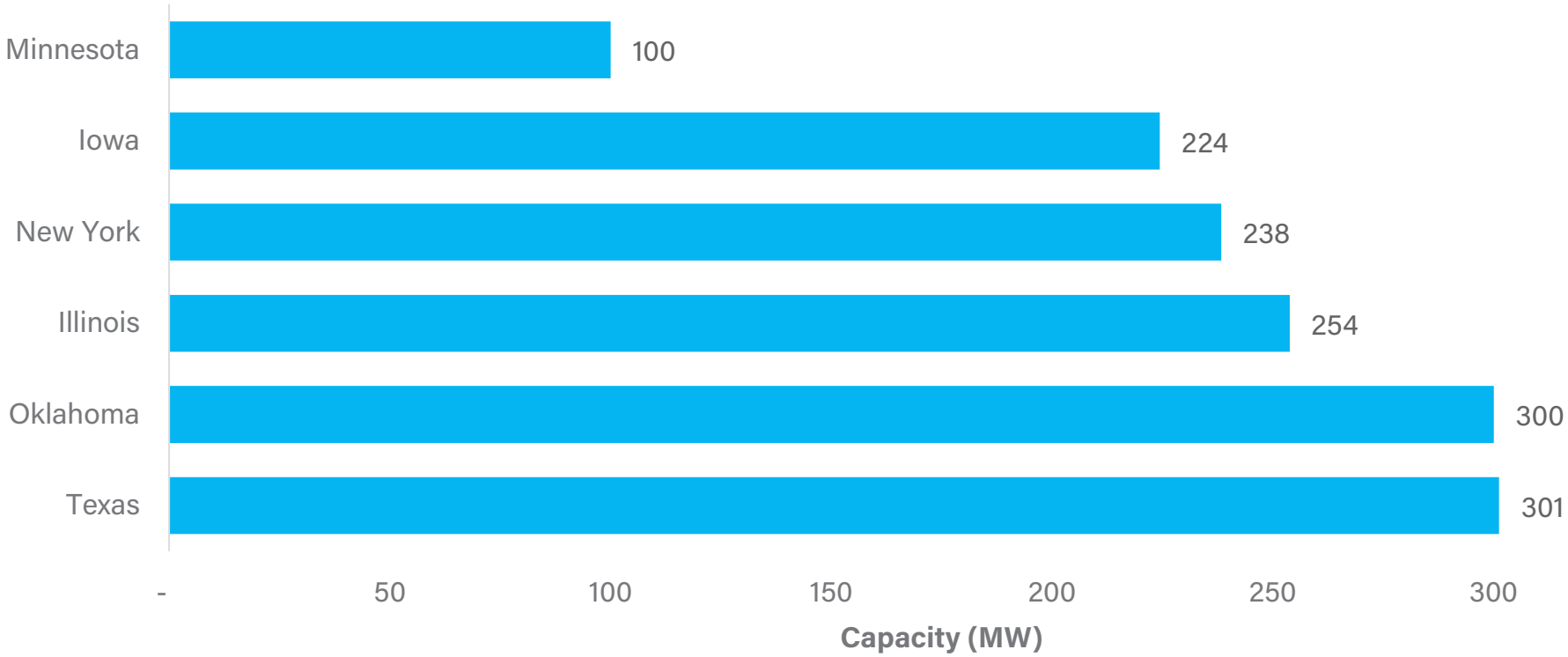


LAND-BASED WIND ACTIVITY

Texas Continues to be Top Wind Installer

- With the commissioning of the 301 MW Inertia Wind Project, Texas continues to be the top installer of land-based wind power. Texas was followed by Oklahoma (300 MW), Illinois (254 MW), New York (238 MW), and Iowa (224 MW). New York was the only state where multiple projects came online.
- In the first quarter of 2023, 7 project phases started commercial operations in 6 states. In total, 43 states and Puerto Rico had operating land-based wind power.

Wind Power Capacity Installations in Q1 2023, by State

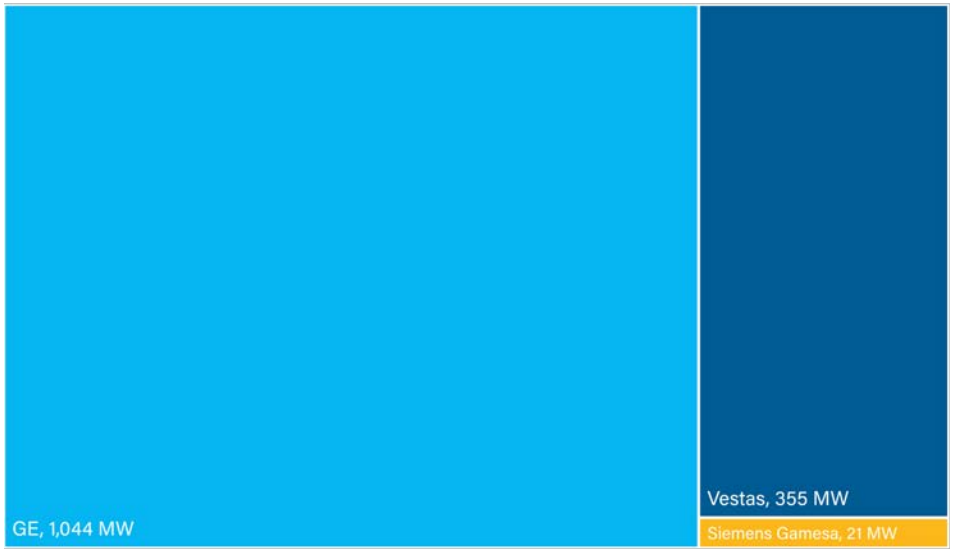


LAND-BASED WIND ACTIVITY

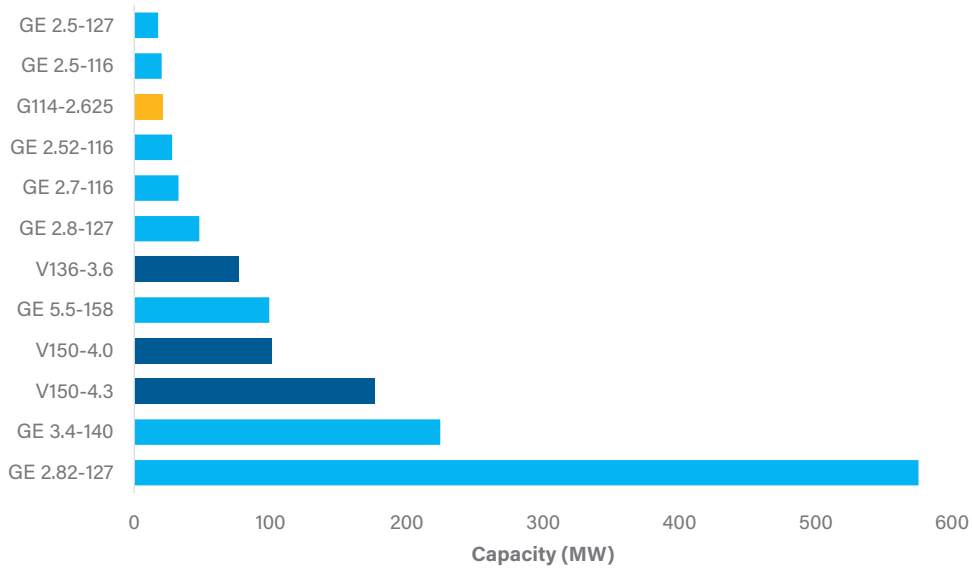
2023 Wind Turbine Market

- In the first quarter of 2023, GE Renewable Energy's turbines accounted for 74% of land-based wind capacity installations. GE was followed by Vestas (25%) and Siemens Gamesa (1%).
- Turbines rated between 2-3 MW made up 52% of installed capacity in the first quarter, a decrease from the previous quarter (65%). The capacity share of turbines rated between 3-4 MW increased to 21% from 9% in the fourth quarter of 2022. Turbines rated between 5-6 MW also saw an increase in the first quarter, making up 9% of all installed capacity compared to 0% in the previous quarter. Finally, turbines rated between 4-5 MW experienced a slight decrease in share of capacity installed, falling from 26% in the fourth quarter of 2022 to 20% in the first quarter of 2023.
- The most popular turbine model installed in the first quarter was GE's 2.82-127 turbine, which made up 41% of capacity installed. In second place was GE's 3.4-140 turbine (16%) followed by Vestas' V150-4.3 turbine (12%).

Wind Turbine Manufacturer Market Share of Wind Power Capacity Installed, Q1 2023



Turbines Installed Q1 2023

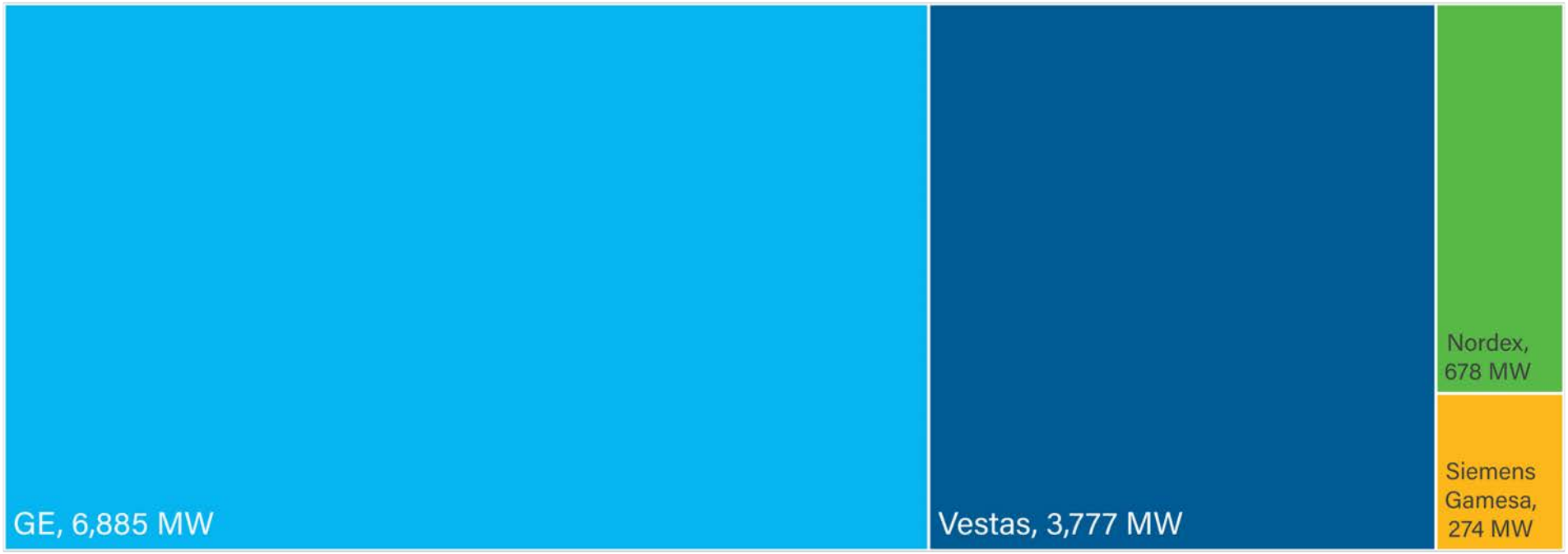


LAND-BASED WIND ACTIVITY

Wind Turbine Pipeline Market

- At the end of the first quarter of 2023, there were 20,176 MW of land-based wind power under construction or in advanced development. About 58% (11,614 MW) have selected and reported a wind turbine provider. The remaining 42% (8,562 MW) have either not selected a turbine manufacturer or publicly reported turbine orders.
- Of the 11,614 MW of wind power capacity with a known turbine provider, GE remains the leader with 6,885 MW (34%), followed by Vestas at 3,777 (19%), Nordex at 678 MW (3%), and Siemens Gamesa at 274 MW (1%).

Wind Project Pipeline by Turbine Manufacturer



Wind Turbine Technology Trends

- Over the past decade, wind turbine OEMs have increased the rotor diameters and hub heights of their turbines in order to capture more wind energy at higher speeds, resulting in higher nameplate capacities for wind turbines.
- The capacity-weighted average of all turbines in the pipeline as of the first quarter of 2023 was calculated to be 2.82 MW, lower than the average nameplate capacities for turbines installed in in the first quarter of 2023, 3.4 MW.
- The nameplate capacities for wind turbines in the pipeline range from 1.79 MW to 6.0 MW, with turbines rated between 4-5 MW continuing to be the most popular, making up 3,208 MW (39%) of capacity within the pipeline.
- Turbines rated between 2-3 MW was the second most popular, with 2,518 MW accounting for 30% of the capacity within the pipeline.
- This was followed by turbines rated between 3-4 MW, which had 1,340 MW and made up 16% of capacity within the pipeline. Finally, there were 1,232 MW of turbines rated above 5 MW in the pipeline, making up 15% of capacity. There were only 7 MW of turbines rated below 2 MW.

Turbine Models for Land-Based Near-Term Pipeline

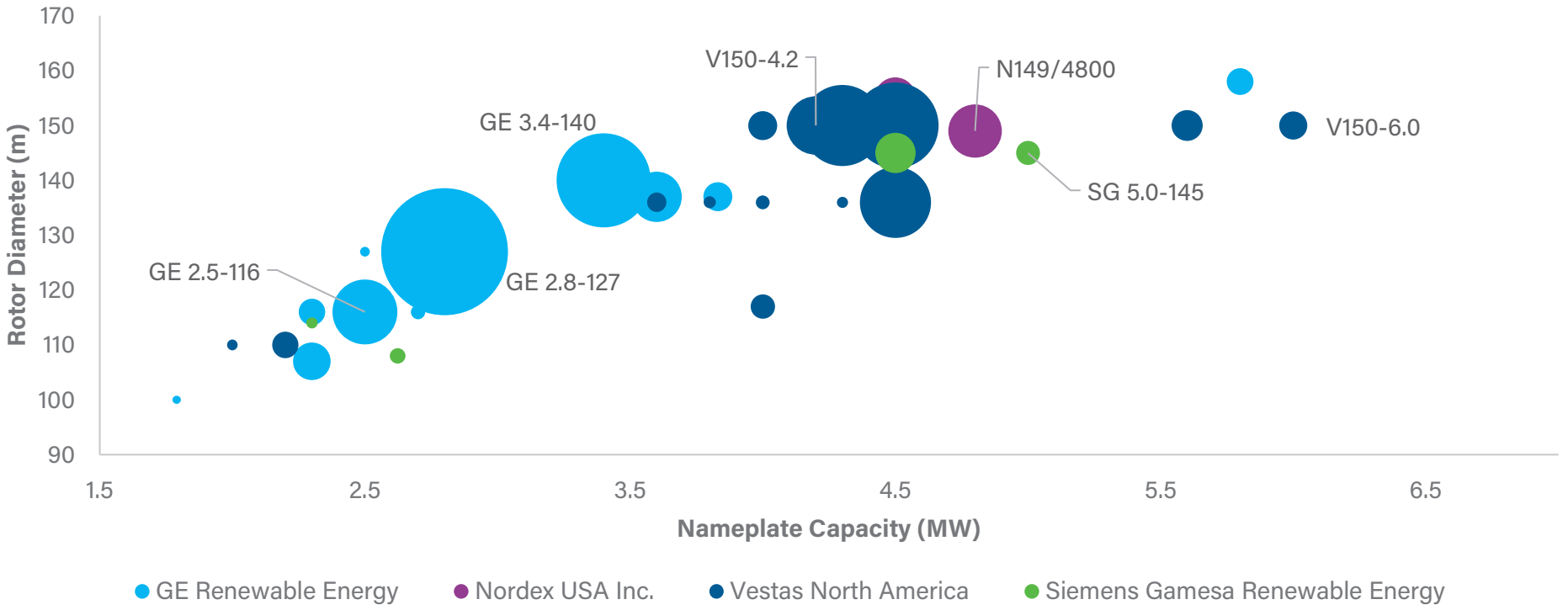


Photo credit: Nextracker

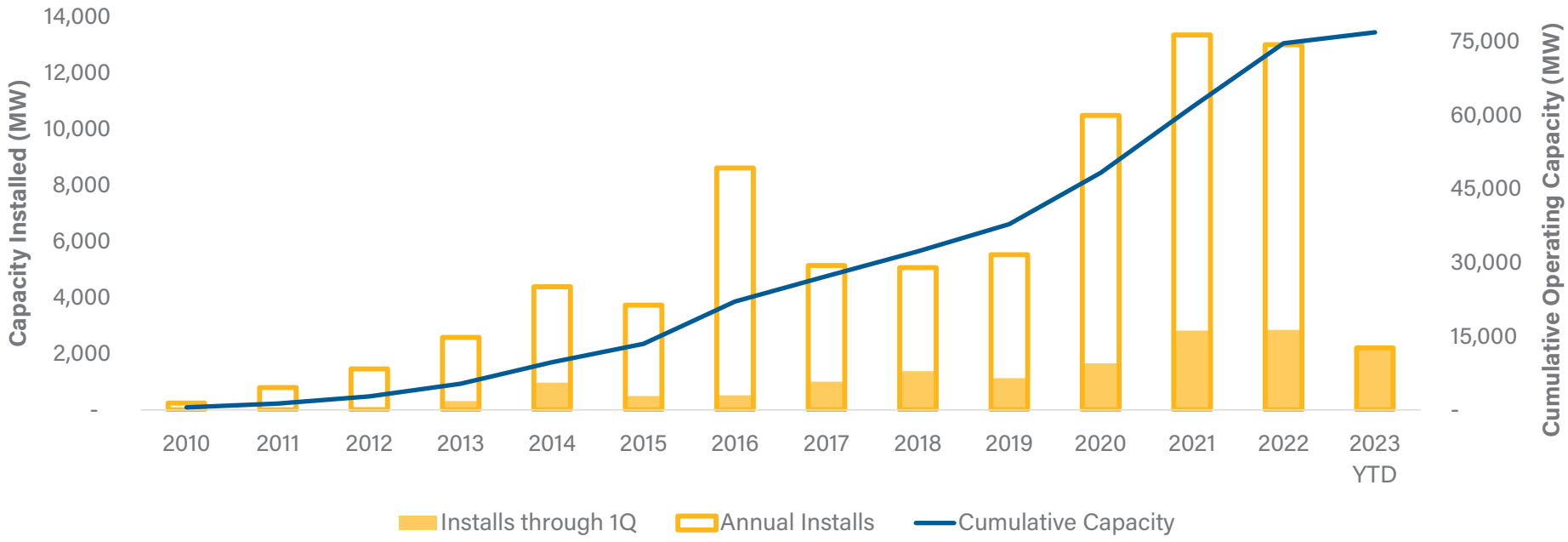
Utility-Scale Solar

UTILITY SCALE SOLAR

Solar Additions Slow Down After Record Fourth Quarter

- The first quarter of 2023 saw a drop in capacity installations for utility-scale solar. About 2,200 MW of solar capacity was added to the electric grid, representing a 23% decrease compared to the same period in 2022. Compared to the fourth quarter of 2022, solar installations fell by 56%.
- Cumulatively, there is now 76,778 MW of utility-scale solar operating in the U.S. All 50 states and the District of Columbia host operating utility-scale solar projects.
- The largest project that came online during the first quarter was Lightsource BP's 152 MW Bellflower Solar Project in Indiana. This was followed by the 102 MW Chaparral Springs Solar in California and 102 MW Cutlass Solar Project in Texas.

U.S. Annual and Cumulative Utility Solar Power Capacity Growth

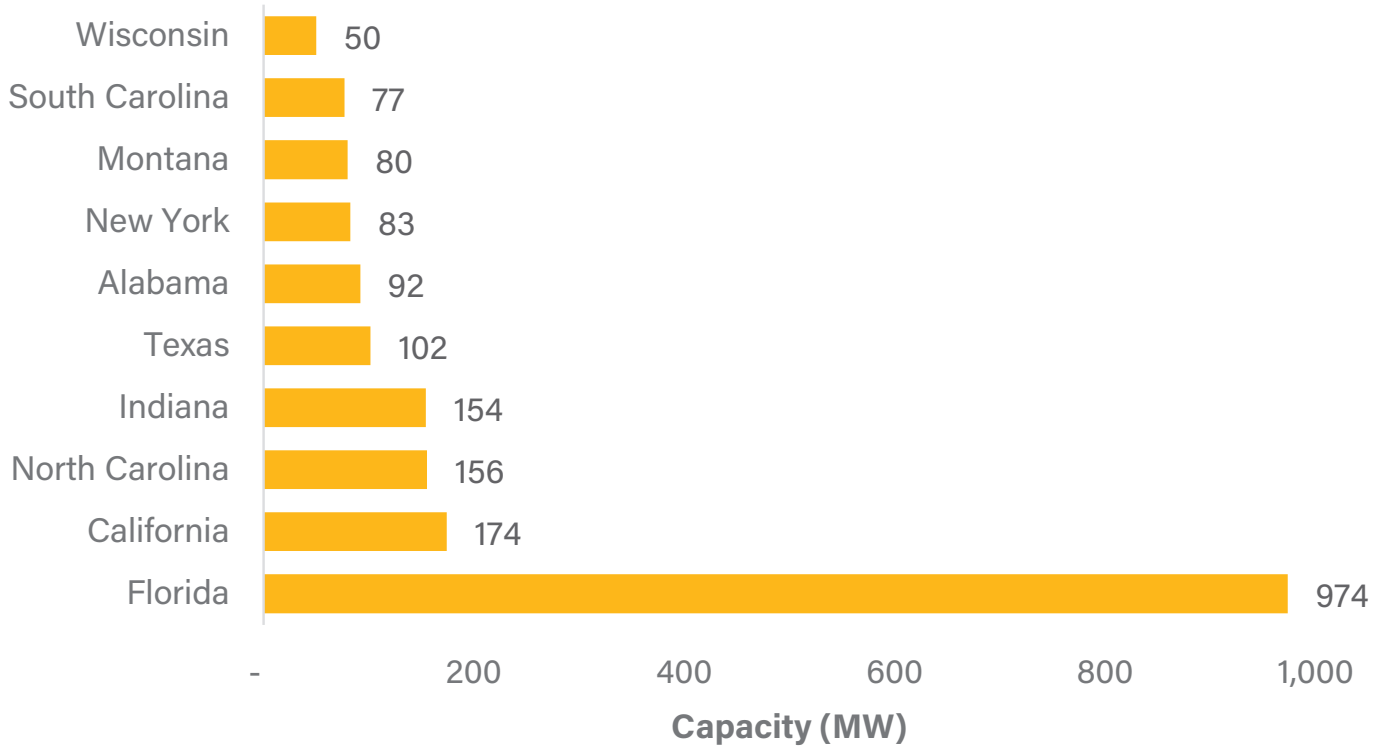


UTILITY SCALE SOLAR

Florida Dominates Q1 Solar Installations

- A total of 71 utility-scale solar projects across 24 states came online in the first quarter of 2023, adding 2,200 MW of utility-scale solar power to the grid.
- With 974 MW coming online, Florida outpaced the rest of the nation for solar installations. Florida's installations accounted for 44% of first quarter additions, followed by California (8%), North Carolina (7%), Indiana (7%), and Texas (5%).
- In terms of total operating capacity, California continues to rank first, with 17,754 MW installed, followed by Texas (12,538 MW), Florida (7,127 MW), North Carolina (6,126 MW), and Nevada (3,788 MW).

Top State for Solar Installations, Q1 2023

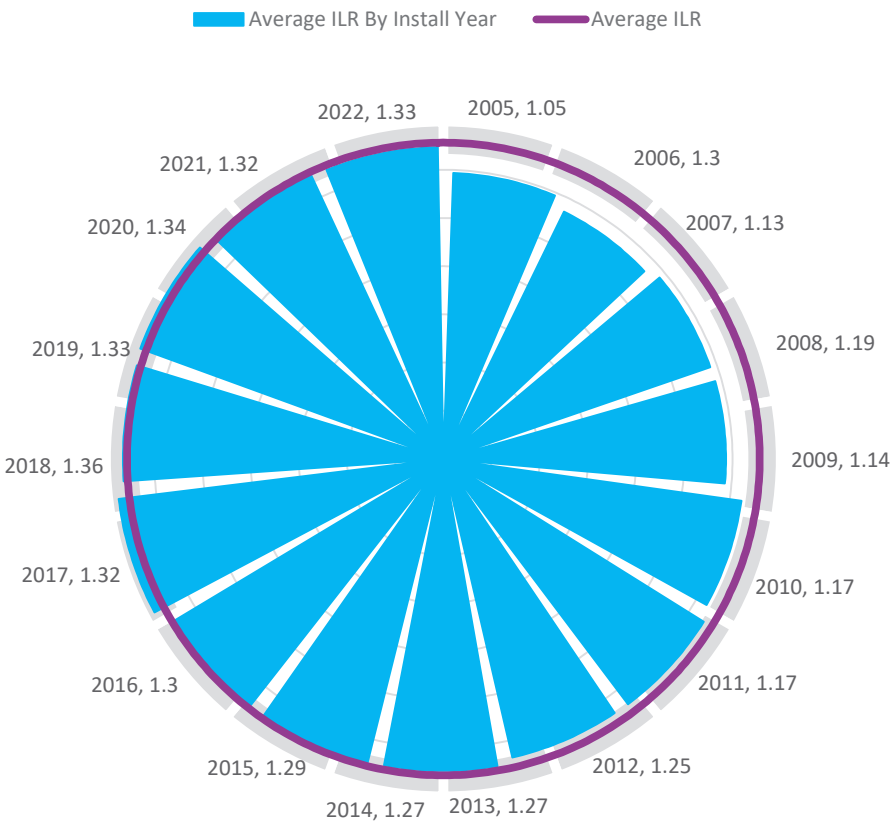


UTILITY SCALE SOLAR

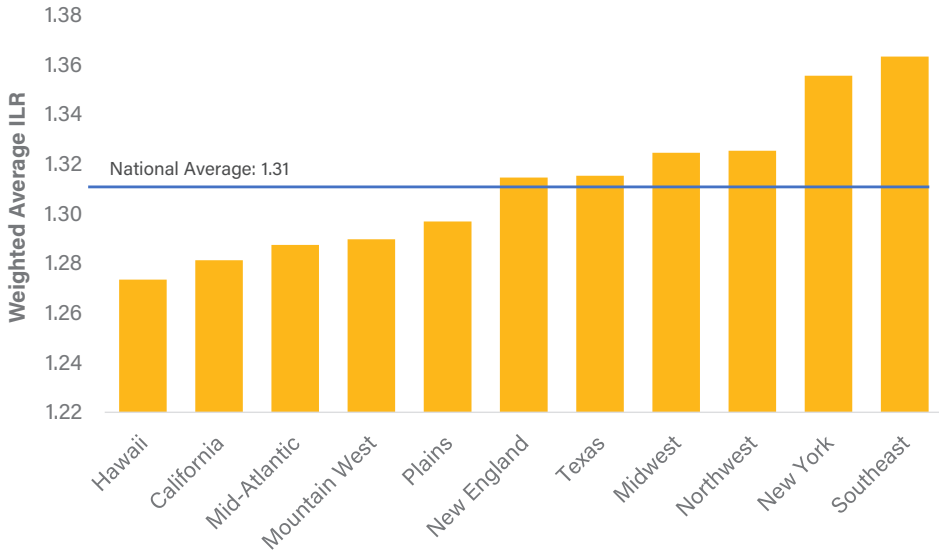
Solar Inverter Loading Ratio

- The inverter loading ratio, also known as the DC-to-AC ratio, steadily increased from 2005 to 2016 before plateauing at about 1.3.
- The reason for the increase in ILR is because the price of solar modules has fallen at a faster rate relative to inverter prices, leading developers to oversize the DC capacity of a project relative to its AC output in order to boost capacity factors, increase revenue. and reduce output variability.
- The ILR for utility-scale solar projects commissioned in the first quarter of 2023 was 1.29.
- By region, solar projects in the Southeast and New York have the highest average IRL at 1.36, while projects in Hawaii have the lowest ILR at 1.27. It is notable that California, the nations leader in operating solar, has the second lowest ILR at 1.28.

Weighted Average ILR by Installation Year



Weighted Average ILR by Region

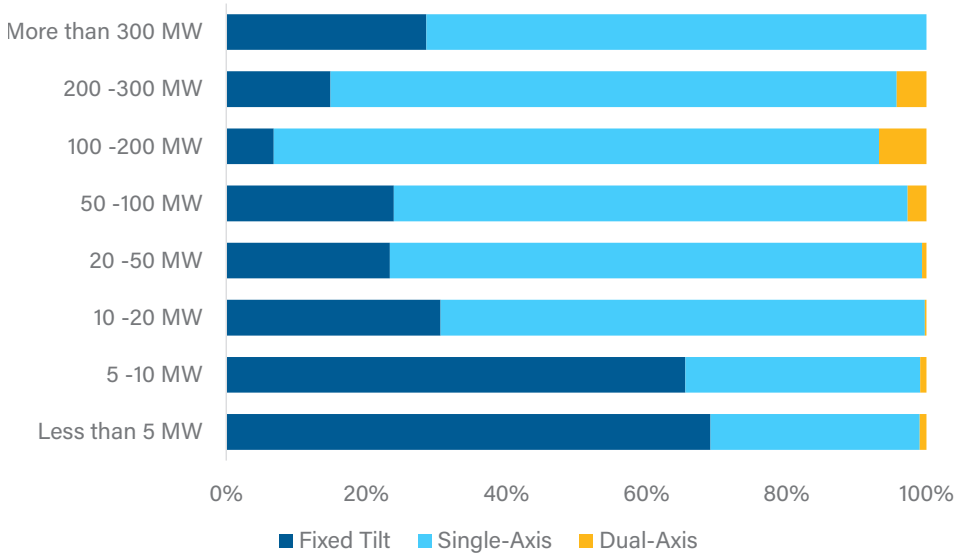


UTILITY SCALE SOLAR

Single-Axis Trackers Used in Vast Majority of Projects

- Where the tracking type was reported, single-axis trackers were deployed in 97% of the solar capacity that came online in the first quarter of 2023, dominating the market. Meanwhile, fixed tilt systems made up 3% of solar capacity commissioned in the quarter. No projects that came online reported utilizing dual-axis trackers.
- Overall, in terms of operating utility-scale solar capacity, 43,269 MW (56%) reported using single-axis trackers and 17,598 MW (23%) reported using a fixed tilt system. Dual-axis trackers accounted for 1,738 MW (2%) while 14,173 MW (19%) did not report the type of tracking system used.
- A trend has emerged where single-axis trackers tend to be used in larger projects and smaller projects tend to employ fixed tilt systems. Over 65% of projects with a capacity under 10 MW are fixed tilt, while the share of projects that deploy single-axis trackers increases along with the capacity of the project. 86% of projects with a capacity of 100-200 MW and 81% of projects with a capacity of 200-300 MW use single-axis trackers.
- While single-axis and dual-axis tracking systems can increase the capacity factors of solar panels, they often have higher upfront costs. Meanwhile, fixed tilt systems are less costly to install, but can be better suited for projects sited on rougher terrain.

Tracking Type Share by Operating Project Size



Operating Solar Capacity Tracking Types

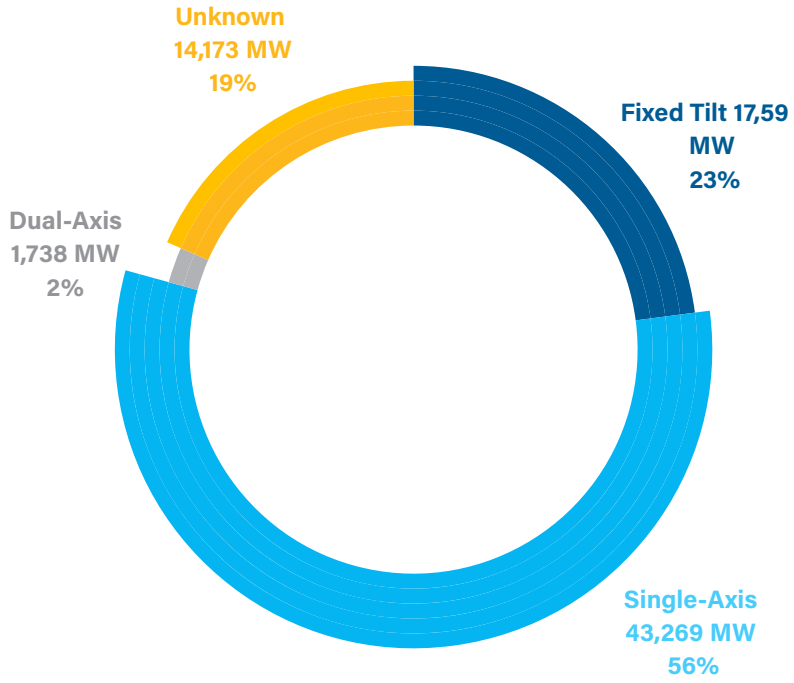


Photo credit: Recurrent Energy

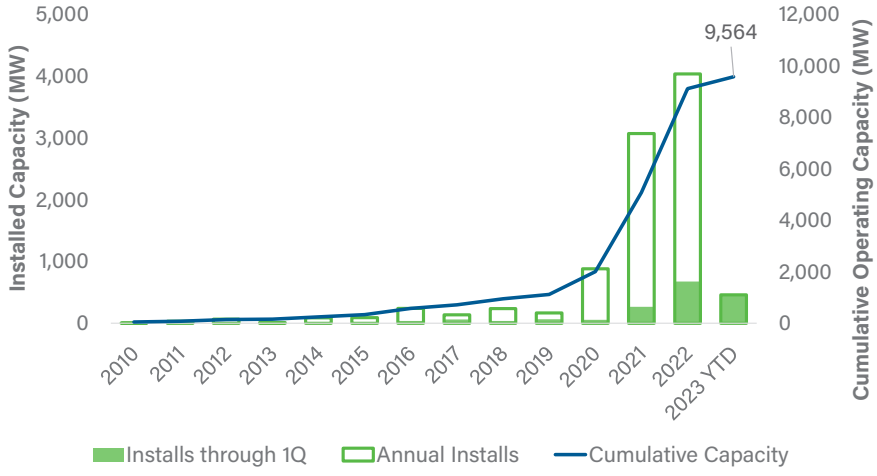
Utility-Scale Battery Storage

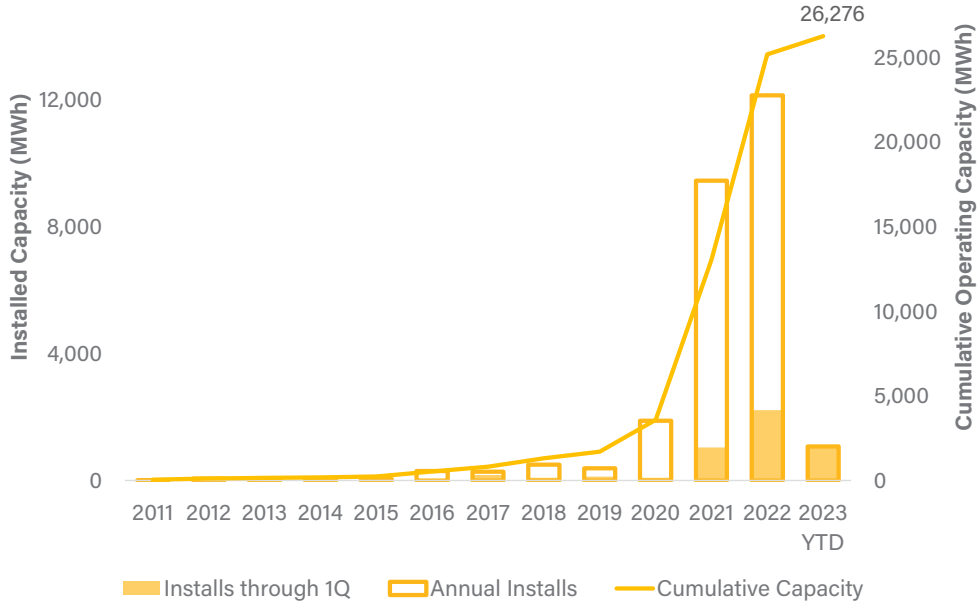
UTILITY-SCALE BATTERY STORAGE

Storage Installations Down 32% Year-Over-Year

- Battery storage capacity is tracked in terms of rated power capacity (MW), the maximum possible instantaneous discharge, and energy capacity (MWh), the maximum amount of stored energy.
- In the first quarter, 17 battery storage projects commissioned with a total capacity of 461 MW/1,075 MWh. This represents a 32% decline from the first quarter of 2022.
- An additional 1.6 GW of battery storage projects were initially expected to commissioned in Q1. Nearly all of those projects are now expected to commissioned later in 2023, with an average delay of 1.5 quarters.
- 12 of the 17 projects installed in Q1 are paired with solar or wind capacity. Those projects on average have smaller capacity than standalone projects commissioned in the quarter, as 53% of capacity online in Q1 is standalone.
- Madero Grid, located in Texas and owned by Madero Grid, was the largest battery storage project to come online this quarter in terms of both MW and MWh capacity. The 100 MW battery has a storage energy capacity of 215 MWh.

Annual Clean Power Offtake Announcements, By Offtake Mechanism



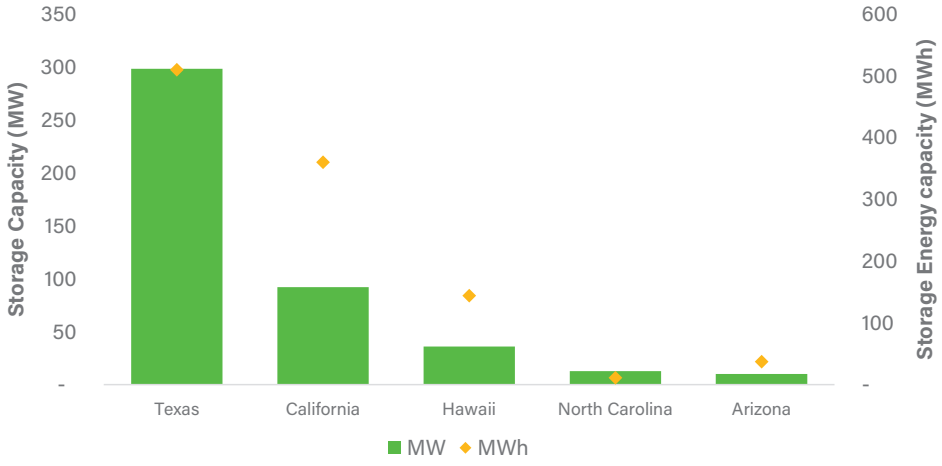


UTILITY-SCALE BATTERY STORAGE

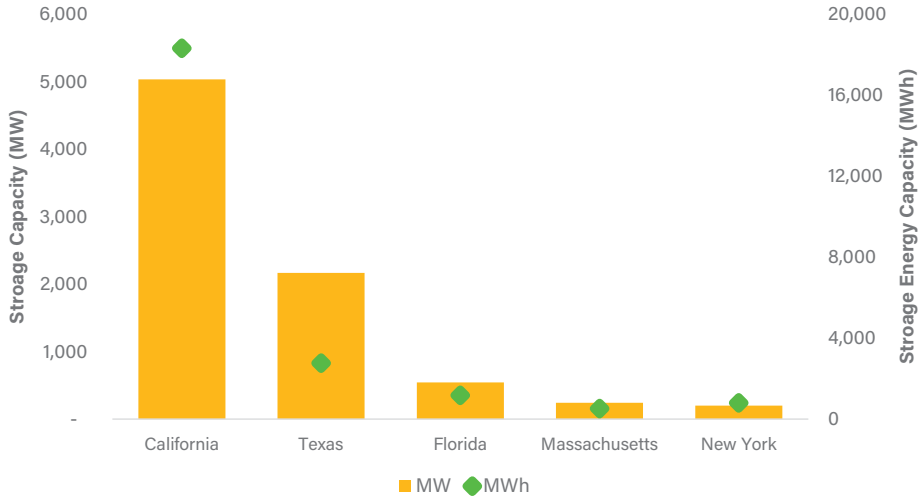
Texas Leads Quarterly Installs; California Leads Overall

- Only seven states installed new battery storage capacity in the first three months of the year, led by Texas at 298 MW. The Lone Star State was the only one to break 100 MW this quarter.
- California ranks second with 92 MW commissioned, followed by Hawaii (36 MW).
- Cumulatively, California has the most battery storage capacity operating, 5,034 MW/18,311 MWh, more than twice as much as any other state.
- Texas follows California with 2,165 MW/2,769 MWh of battery storage operating. Florida closes out the top three at 543 MW/1,1183 MWh online.
- There are now battery storage projects operating and helping to improve grid reliability in 42 states and Puerto Rico.

Top States for Battery Storage Installations, 2023 Q1



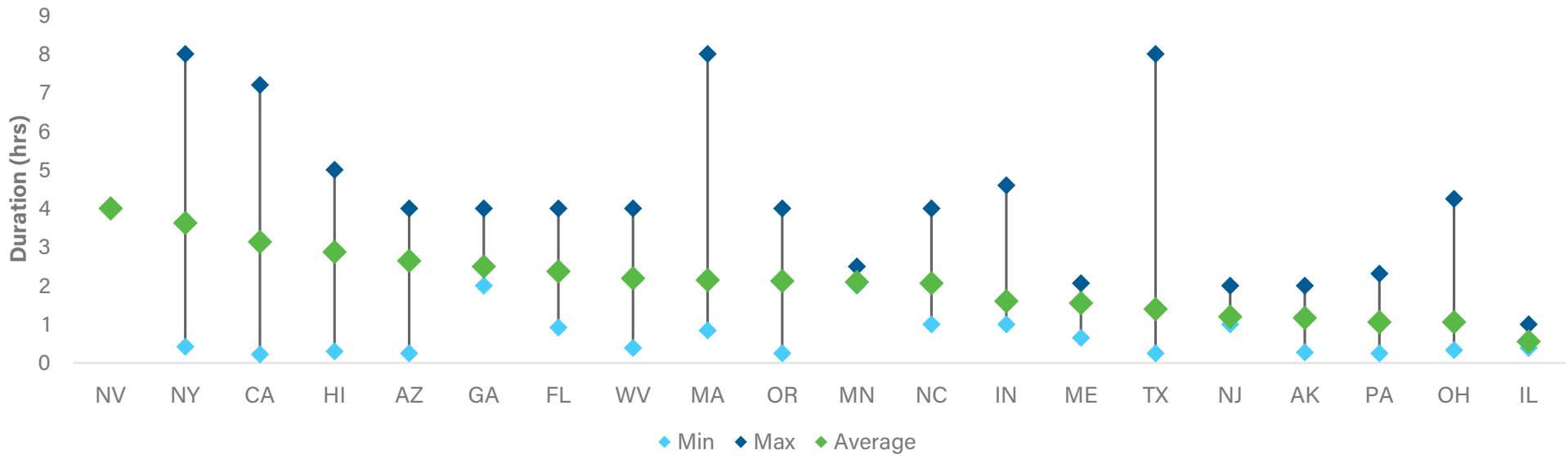
Top States for Total Operating Battery Storage Capacity



Variation in Storage Duration by State

- Storage duration—the amount of time a storage system can discharge at its rated power capacity before depleting its energy—of battery storage projects has steadily increased, from only 0.5 hours for projects commissioned in 2014 to 3.04 hours for projects online in 2022.
- Project installed in the first three months of 2023 had a slightly lower average duration at 2.49 hours.
- At the state level, there is substantial variation in average project duration. Storage projects in Nevada have the highest average duration of 4 hours, through there are only seven operating storage projects in the state and four with duration data available. New York ranks second (3.6 hours) and California third (3.1 hours). Texas ranks second for operating storage capacity, though projects have a lower average duration (1.4 hours).
- Hybrid-paired storage projects typically have a longer duration (2.34 hours) compared to standalone battery projects (2.11 hours). Before 2019, hybrid-paired storage projects had shorter durations than standalone battery projects. However, since 2019, this trend has shifted, and hybrid-paired storage projects now have consistently higher average durations than standalone battery projects.

Average Battery Storage Duration by State



UTILITY-SCALE BATTERY STORAGE

Hybrid versus Standalone Battery Storage

- Of the 461 MW of battery storage installed in the first quarter of 2023, 51% was hybrid-paired. Hybrid-paired projects make up 53% of all operating storage capacity.
- Back in 2010, all of the operating battery storage capacity in the nation was standalone. After that point hybrid-paired storage systems entered the market.
- The hybrid-share of installations in any given year varies; in 2020, only 8% of installed storage projects were hybrid-paired, compared to 67% the following year.
- The market share of hybrid versus standalone storage can be influenced by available incentives. Previously, storage systems were not eligible for the ITC and had to be combined with wind or solar resources for qualification. However, the IRA now extends ITC qualification to standalone storage systems.

Cumulative Operating Hybrid and Standalone Battery Storage Capacity

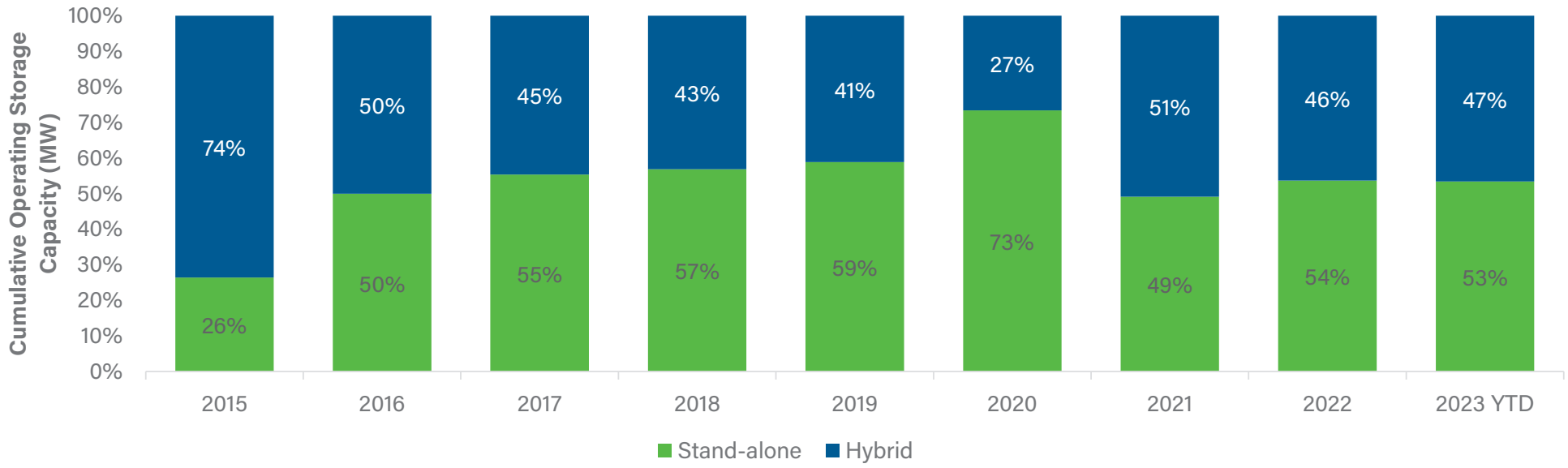


Photo credit: Nextracker

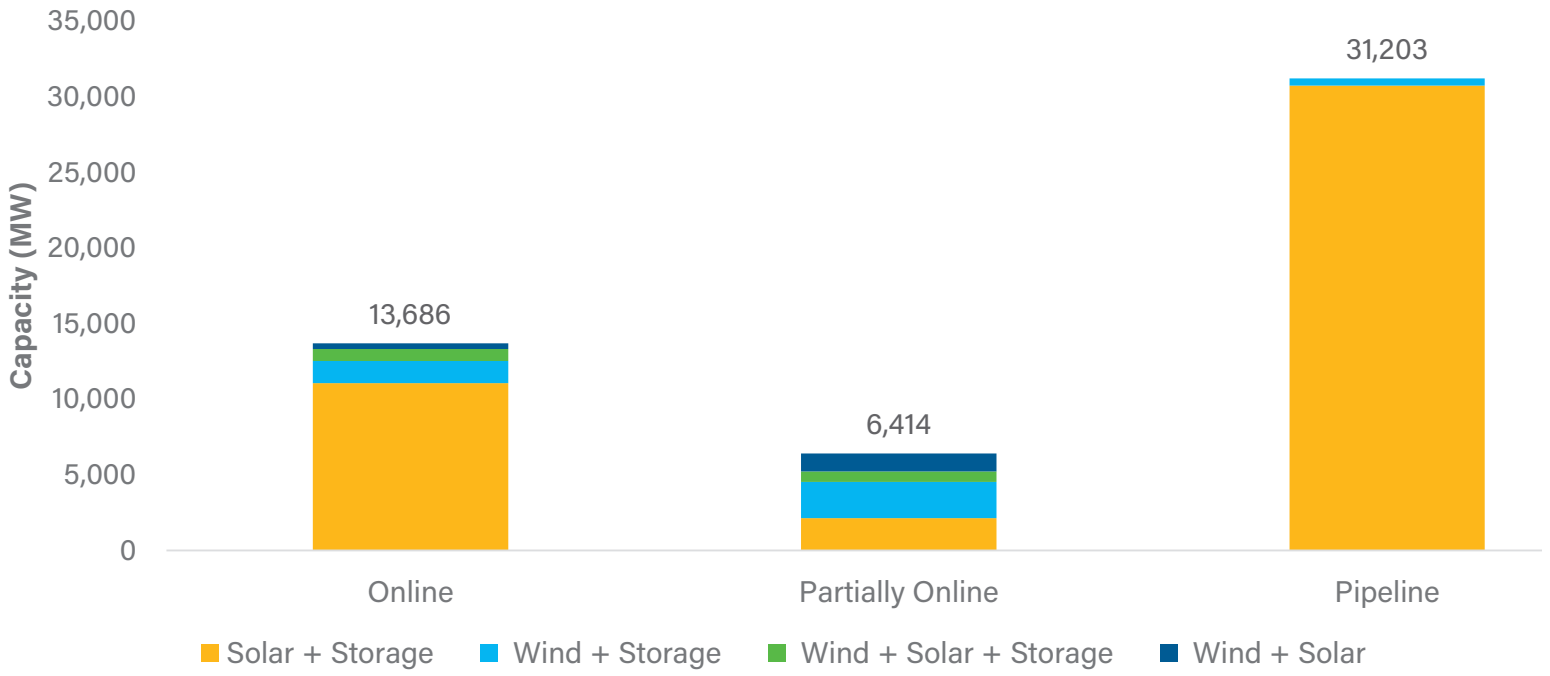
Hybrid Projects

HYBRID PROJECTS

Nearly 500 MW of Solar + Storage Online in Q1

- In the first quarter of 2023, only 485 MW of solar + storage projects came online.
- In total, 13,686 MW of hybrid projects are fully online, meaning that all phases and technologies included in the project are operating. More than 80% of those projects are solar + storage projects.
- Additionally, there are 6,414 MW of hybrid projects partially online, meaning one or more phases/technologies are operating, but other phases or technologies within the project are still in development.
- Finally, there are 31,203 MW of hybrid projects currently in the pipeline. The vast majority of that capacity, 98%, is from solar + storage projects. The remaining 2% is wind + storage projects in development.
- The Azure Sky Solar + Storage project was the largest project to fully commission in Q1. Owned by Enel, the solar portion of the Texas project (225 MW) came online at the end of 2021, and the storage portion (78 MW/135 MWh) commissioned in Q1 2023.

Hybrid Clean Power Projects

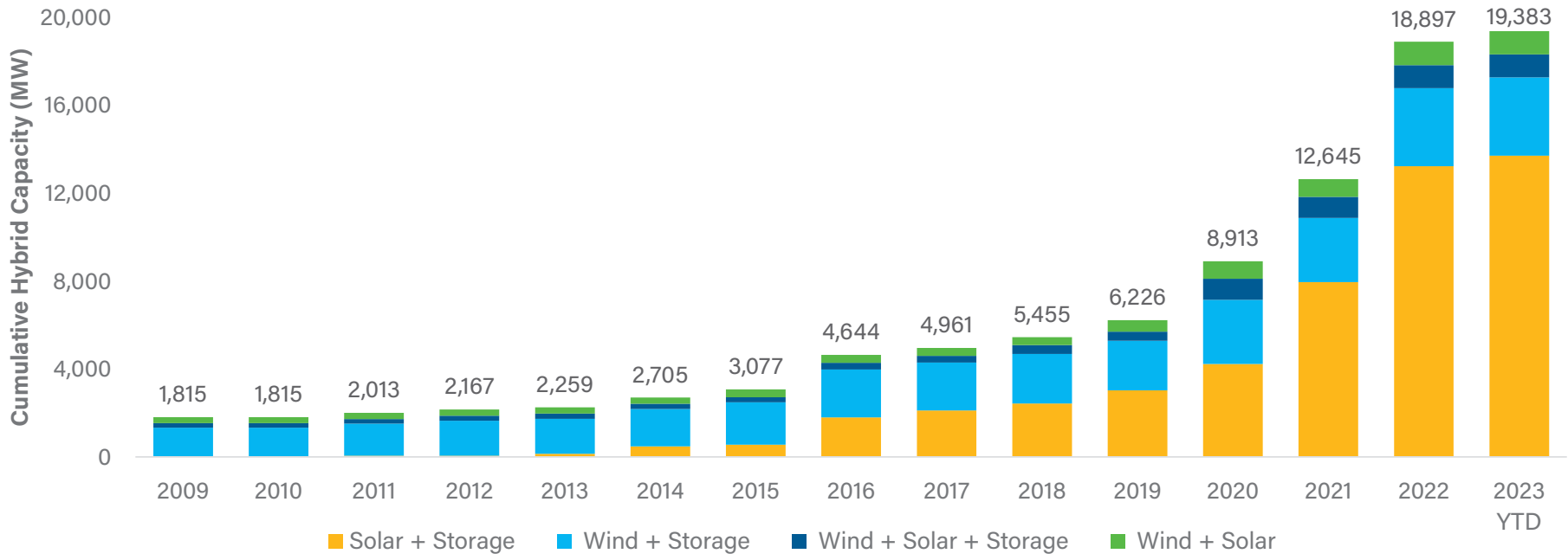


HYBRID PROJECTS

Operating Hybrid Capacity Tops 19 GW

- Operating hybrid capacity, including fully operational projects and phases of projects that are operating, is now 19,383 MW.
- Very few hybrid projects came online in the first quarter, so the increase in cumulative operating hybrid capacity is minimal. However, over the past five years operational hybrid capacity has increased by an average of 32% each year.
- Solar + storage projects are the dominant hybrid type, accounting for 71% of all operating hybrid capacity. Wind + storage, the prior dominant hybrid type, now accounts for just 18% of operating hybrid capacity.
- There are very few wind + solar + storage and wind + solar projects operating in the U.S., combined accounting for 11% of operating hybrid capacity.

Operational Hybrid Capacity Over Time

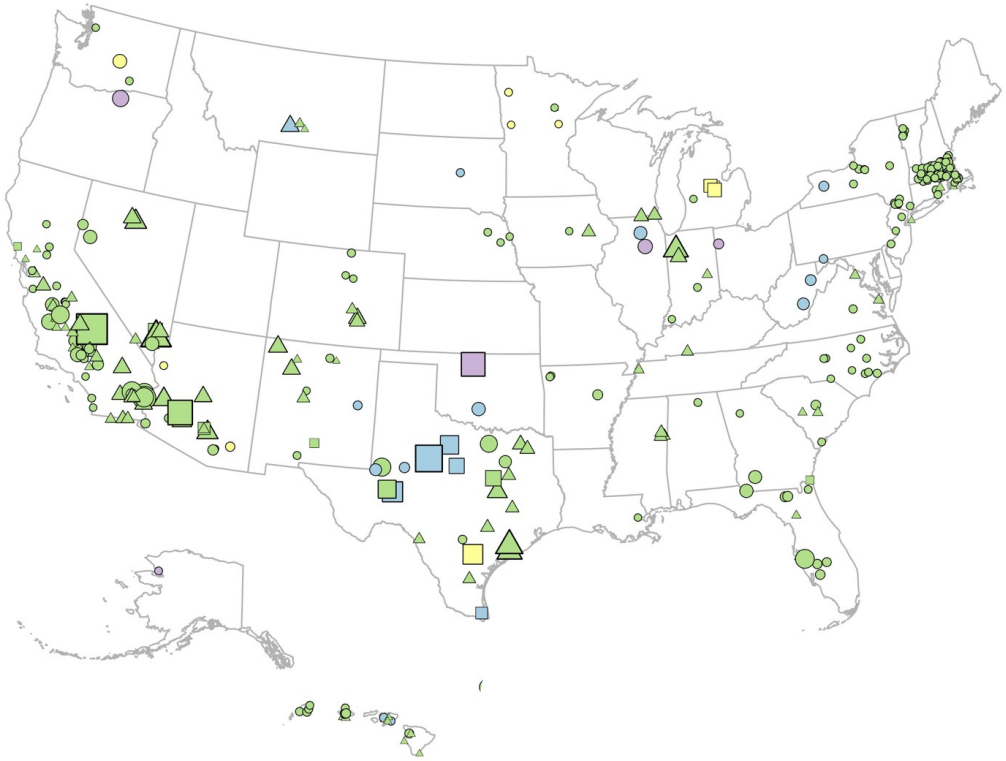


HYBRID PROJECTS

California Leads in Hybrid Space

- There are hybrid projects operating in 36 states across the nation. California leads with 6.8 GW operating, representing 35% of all operating hybrid capacity.
- Texas ranks second with 4.9 GW of hybrid projects operating, accounting for a quarter of all operating capacity. While California only has solar + storage hybrid projects online, the hybrid landscape in Texas is more diverse. There are solar + storage, wind + storage, and wind + solar projects operating in Texas, with wind + storage being the dominant type.
- The 33.4 GW of hybrid capacity in the pipeline is enough to nearly triple existing operating hybrid capacity. The pipeline includes both projects fully in development and not yet operating phases of partially online projects.
- California leads in the pipeline as well with 9.6 GW in development, nearly twice as much any other state. All of the hybrid capacity in development in California is part of solar + storage projects.
- Texas ranks second in the pipeline, with 5.2 GW of solar + storage, 292 MW of wind + storage, and 268 MW of wind + solar projects in development.
- Only one state, Oklahoma, has a wind + solar + storage project in development.
- Overall, 25 states have hybrid projects in development.

Operating Hybrid Projects

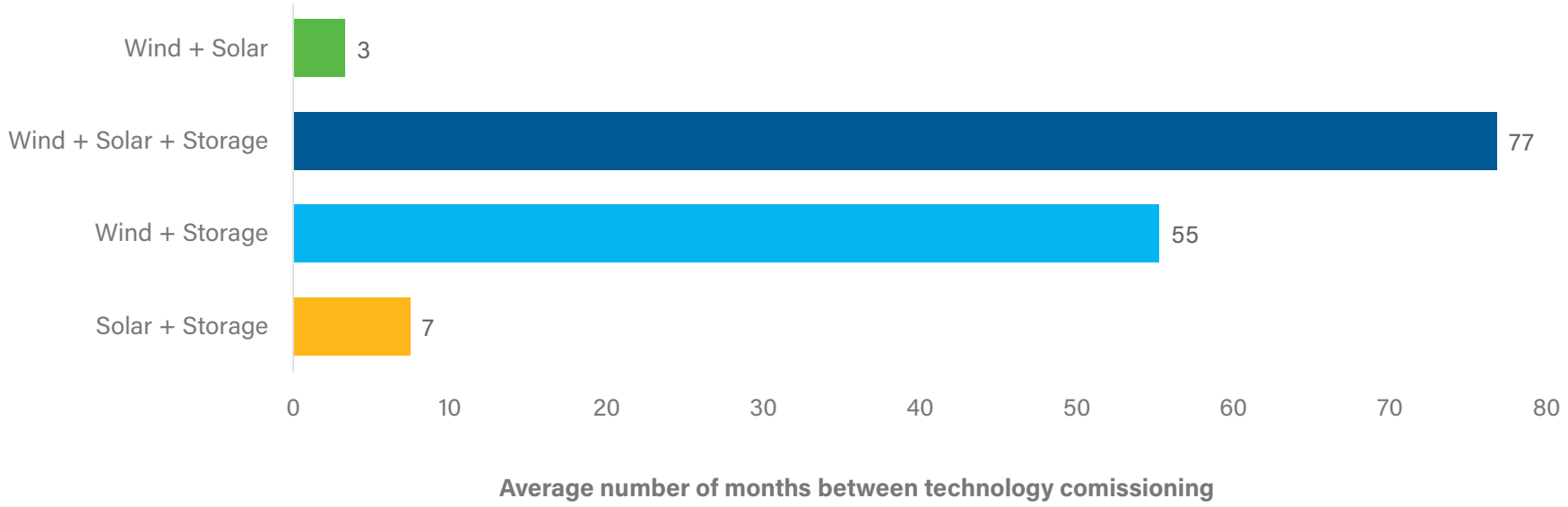


HYBRID PROJECTS

Lag Between Technology Commissioning

- Hybrid projects can be designed to include storage from the outset, or storage capacity can be retrofitted onto an existing wind or solar facility. In either scenario, there may be a delay between the installation of the wind or solar capacity and the installation of the storage capacity.
- Solar + storage projects have the highest likelihood of commissioning both technologies simultaneously, with 85% of such projects commissioning both at the same time. If commissioned separately, the average time lag between the commissioning of solar and storage is seven months. This is an increase from the four month average reported in Q4 2022, likely due to interconnection and supply chain challenges delaying projects.
- In contrast, hybrid projects that combine wind and storage experience a lengthier delay before both wind and storage capacity are operational. Wind + storage projects have the longest time lag, averaging 4.6 years, and only 39% of projects commission both technologies simultaneously.
- There are only four operating projects that combine all three technologies. Of those, only one commissioned all three technologies at the same time. The other three had an average lag of 6.4 years between the first and final technologies coming online.

Average Number of Months Between Technologies Commissioning by Hybrid Type



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