AMERICAN CLEAN POWER®

CLEAN POWER ANNUAL MARKET REPORT 2022

Building The Clean Energy Economy

ACP sincerely thanks its member companies and other organizations for their contributions to the industry data provided in this report. ACP strives to provide the best information on the clean power industry—for the industry and by the industry—and therefore welcomes your comments.

We united the power of the renewable energy industry.

The American clean power sector is providing cost-effective solutions to the climate crisis while creating jobs, spurring investment, and driving innovation.

The American Clean Power Association enables the transformation of the U.S. power grid to a low-cost, reliable and renewable power system. By uniting the power of wind, solar, transmission, and storage companies and their allied industries, both public and private, we are championing policies that enable the continued and aggressive growth in renewable energy in the United States.

Table of Contents

Clean Power 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.

Clean Power Acronyms

AC	Alternating Current
C&I	Commercial & Industrial
CAISO	California ISO
CES	Clean Energy Standard
CO_2	Carbon Dioxide
DC	Direct Current
EPA	Environmental Protection Agency
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
FRCC	Florida Reliability Coordinating Council
GHI	Global Horizontal Irradiance
GW	Gigawatts
GWh	Gigawatt hours
ILR	Inverter Loading Ratio
IOU	Investor-Owned Utility
ISO	Independent System Operator
ISO-NE	ISO New England
LCOE	Levelized Cost of Energy
MISO	Midcontinent ISO
MRO	Midwest Reliability Organization
MW	Megawatts
MWh	Megawatt hours
NERC	North American Electric Reliability Corporation
NO_x	Nitrogen Oxides
NPCC	Northeast Power Coordinating Council
NYISO	New York ISO
OEM	Original Equipment Manufacturer
OREC	Offshore Renewable Energy Credit
PM2.5	Particulate Matter
PPA	Power Purchase Agreement
REC	Renewable Energy Credit
RFC	Reliability First Corporation
RPS	Renewable Portfolio Standard
RTO	Regional Transmission Organization
SREC	Solar Renewable Energy Credit
SERC	Southeast Reliability Corporation
SO_2	Sulfur Dioxide
SPP	Southwestern Power Pool
TRE	Texas Reliability Entity
TW	Terrawatts
TWh	Terrawatt Hours
WECC	Western Electricity Coordinating Council
WRO	Withhold Release Order

Introduction

Photo Credit: AES

Dear ACP Members,

The clean energy revolution is underway. Last year, Congress made historic investments to modernize our energy systems. The Bipartisan Infrastructure Law and Inflation Reduction Act are motivating hundreds of billions of dollars of private investment that will increase our nation's security, strengthen our global competitiveness and confront the risks of climate change. This legislation is already supercharging clean energy deployment and increased investment is projected to more than triple annual installations of wind, solar, and energy storage by 2030.

Our 2022 *Clean Power Annual Market Report* charts both our achievements and challenges as the industry prepares for a decade of rapid growth.

2022 ended as the third-largest year for clean power installation, with over 25 gigawatts (GW) of new clean energy capacity added, accounting for nearly 80 percent of all new power added to the grid. With these additions, the U.S. has nearly 228 GW of wind, solar, and energy storage capacity online, producing 15 percent of U.S. electricity and powering the equivalent of over 62 million homes.

However, 2022 also saw a decline in deployment for the first time in five years. Trade barriers, supply chain issues, permitting delays and regulatory challenges resulted in a 15 percent slowdown in installations compared to 2021. ACP is working with bipartisan Congressional leaders, Governors and the Administration to develop the innovative and durable solutions needed to drive progress.

The clean power industry currently employs close to 450,000 American workers across the wind, solar, and energy storage sectors – with plans to more than double domestic employment by 2030. We've also announced nearly 50 new clean energy manufacturing facilities or expansions in the last ten months, bringing more than 18,000 new American jobs and representing over $150 billion in private investment.

Clean power benefits all Americans. Our industry is deploying projects in all 50 states and 93 percent of congressional districts, with 80 percent of projects located in low-income communities.

This is an exhilarating time for our country and the future of American clean energy. It is vital to learn from our challenges while celebrating our victories. This *Clean Power Annual Market Report* reflects our industry's tenacity, creativity, and commitment to a cleaner, healthier future. I invite you to read the report and join us in unlocking our nation's clean energy potential.

Together in progress,

Jason Grumet
CEO, American Clean Power Association

Key 2022 Highlights

1. **Third-Largest Year**
   25.5 GW of new clean power was commissioned in 2022, making it the third-largest year on record and bringing the total amount of American clean power online to nearly 228 GW.
2. **Leading Source of New Power**
   Clean power represented 79% of all new capacity added.
3. **Powering More of America**
   The country now produces 15% of its electricity from wind and solar, equivalent to powering over 62 million homes.
4. **Net-Zero Progress**
   Maintaining last year's project installation volume would provide only 30% of what is needed to reach a net-zero grid by 2035.
5. **Significant Delays**
   53 GW of projects experienced delays due to ongoing regulatory, supply chain and interconnection challenges.
6. **Development Pipeline**
   137 GW of clean energy projects were under development at the end of 2022.
7. **Storage Soars**
   In 2022, energy storage witnessed a record year with 4 GW/12 GWh commissioned, representing an 80% increase in total operating storage capacity.
8. **Growing Workforce & Investment**
   Clean power industry employs 443,000 workers and invested $35 billion in projects in 2022.
9. **United States of Clean Energy**
   Clean power is red, white, and blue with projects or manufacturing facilities in 93% of Congressional districts. Projects can be found in all 50 states.
10. **Booming Manufacturing**
    There are 550 U.S. manufacturing facilities dedicated to producing components and parts for wind, solar, and storage projects in the clean power industry – and since the passage of the Inflation Reduction Act, 47 new clean energy manufacturing facilities or expansions have been announced, bringing more than 18,000 new American jobs.

Clean Power in America

Nearly 228 GW
of **WIND, SOLAR,** and **BATTERY STORAGE** capacity online.

WIND, SOLAR, and **BATTERY STORAGE** represent **68%** of new power additions to the grid over the past five years.

WIND & SOLAR POWER were the **top 2 choices** of utility-scale power generation across all technology types in 2022.

2022 was a record year for **BATTERY STORAGE** with **4 GW/12 GWh** commissioned, representing an **80% increase** in total operating storage capacity in 2022.

There's nearly **228 gigawatts** of clean power operating in the U.S.

That's enough to power:

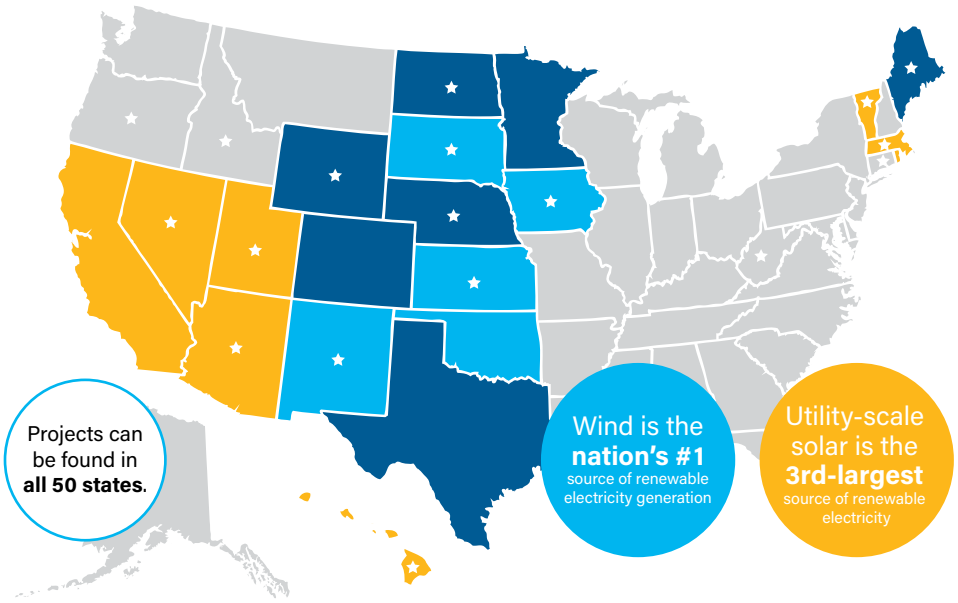
3 out of 5 light bulbs in U.S. homes
more than **62 million** homes

Three **OFFSHORE WIND** lease sales in 2022 resulted in **13 new leases** across the NY Bight, Carolina Long Bay and California

The U.S. has enough installed utility-scale **WIND AND SOLAR** capacity to power more than **62 million homes**.

25.5 GW of clean power was installed in 2022, enough to power **406 million LED light bulbs**.

Clean power prevents **426 million** metric tons of CO_2 from being released into the atmosphere each year, equivalent to removing **93 million cars from the road**.



Clean power is **red, white, and blue** with projects or manufacturing facilities in **93% of Congressional districts**.

WIND & SOLAR projects produced the same amount of electricity used in these states combined in 2022:
AZ, CT, HI, IA, ID, KS, MA, ME, ND, NE, NM, NV, OR, RI, SD, UT, VT, WV, WY

States where **SOLAR** energy delivers **more than 10%** of the electricity:
AZ, CA, DC, HI, MA, NV, RI, UT, VT

States where **WIND** energy delivers **more than 20%** of the electricity:
CO, IA, KS, ME, MN, ND, NE, NM, OK, SD, TX, WY

States where **WIND** was the **largest source of electricity** in 2022:
IA, KS, NM, OK, SD

550 manufacturing facilites across the U.S. dedicated to producing components and parts for **wind, solar, and storage** projects.

443,000 good-paying jobs in **wind, solar, and storage** to employ Americans across the country.

Since the passage of the IRA, **47 new utility-scale clean energy manufacturing facilities** were to have been announced, bringing an expected **18,000+ new American jobs**.

The passage of the IRA has led to **$150 billion of capital investment** announced for clean energy projects and manufacturing facilities.

Corporations are rapidly signing onto the clean energy revolution after announcing a record **16 GW** of new **Power Purchase Agreements** in 2022.

WIND & SOLAR deliver over **$2.9 billion** every year in state and local tax payments and landowner lease payments to local communities.

81% of operating clean power is located in low-income communities where projects create jobs, revenue, and foster economic growth.

2022 Clean Power Activity

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Photo Credit: Nextracker

2022 Clean Power Activity Highlights

- More than 25.5 GW of clean power was installed in 2022, representing enough electricity to power 5 million American homes. Due to issues restricting the industry such as supply chain constraints, interconnection issues, and policy uncertainty, 2022 experienced a 15% decline in clean power installations compared to 2021.
- In total, 227,852 MW of clean power is operating and powering American homes and businesses.
- Texas and California led the nation in annual installations, each setting new clean power commissioning records in 2022, along with 18 other states.
- Clean power is red, white, and blue, with projects or manufacturing facilities in 93% of congressional districts.
- Wind and solar are becoming increasingly vital parts of our electricity generation system; in 2022, wind and solar provided 15% of the nation's electricity.
- Following the passage of the Inflation Reduction Act (IRA), clean power market analysts significantly revised their forecasts to account for the impacts of the landmark legislation. On average, the total forecast for utility wind, solar, and battery storage increased 30%, with forecasters now anticipating 425 GW to be built over the next 8 years.

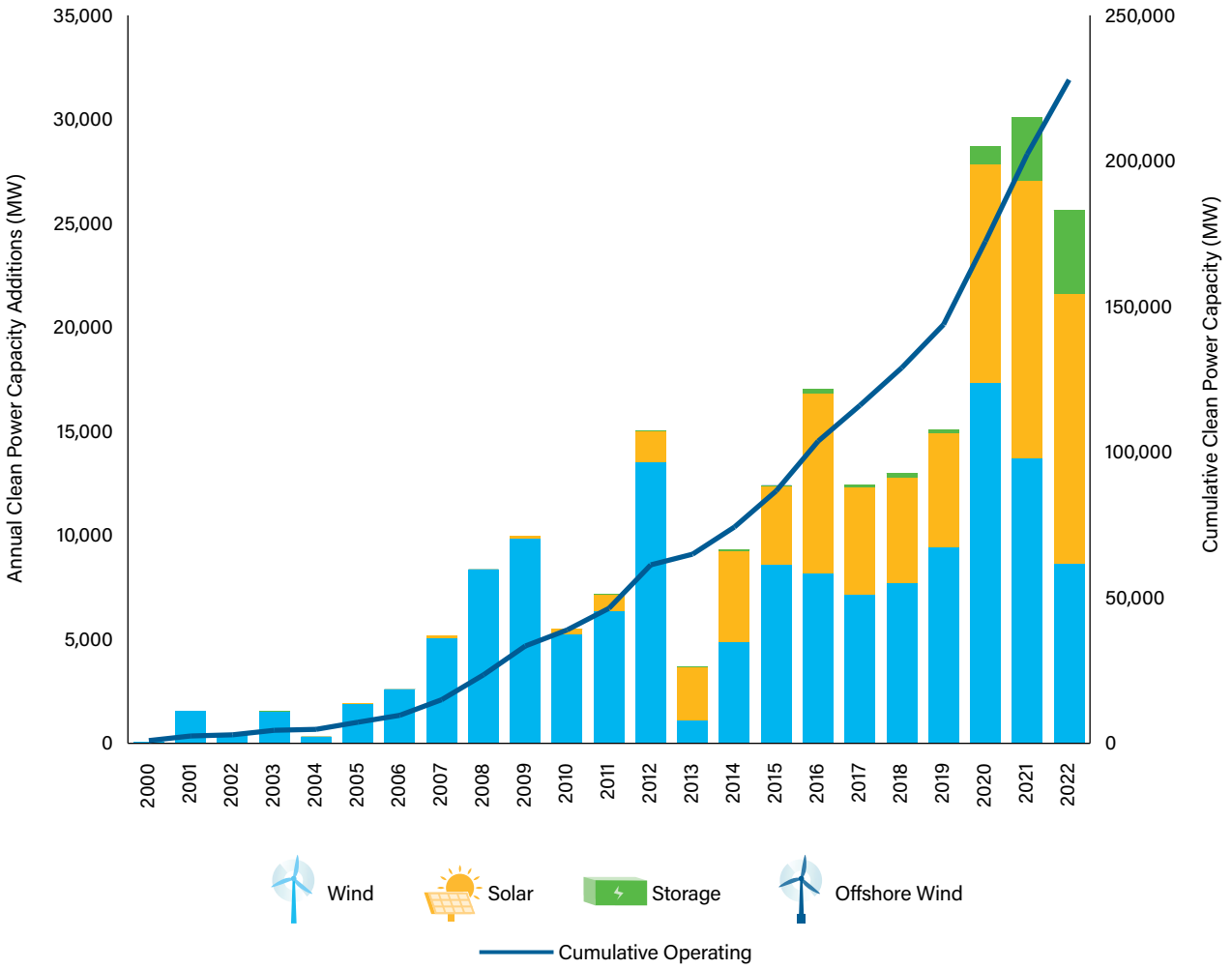
2022 Clean Power Activity

Annual and Cumulative Clean Power Capacity

More than 25.5 GW of clean power installed in 2022

- In 2022, clean power developers commissioned 25,538 MW of new clean power capacity. This represents enough electricity to power more than 5 million American homes.
- Despite years of consecutive growth in annual clean power installations, there was a 15% decrease in 2022 compared to the record year of 2021. As a result, 2022 is now only ranked as the third highest year for annual installations to date.
- The level of 2022 clean power installations has been affected by delays in nearly 53 GW of projects since the final quarter of 2021. The delays were caused by several factors, including challenges in sourcing solar panels, supply chain constraints, interconnection issues, and policy uncertainty related to the previous phase-down schedule of the PTC. These factors proved to be significant barriers for many clean power projects.
- In total, 227,852 MW of clean power is operating and powering American homes and businesses. Land-based wind, which dominated clean power installations through 2015, accounts for 63% of all operating clean power. Solar makes up 33% of operating capacity, and battery storage 4%.
- The nearly 26 GW of clean power capacity installed in 2022 represents a sizable capital investment of nearly $35 billion. Cumulative clean power capital investment has now exceeded $434 billion.

U.S. Annual and Cumulative Utility-Scale Clean Power Capacity Growth

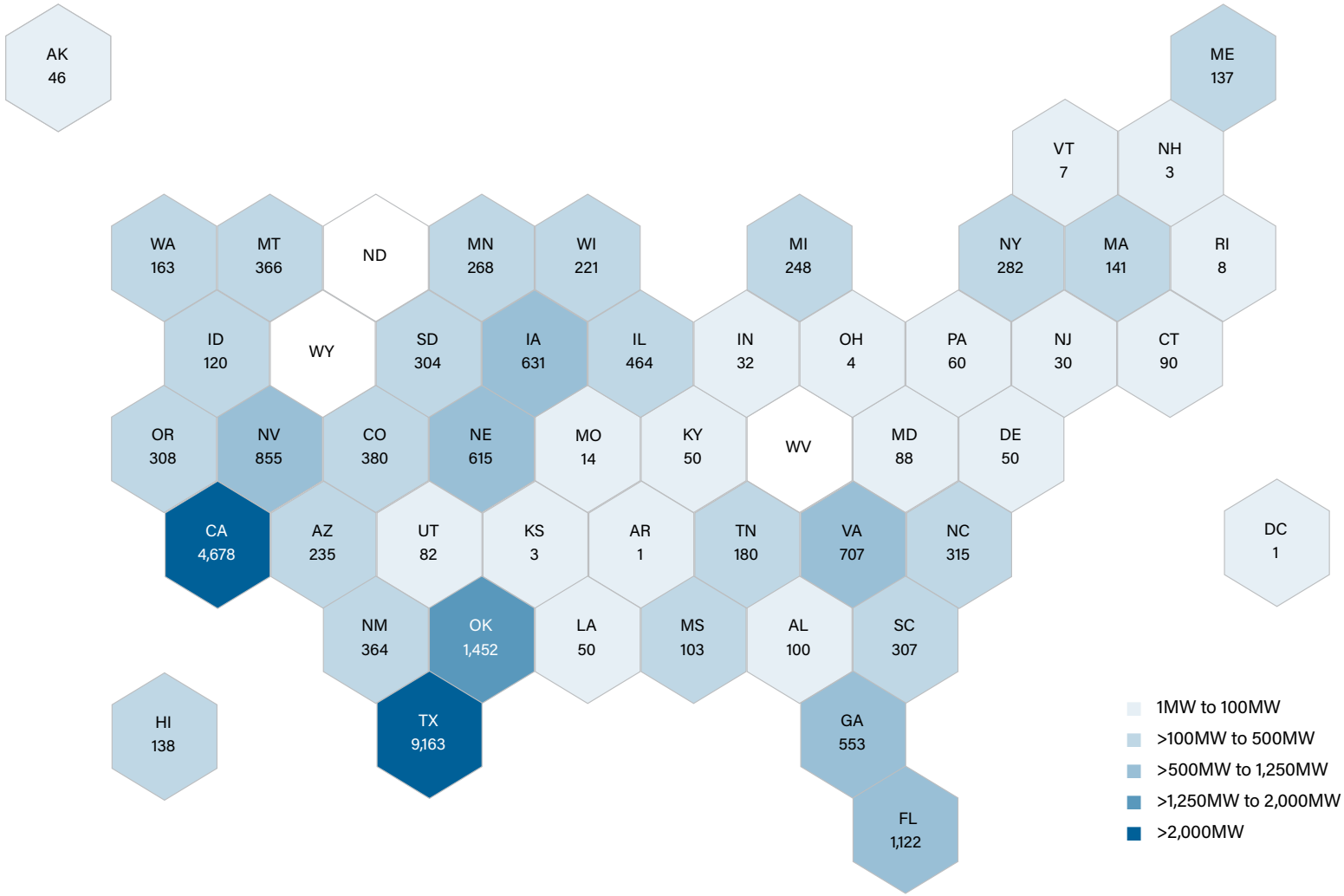


2022 Clean Power Activity

Clean Power Capacity Installations in 2022 by State

Industry built 531 clean power projects across 47 states, totalling 25.5 GW

Clean Power Projects Installed in 2022

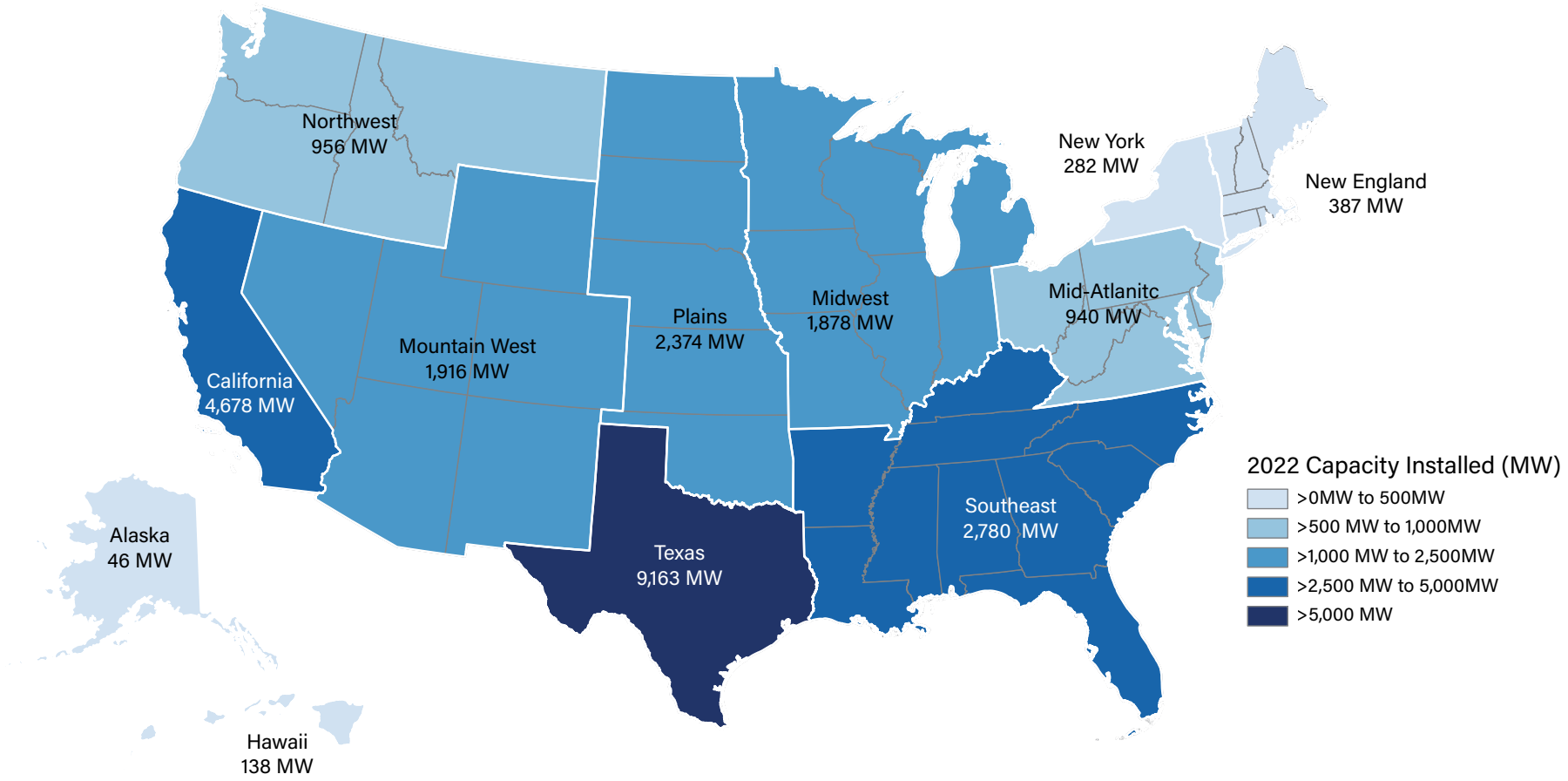


2022 Clean Power Activity

2022 Installations by Region

Industry built clean power projects across all regions, with Texas experiencing the highest increase in capacity

2022 Clean Power Installations by Region

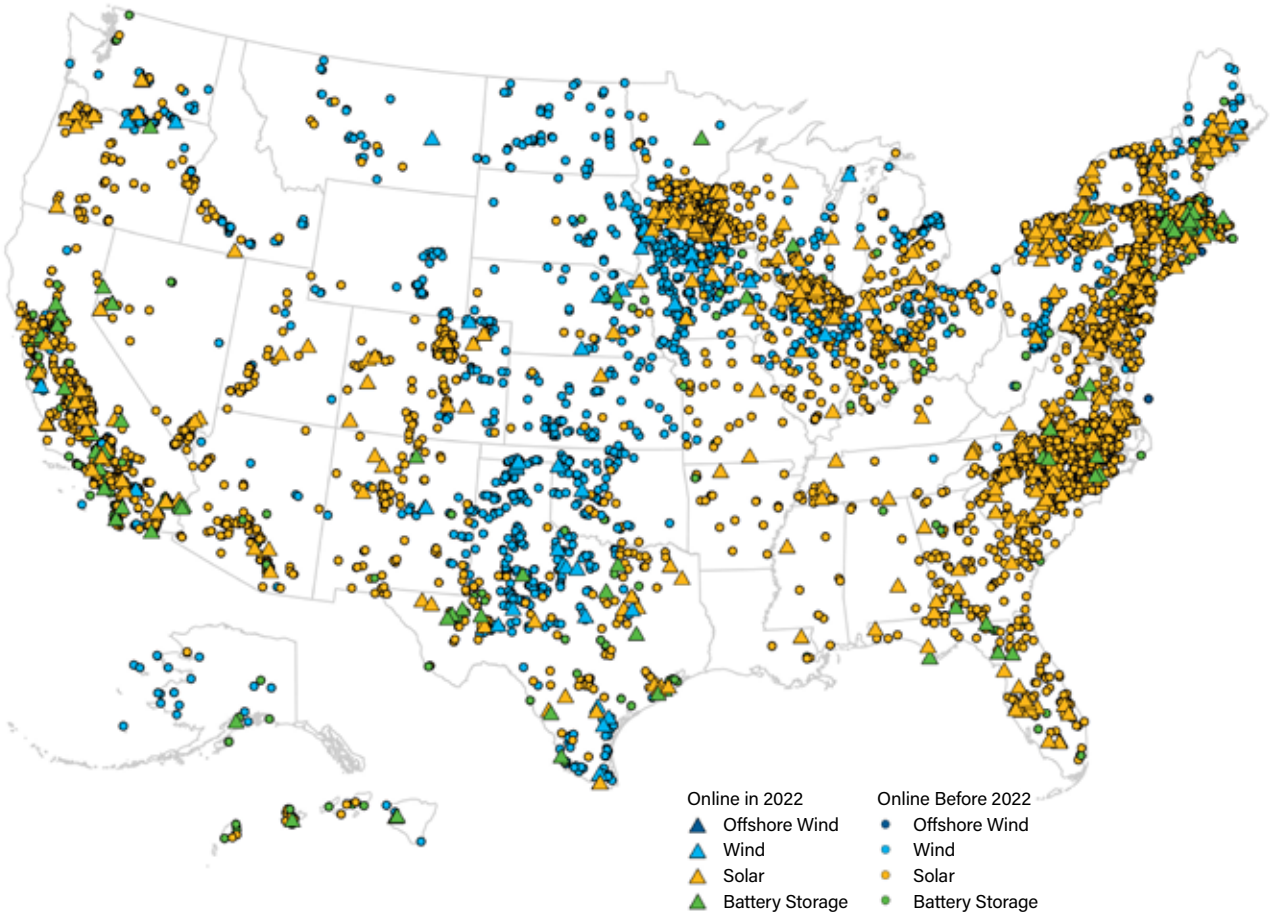


U.S. Clean Power Projects

Projects generate renewable energy in all 50 states

- The Great Prairie Wind (Firewheel Wind) took the top spot for the largest wind project built in 2022 at over 1 GW across 4 phases. This was followed by the 996 MW Traverse Wind project in Oklahoma, and the 499 MW Young Wind project in Texas.
- The top solar project phase to come online in 2022 was the 430 MW Old 300 Solar project located in Texas. The 350 MW Fighting Jays Solar Project also located in Texas and the 300 MW Slate Solar project in California round out the top three spots.
- The 350 MW/1,400 MWh Crimson Storage project phase built in California took the top spot in terms of capacity and energy in 2022. In capacity terms, this was followed by the 260 MW DeCordova Energy Storage project in Texas and the 230 MW Desert Sunlight Storage project located in California.
- The DeCordova Energy Storage project has a duration of one hour (260 MWh total energy) while the Desert Sunlight Storage project has a four hour duration (920 MWh total energy).

Operating U.S. Clean Power Projects

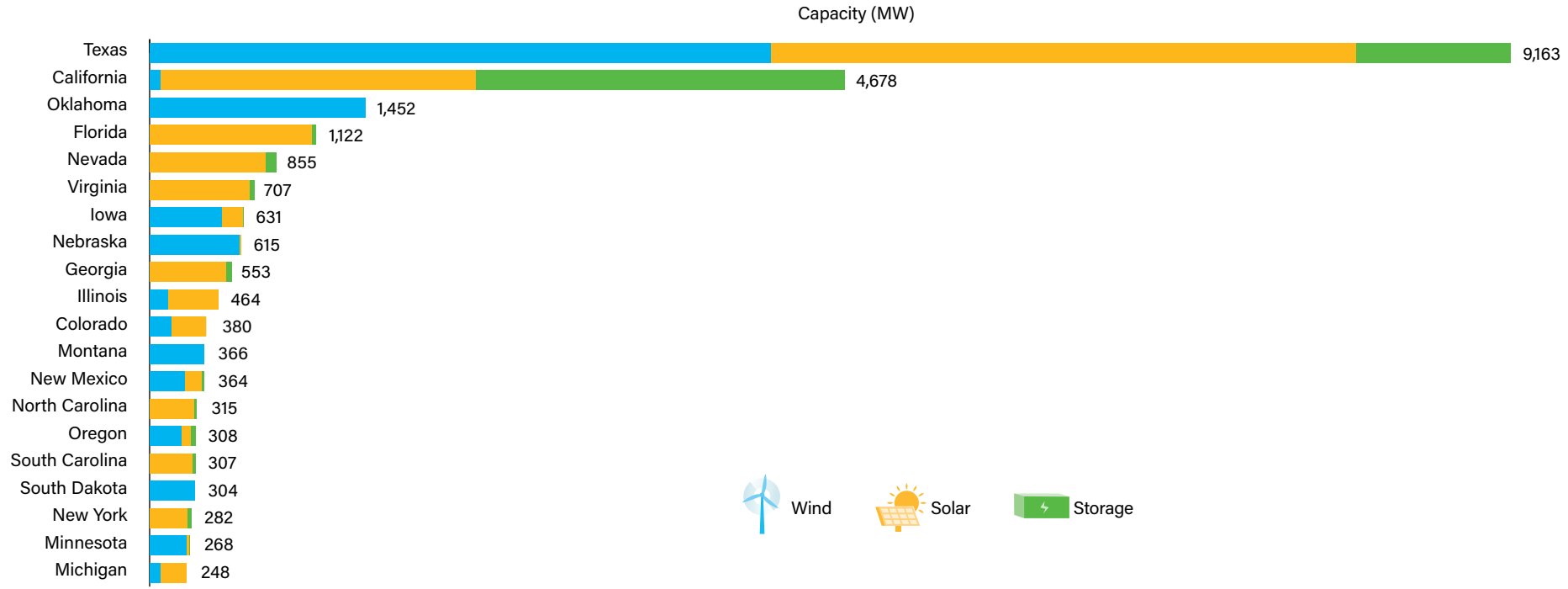


2022 Clean Power Activity

Clean Power Additions, Top States

Texas maintains position as clean power leader

Top States for Clean Power Additions in 2022



- Texas has led the nation in annual clean power installations since 2017. In 2022, Texas installed nearly twice as much capacity as any other state.
- Despite an overall decline in installations, Texas and California, along with 16 other states, set new annual commissioning records in 2022.
- By technology, Texas leads for both wind and solar capacity, with approximately 4 GW of each technology online. California leads the nation for operating battery storage capacity, at nearly 2.5 GW.

2022 Clean Power Activity

State Capacity Rankings

Texas leads in capacity, Kentucky leads in growth

U.S. Clean Power Capacity Rankings

Rank	State	Capacity Additions in 2022 (MW)
1	Texas	9,163
2	California	4,678
3	Oklahoma	1,452
4	Florida	1,122
5	Nevada	855
6	Virginia	707
7	Iowa	631
8	Nebraska	615
9	Georgia	553
10	Illinois	464
11	Colorado	380
12	Montana	366
13	New Mexico	364
14	North Carolina	315
15	Oregon	308
	Rest of U.S.	3,673

- In 2022, only four states installed 1 GW or more of clean power, while nine states installed 500 MW or more. This marks a notable decrease from 2021, when as many as 18 states managed to install 500 MW or more.

Rank	State	Cumulative Capacity (MW)
1	Texas	54,454
2	California	28,638
3	Iowa	13,052
4	Oklahoma	12,277
5	Kansas	8,273
6	Illinois	8,232
7	Florida	6,697
8	Colorado	6,503
9	North Carolina	6,218
10	Minnesota	5,935
11	New Mexico	5,196
12	Oregon	4,891
13	North Dakota	4,302
14	Indiana	4,180
15	Nevada	4,141
	Rest of U.S.	54,863

- There are now 35 states with one gigawatt or more of operating clean power. Four more states have at least 500 MW operating, and Delaware is the only state in the nation with less than 100 MW of utility-scale clean power operating.

Rank	State	% Increase in Cumulative Operating Capacity
1	Kentucky	190%
2	Delaware	129%
3	Tennessee	84%
4	Louisiana	67%
5	Mississippi	47%
6	Connecticut	39%
7	Virginia	32%
8	Montana	32%
9	Alaska	30%
10	South Carolina	27%
11	Nevada	26%
12	Alabama	24%
13	Hawaii	23%
14	Nebraska	21%
15	Texas	20%
	Rest of U.S.	13%

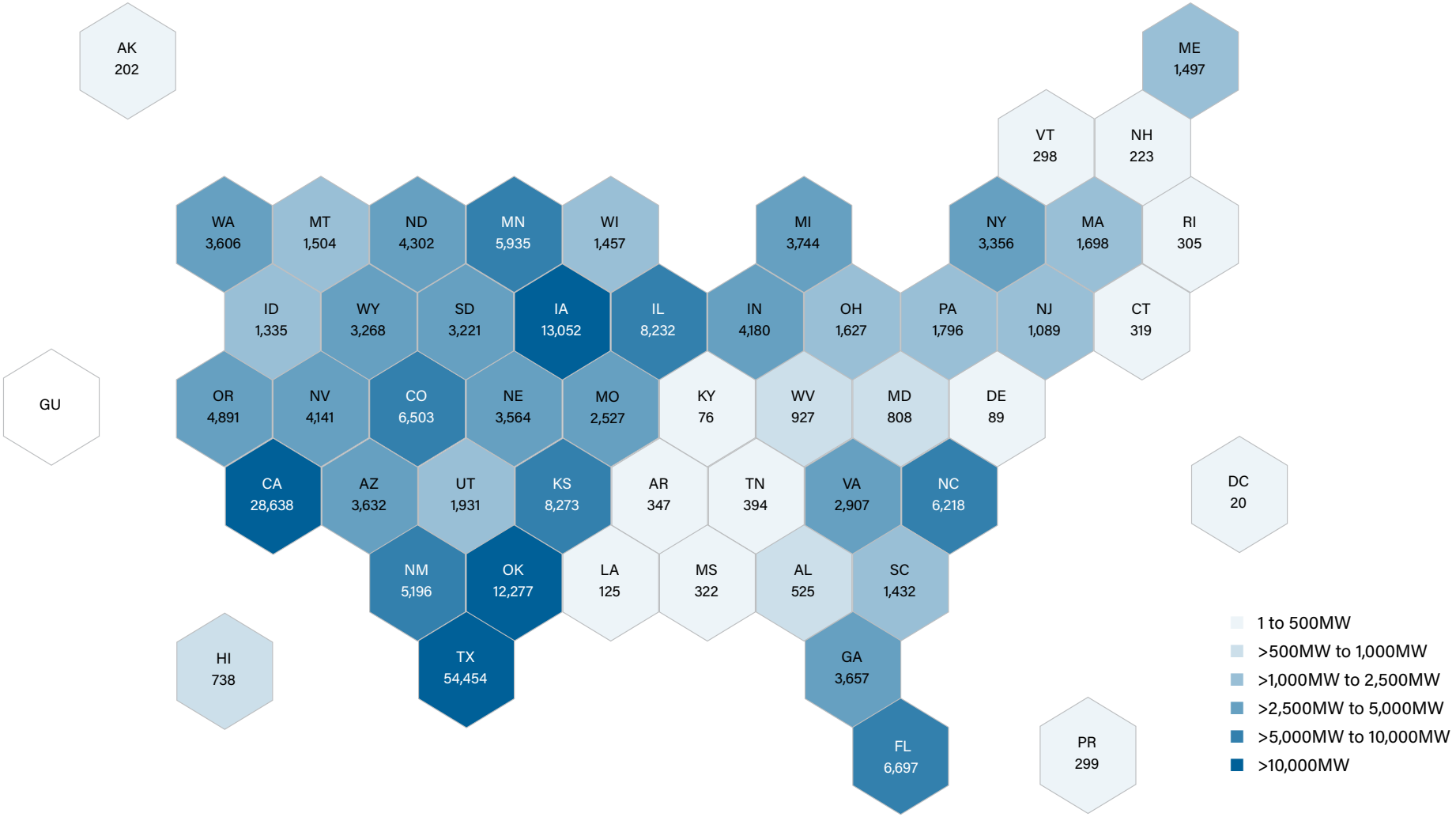
- In 2022, there was a 13% increase in cumulative clean power capacity. States with relatively low levels of operating clean power in 2021 showed the highest percentage increase in operating clean power. For instance, Kentucky had only 26 MW of clean power online in 2021 but installed an additional 50 MW in 2022.

2022 Clean Power Activity

Clean Power Capacity, by State

Clean power is present in all 50 states; 11 have 5 GW or more installed

Operational Clean Power Capacity, by State



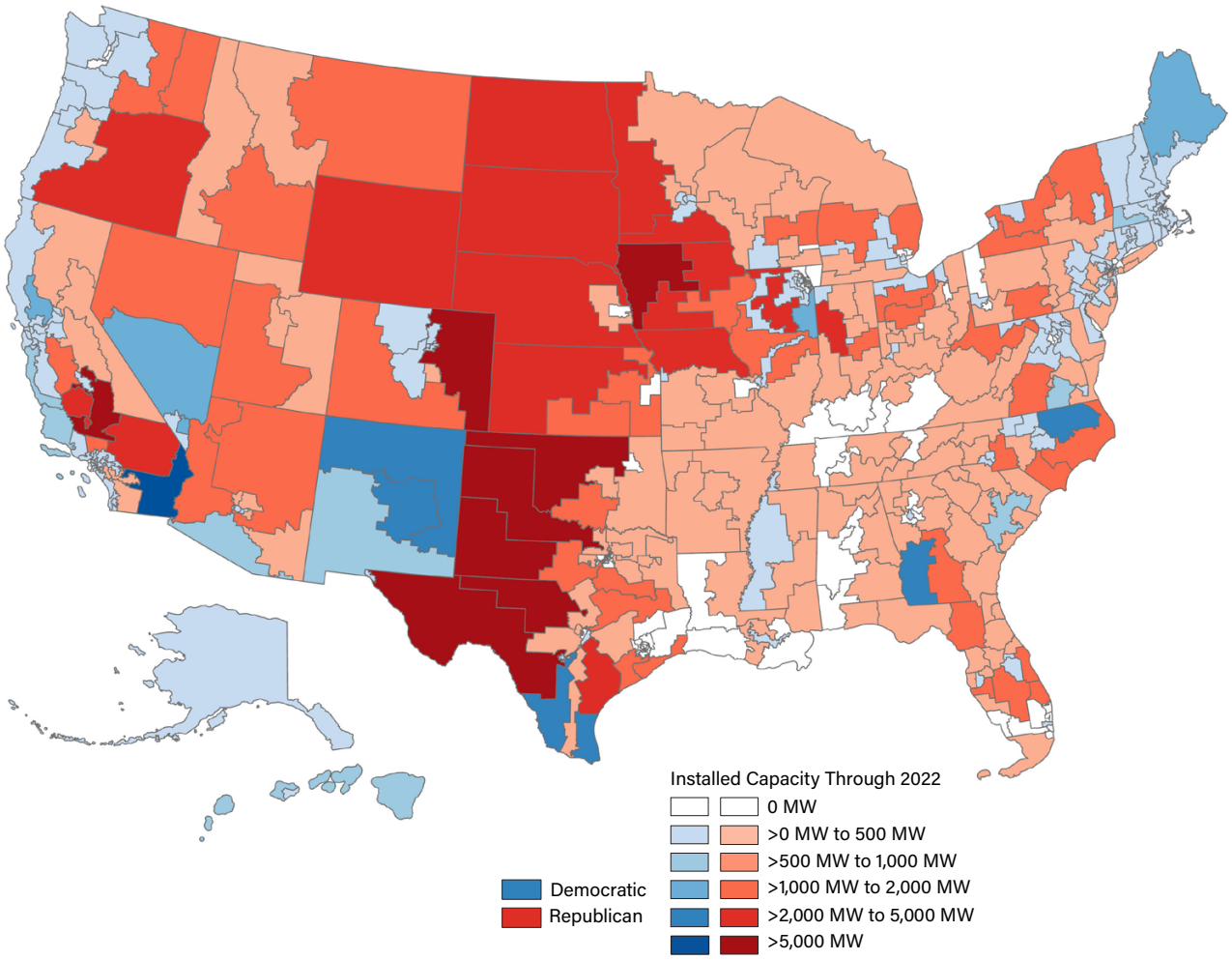
2022 Clean Power Activity

Clean Power Capacity by U.S. Congressional District

Clean power is present in 93% of U.S. congressional districts

- Clean power is red, white, and blue with projects or manufacturing facilities in 93% of congressional districts.
- There are 185 districts with at least 100 MW of clean power capacity installed and there are 56 congressional districts with at least 1,000 MW installed. A single megawatt of wind power can provide enough electricity to power over 325 homes, while a single MW of solar capacity can power over 200 homes. Wind projects and solar projects of the same size are capable of powering a varying number of homes due to the higher average capacity factor of wind, compared to solar.
- Seventeen of the top twenty districts for clean power capacity are represented by Republicans. Texas's 19th district, represented by Congressman Jodey Arrington, hosts more clean power than any other district in the country with nearly 15.3 GW of clean power installed. This includes nearly 12.5 GW of wind capacity, nearly 2.7 GW of solar capacity, and over 110 MW of storage capacity.
- Roughly 80% of all clean power capacity is installed in districts represented by Republicans.
- The top district represented by a Democrat is California's 25th, represented by Congressman Raul Ruiz. The district hosts over 5.2 GW of solar capacity, over 1.7 GW of storage capacity, and 614 MW of wind capacity.

Clean Power Capacity by U.S. Congressional District



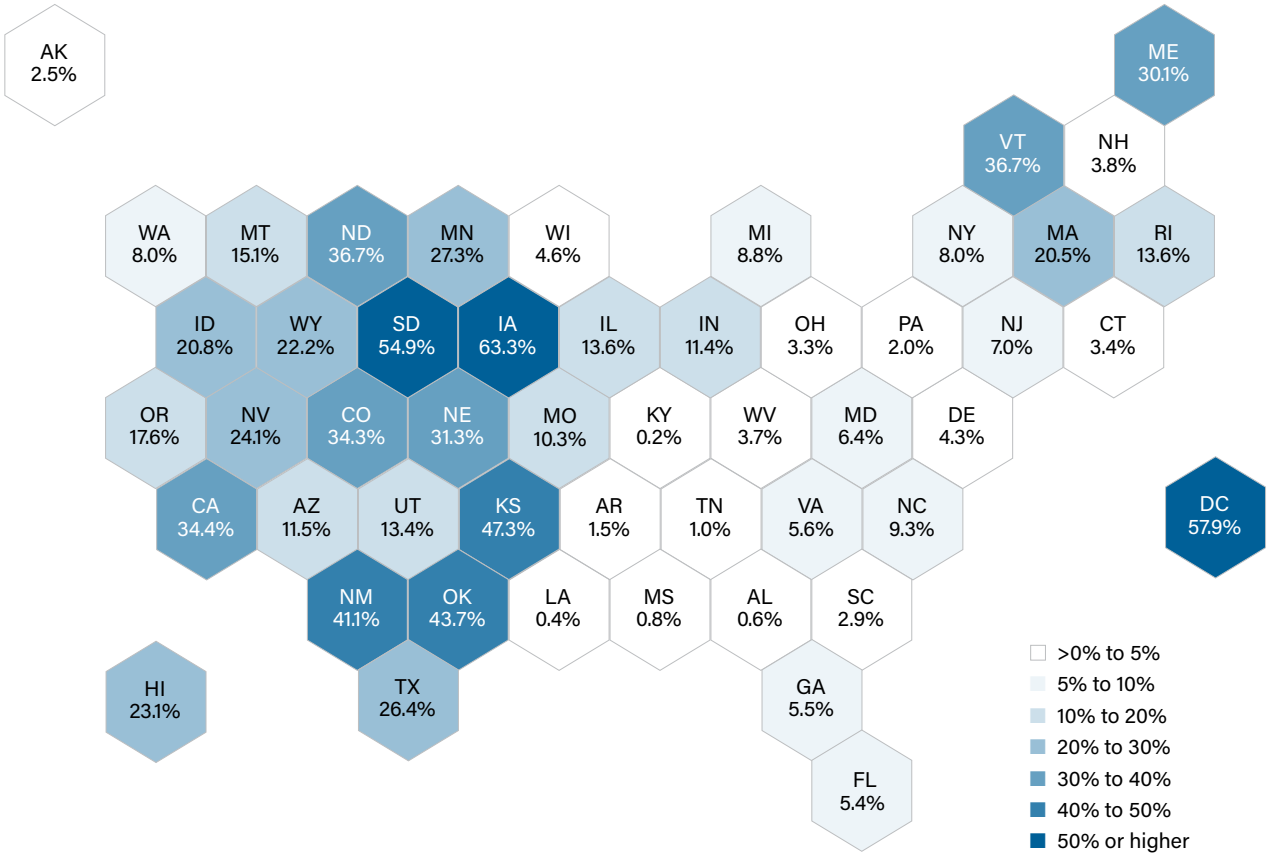
2022 Clean Power Activity

Clean Power's Share of Electricity Generation

Wind and solar provided 15% of the nation's electricity in 2022

- By the end of 2022, 27 states were generating at least 10% of electricity from wind, utility-scale solar, and small-scale solar.
- Iowa remains the leader in clean power share at 63%, up from 56% last year. South Dakota follows at 55%. The District of Columbia, buoyed by large amounts of distributed solar and limited overall generation, generated nearly 58% of electricity from clean power.
- Kansas (47%) and Oklahoma (44%) are joined for the first time by New Mexico (41%) as the only other states above 40%. In 2021, 36% of electricity generated in New Mexico was from wind and solar, marking a sizeable increase.
- Additionally, there are six other states above a 30% clean power share of electricity generation and another six states between 20% and 30%.
- The pattern of top performers generally coincides with windy Midwestern states where there are significant amounts of wind capacity installed.

Wind + Solar Share of State Electricity Generation



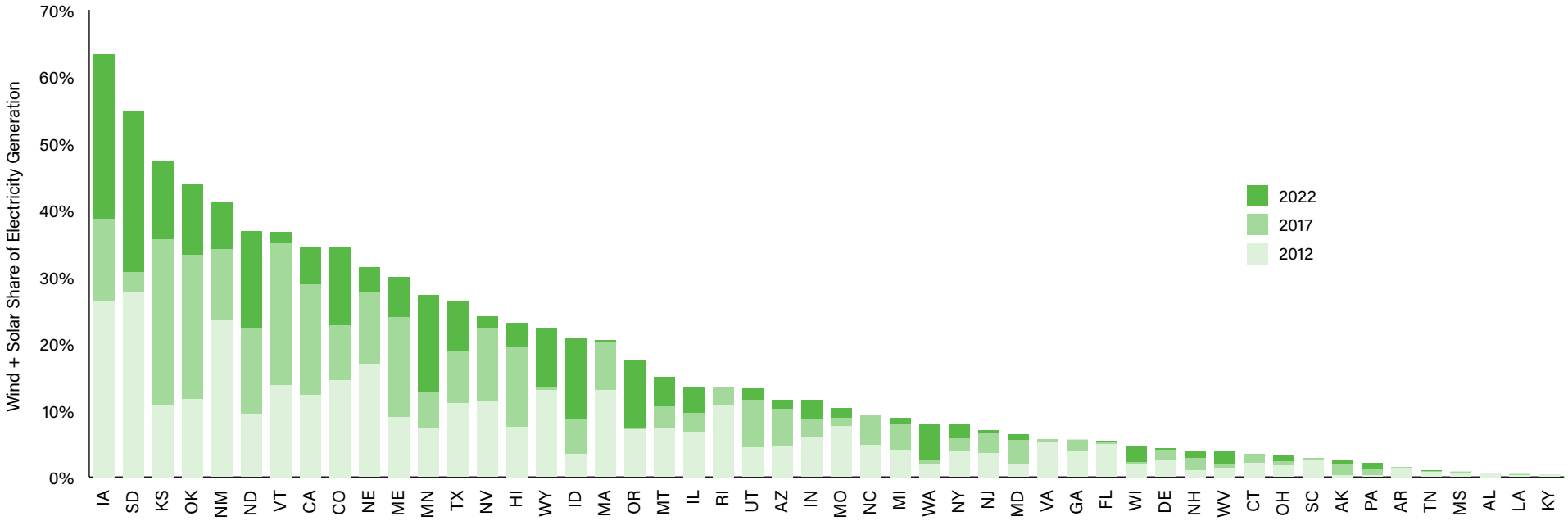
Source: EIA

2022 Clean Power Activity

Clean Power Penetration Over Time

Thirteen states generate at least 25% of their electricity from wind and solar

Clean Power Penetration, 2012-2022



Source: EIA

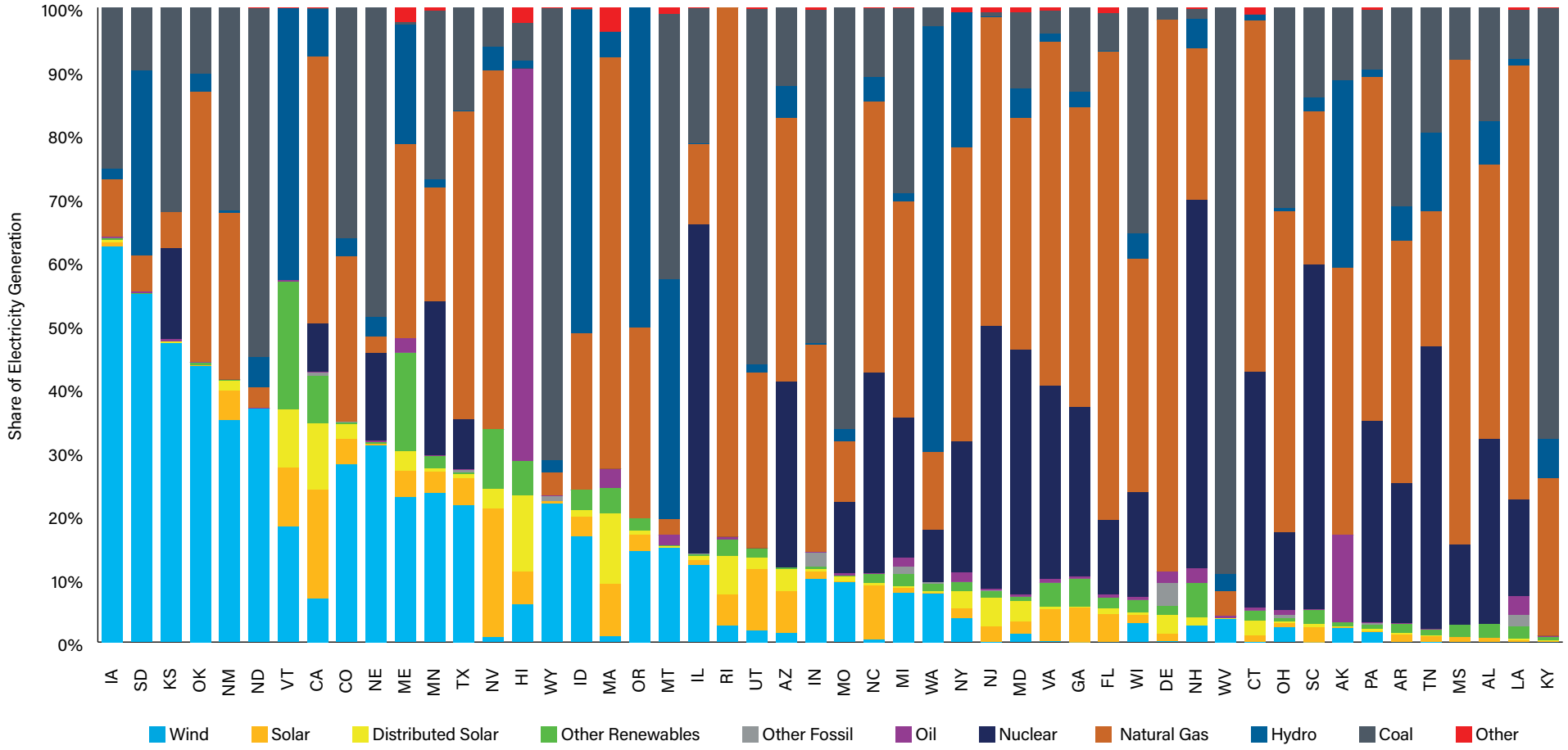
- Wind was the largest source of electricity generation in Iowa, South Dakota, Kansas, Oklahoma, and New Mexico in 2022. In New Mexico, wind was responsible for 34.9% of all generation, edging out coal at 32.1%. In 2021, coal led all forms of generation in New Mexico with a 35.1% share of electricity generation.
- In 2022, solar was the second largest source of generation in California, Hawaii, Massachusetts, Nevada, and Rhode Island.
- Wind and solar power's share of electricity generation has grown significantly during the last decade. In 2012, just 15 states produced more than 5% of their electricity from wind and solar generation, while nine states exceeded 10%, and two states (Iowa and South Dakota) exceeded 20%. Five years later, in 2017, 25 states produced at least 5% of their electricity from wind and solar and 17 states generated over 10%, with nine states exceeding 20%. In 2022, the number of states exceeding 5% of electricity generation from wind and solar has increased to 35; 18 states generated over 20% and five states generated over 40%.
- At the national level, the share of wind and solar electricity generation has grown from just 3.6% in 2012 to 14.9% in 2022.

2022 Clean Power Activity

Electricity Generation Mix by State

Iowa leads all states by generating 63% of its electricity from wind and solar

Electricity Generation Mix in 2022 by State



Source: EIA

2022 Clean Power Activity

State Generation Rankings

Iowa again leads in clean power penetration, Texas produced the most clean electricity, and Alabama experienced rapid growth

State Clean Power Generation Rankings

Rank	State	Clean Power Share (%)
1	IA	63.3%
2	SD	54.9%
3	KS	47.3%
4	OK	43.7%
5	NM	41.1%
6	ND	36.7%
7	VT	36.7%
8	CA	34.4%
9	CO	34.3%
10	NE	31.3%
11	ME	30.1%
12	MN	27.3%
13	TX	26.4%
14	NV	24.1%
15	HI	23.1%

Rank	State	Clean Generation (MWh)
1	TX	139,332,419
2	CA	78,701,265
3	IA	45,365,148
4	OK	37,583,187
5	KS	29,619,777
6	IL	25,899,726
7	CO	20,525,350
8	NM	17,040,480
9	MN	16,572,772
10	ND	16,572,080
11	FL	13,988,144
12	NE	12,677,124
13	NC	12,613,918
14	AZ	12,506,765
15	IN	11,211,831

Rank	State	Growth in Clean Generation (%)
1	AL	77.8%
2	TN	75.7%
3	RI	56.3%
4	AR	50.1%
5	WV	47.3%
6	VA	44.9%
7	WI	39.4%
8	GA	38.3%
9	KY	33.4%
10	CT	32.3%
11	NV	29.2%
12	NY	27.7%
13	IN	24.6%
14	FL	23.8%
15	NE	22.7%

Source: EIA

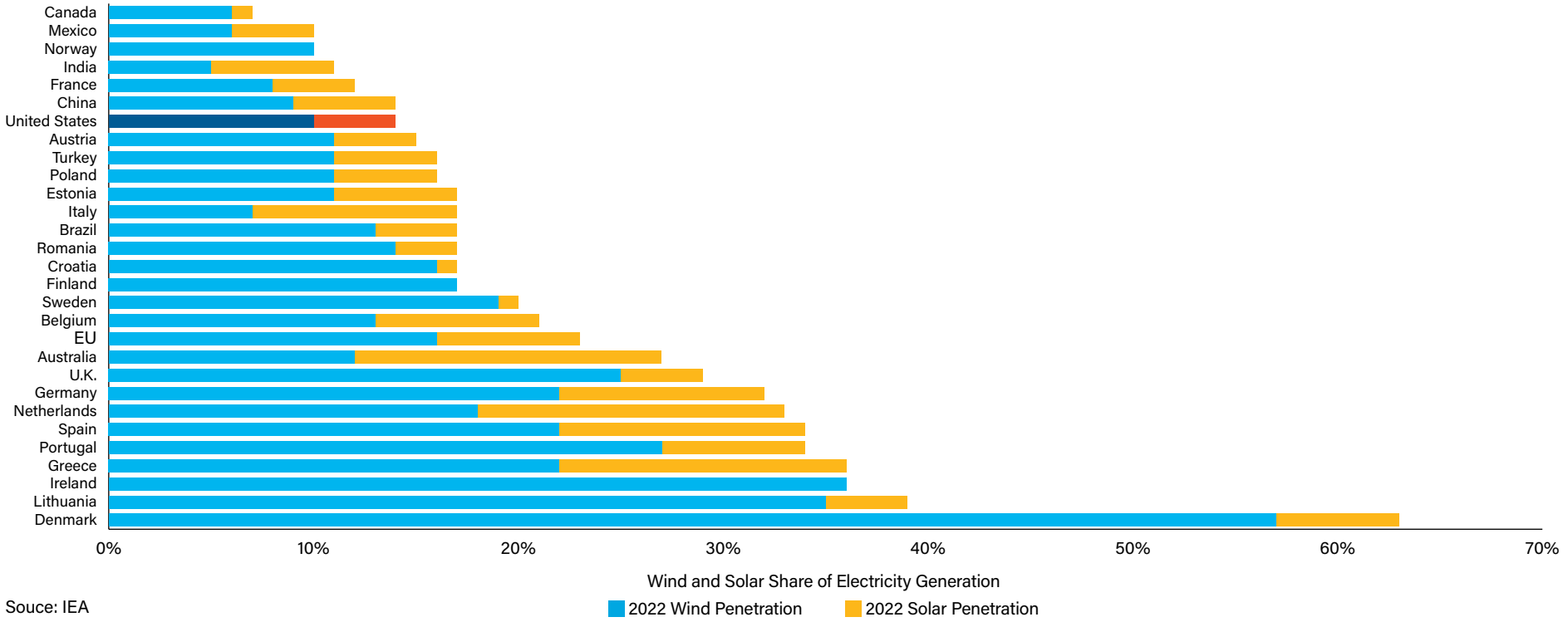
- While both Iowa and South Dakota generate more than 50% of their electricity from wind and solar, their total annual energy production (AEP) measured in total megawatt hours (MWh) is lower than other states with higher total electricity generation. Texas and California lead the nation in total MWh generated from wind and solar, followed by Iowa, Oklahoma, and Kansas.
- In terms of year-over-year growth in clean energy generation, Alabama leads the pack with a nearly 78% increase over 2020 generation driven in part by the 227 MW Muscle Shoals project which came online in September 2021 as the first utility-scale solar project in the state.

2022 Clean Power Activity

Wind and Solar Penetration Around the Globe

Denmark leads with a renewable energy penetration of 63%

Global Clean Energy Penetration



Souce: IEA

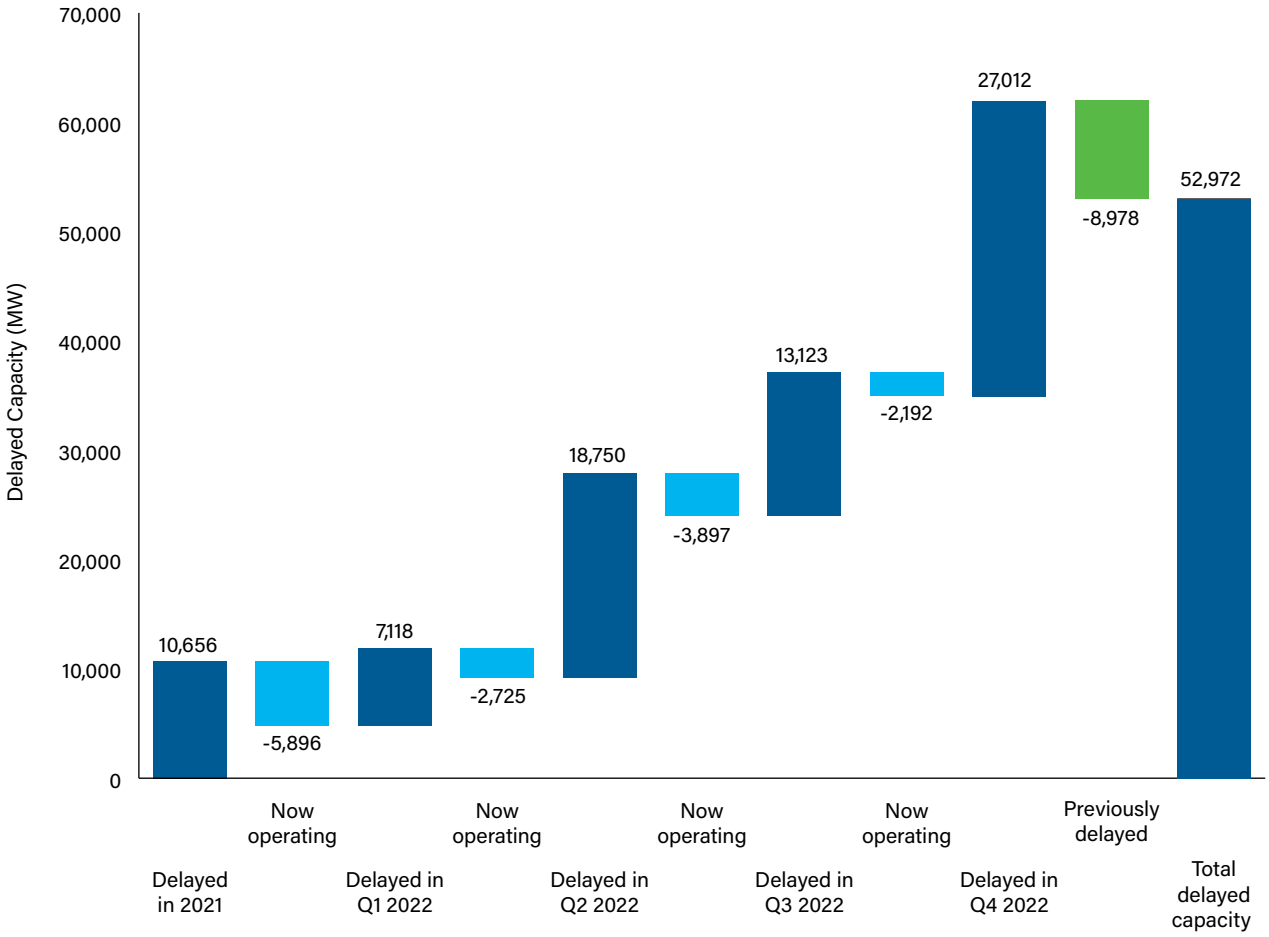
- According to data published by the International Energy Agency, Denmark had the highest penetration of renewable energy out of a selection of OECD and other high-income countries. 63% of electricity generated in Denmark was from renewable sources.
- Denmark was followed by Lithuania and Ireland, which generated 38% and 36% of their electricity from solar and wind energy, respectively.
- While the U.S. ranks second in operating wind and solar power capacity, it sits low on the leader board in terms of the share of electricity generation that comes from these clean energy sources. There are at least 21 countries with higher penetration rates, though the U.S. just edges out China.

Clean Power Delays

More than 53 GW of clean power capacity experiencing delays

- Delays in clean power projects were prominent throughout 2022 and help explain the decline in 2022 clean power installations compared to 2021.
- At the end of 2021, nearly 11 GW of clean power projects experienced delays, more than half of which have since come online. In 2022, 66 GW of clean power experienced delays. Nearly 9 GW of those delayed projects are now operating, and another 9 GW have experienced multiple delays. In total, since the end of 2021, nearly 53 GW of clean power has experienced delays and has been unable to come online.
- Solar accounts for 68% of delayed clean power capacity, due primarily to difficulty sourcing panels as a result of trade restrictions.
- Wind represents 18% of total delays. Causes of wind delays range from ongoing supply chain constraints to grid interconnection delays.
- Battery storage projects are the least affected, making up just 14% of delays. Most delayed storage projects are co-located with delayed solar projects.

Clean Power Project Capacity Delayed



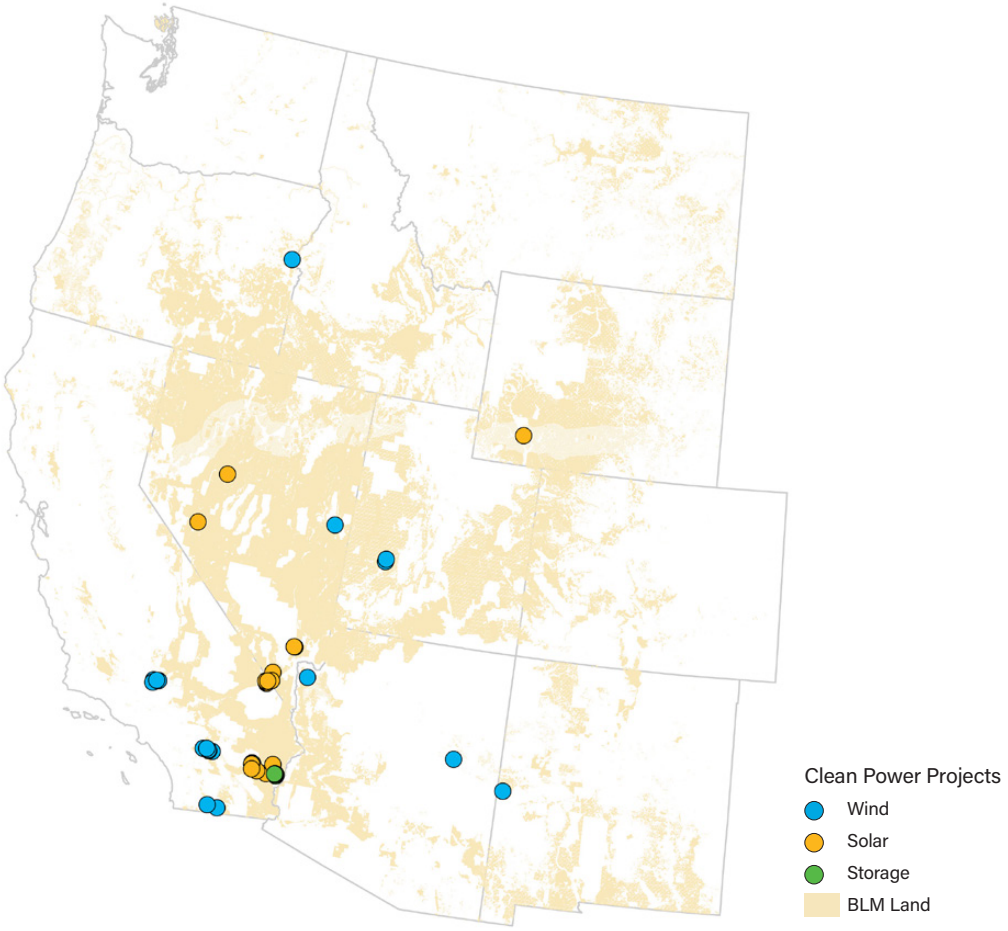
2022 Clean Power Activity

Clean Power Projects on Federal Lands

Over 5 GW of wind and solar capacity is deployed on federal lands managed by the Bureau of Land Management (BLM)

- Some of the best areas for wind and solar resources are located on federal lands managed by the Bureau of Land Management (BLM). The BLM works to provide appropriate sites for environmentally sound development of renewable energy on public lands.
- As of the end of 2022, there was 3,728 MW of solar operating on BLM lands, some of which is paired with energy storage. This capacity is set to expand – BLM has permitted 9,272 MW of solar capacity on public lands, much of which is pending construction.
- According to BLM, 1,438 MW of wind capacity is operating on public lands, with a total of 3,038 MW of wind capacity permitted.

Online Clean Power Projects on Federal Lands

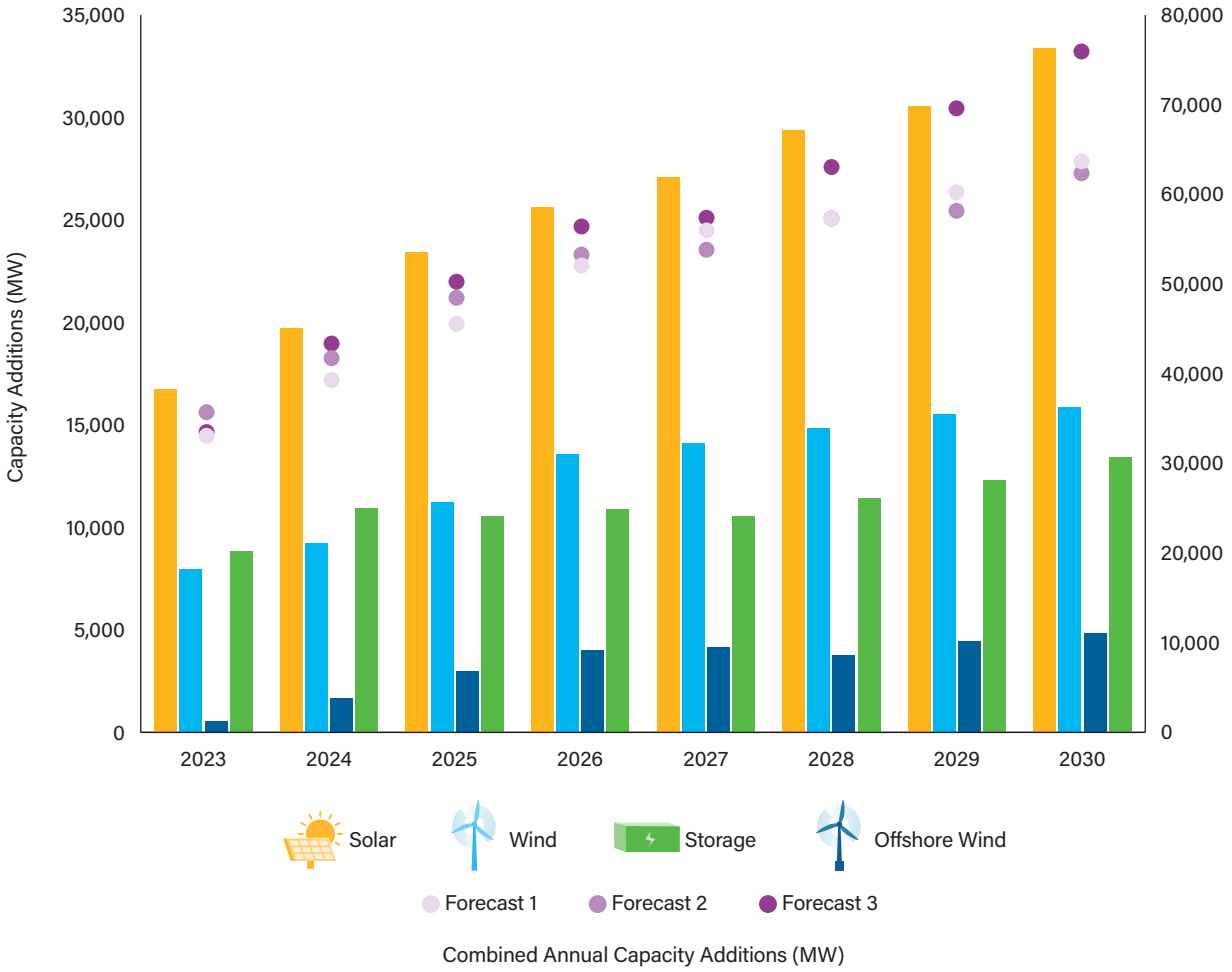


Clean Power Forecast

Market observers estimated 425 GW of utility clean power will be built from 2023-2030

- Clean power market consultants significantly revised their forecasts following the passage of the Inflation Reduction Act. On average, the total forecast for utility wind, solar, and battery storage increased 30%, with forecasters now anticipating 425 GW to be built over the next eight years.
- Utility-scale solar accounts for 49% of the forecast, with expectations for 206 GW. Onshore wind follows with 102 GW—24% of the forecast—projected. Battery storage makes up 21% of the market as consultants expect 89 GW. Offshore wind rounds out the remaining 6% with an expectation of 26 GW.
- The three forecasters are in relatively tight alignment. The lowest overall forecast is 408 GW by 2030 while the most bullish forecast calls for 451 GW. Differences in battery storage expectation are the biggest driver of the gap.
- If the average forecast proves correct, operating clean power will nearly triple to 651 GW by 2030. Fold in expectations for distributed clean power and the figure swells over 700 GW.

Industry Consultant Clean Power Capacity Forecast, 2023-2030



Souce: BNEF, S&P, Wood Mackenzie

U.S. Electricity Sector

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

U.S. Electricity Sector Highlights

- Solar, wind, and battery storage accounted for 79% of the 32,482 MW of new power capacity added to the electric grid in 2022. Clean power technologies have represented the majority of new power installations since 2014.
- Natural gas is the largest source of electricity, providing 39% of U.S. supply. Coal follows at 19%, while nuclear is the third largest source at 18%. The combination of wind, solar, and other non-hydro renewables made up 16.5% of total generation. Including hydroelectric, renewables' share of total electricity now sits at 22.6%.
- At least 92 power plants with a total capacity of more than 16 GW were retired in 2022, the majority being coal plants. Based on S&P Global forecasts, announced retirements from 2023-2030 total 64,000 MW. Of this total, 46% are coal-fired plants and 36% are nuclear facilities. As the market continues to evolve, retirements are expected to grow and even accelerate.

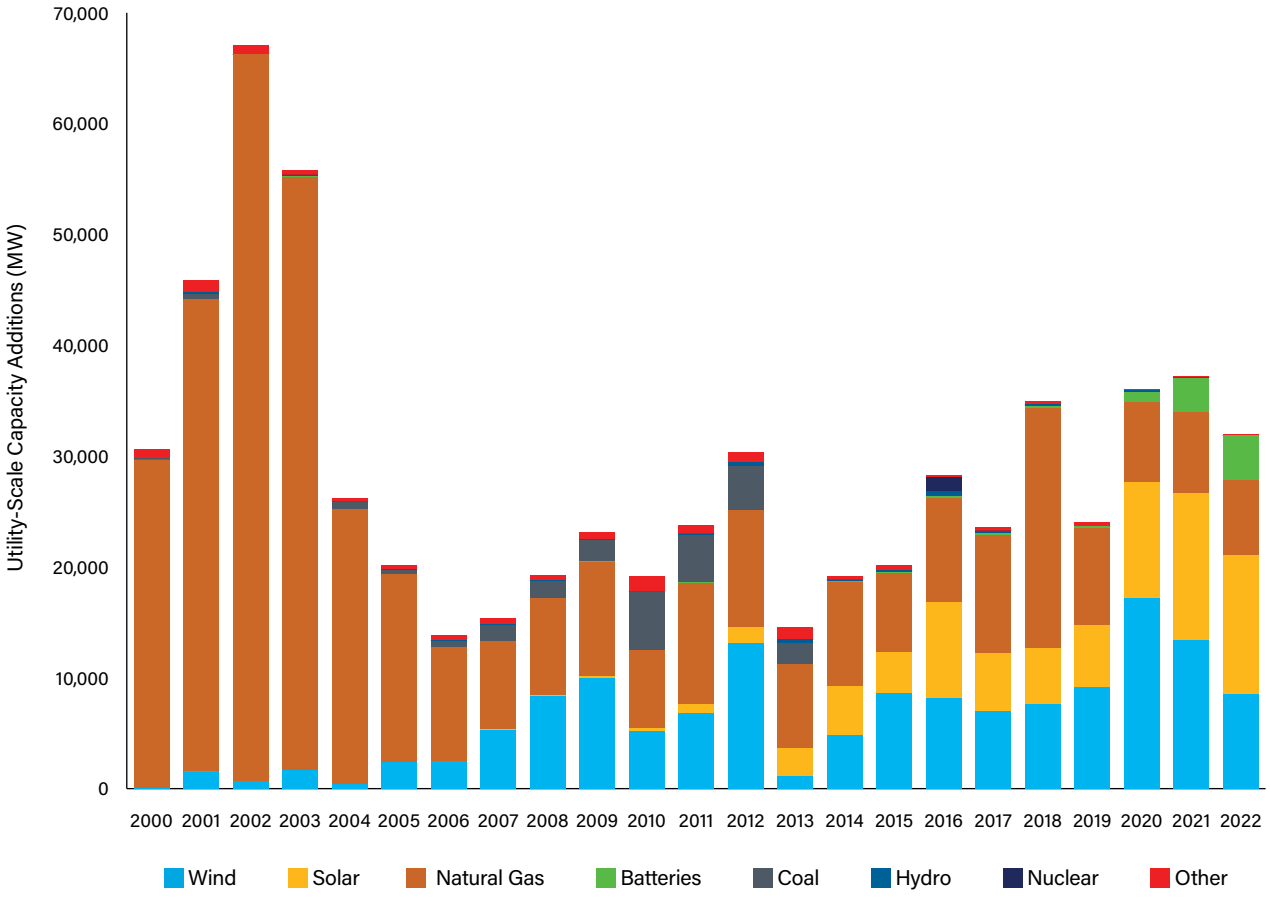
U.S. Electricity Sector

Annual Utility-Scale Power Capacity Additions

Grid adds 32 GW of utility-scale capacity additions, down 14% from 2021

- Project developers added 32,485 MW of new power capacity to the electric grid in 2022. This is down 13% from the 37,374 MW added in 2021. It is the fourth highest year in the last decade.
- For just the second time, solar capacity additions outpaced land-based wind, capturing 40% of the market. Land-based wind followed in second with 26% of new additions. Utility-scale battery storage captured 12% of the market, leaving clean power resources with 79% of 2022 installations.
- Natural gas projects totaling 6,742 MW were added to the grid in 2022. Gas-fired capacity continues to be added to the grid in significant quantities, but natural gas additions haven't exceeded renewable additions since 2014.
- Clean power technologies – wind, solar, and battery storage, coupled with gas, captured essentially the entire market in 2022. This has been the case every year since 2014.

Utility-Scale Power Capacity Additions



Souce: ACP, EIA

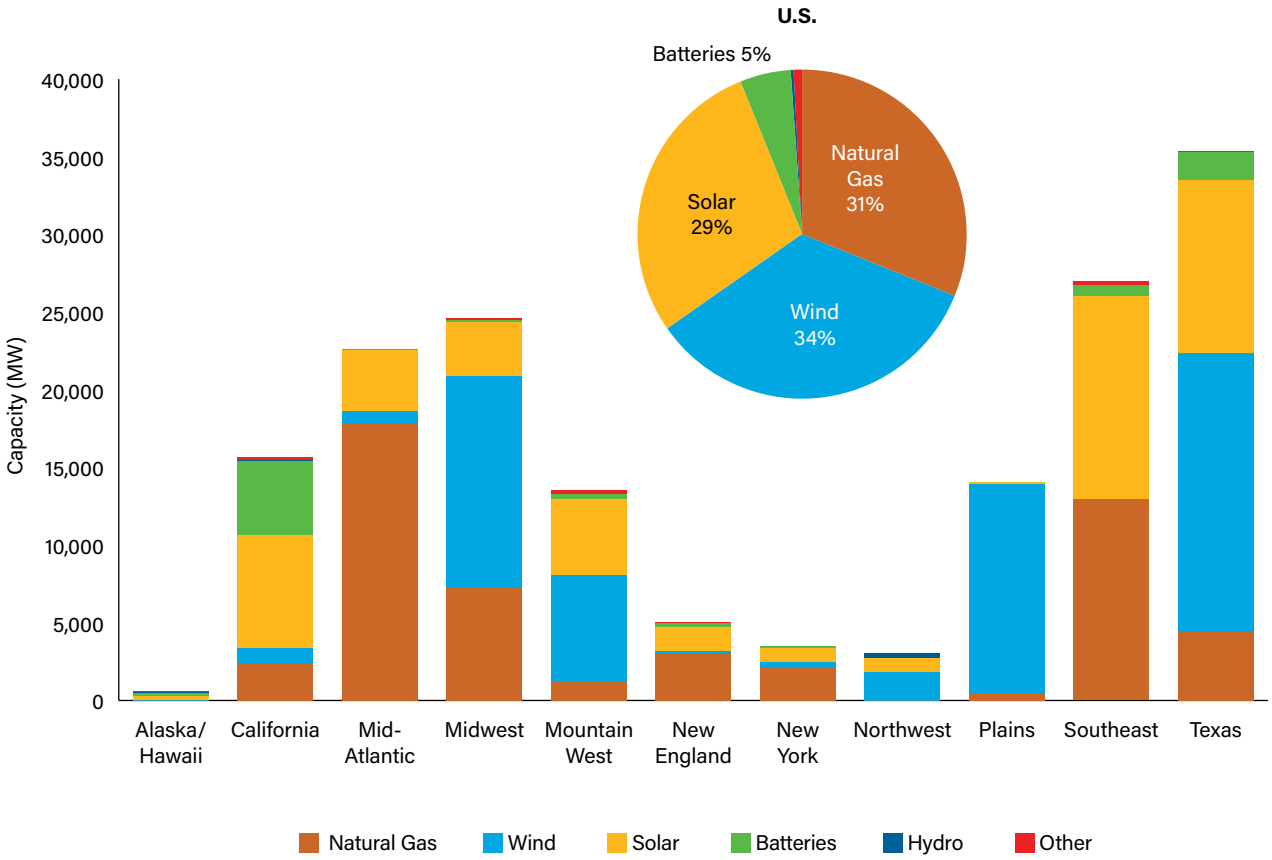
U.S. Electricity Sector

Regional Capacity Additions, 2018-2022

Clean power represents 68% of the five-year market

- Utilities and power customers across the country increasingly prefer clean power resources over other generation technology. In eight out of 11 regions, clean power represents the majority of capacity installations over the past five years.
- The Plains led all regions with wind, solar, and storage representing over 96% of the 14 GW added in the region since 2018. The Northwestern states follow with 90% and the Mountain West comes in third with 89%.
- Solar and battery storage additions in the Southeast surpass natural gas additions over the last five years, with 51% of total additions.
- The Mid-Atlantic states saw the lowest share of clean power additions at just 21%. Natural gas was the overwhelming choice for new capacity in that region.
- Wind made up 96% of installations in the Plains states while solar captured 46% of installations in California. Battery storage captured the most market share, 34%, in Alaska and Hawaii, followed closely by California at 31%.

Regional Capacity Additions, 2018-2022



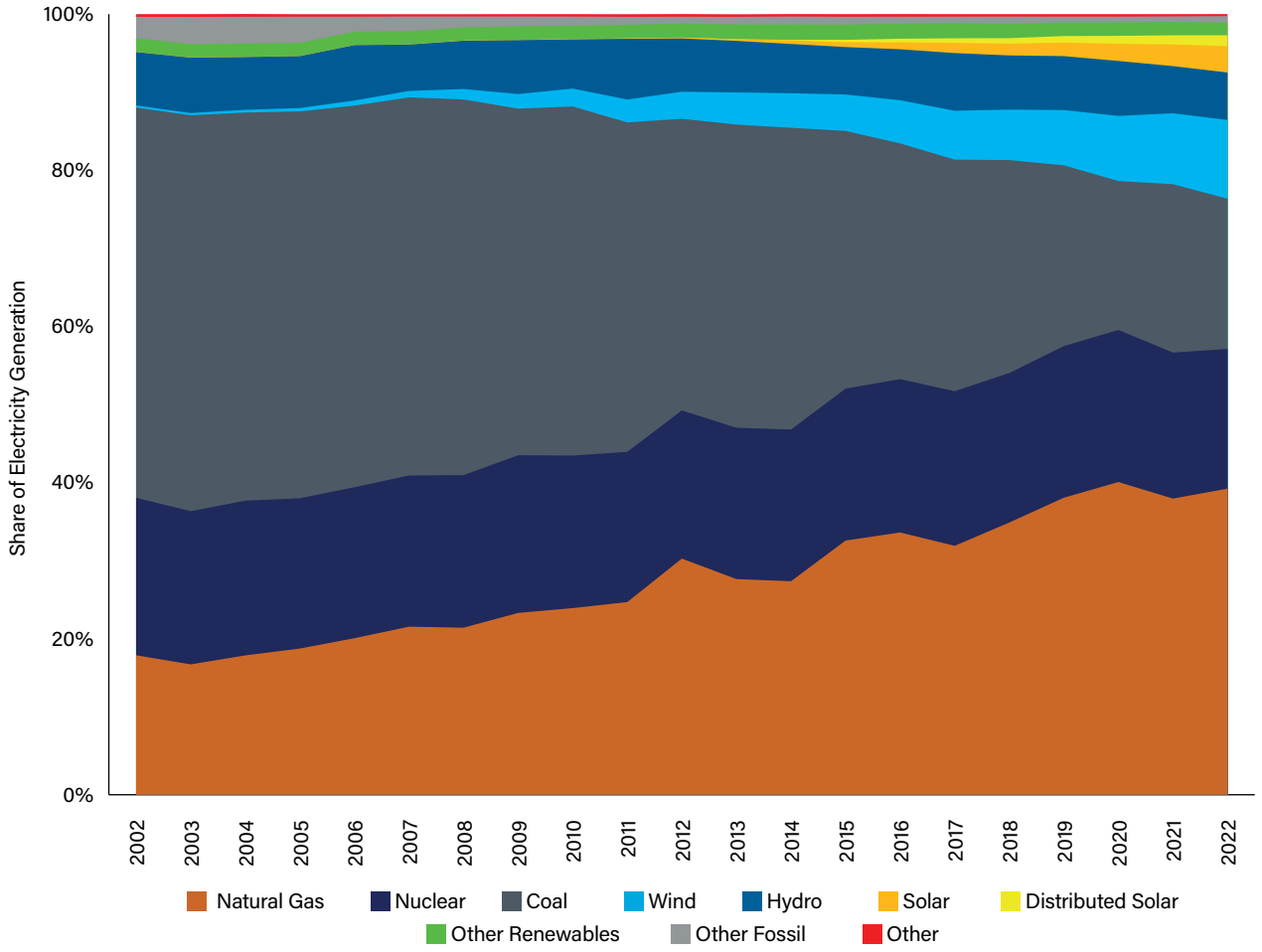
Souce: ACP, EIA

U.S. Electricity Generation Mix by Fuel

Wind and solar provide 15% of nation's electricity, combine with hydroelectric to outstrip coal

- In 2022, natural gas represented 39.2% of U.S. electricity generation, followed by coal at 19.2% and nuclear at 17.9%. The combination of wind, solar, and other non-hydro renewables made up 16.5% of total generation. Including hydroelectric, renewables' share of total electricity grows to 22.6%.
- Coal's share of total generation had increased in 2021, up from 19% in 2020 to 22% in 2021. Coal's jump in share in 2021 came mainly at the expense of natural gas. After providing 40% of electricity generation in 2020, natural gas fell to 38% in 2022. This year represents a reversal of that trend, with coal's share falling and natural gas' share increasing.
- Wind made up 10.1% of U.S. electricity generation while solar was responsible for 4.8% of total generation. Breaking this down further, utility-scale solar generation made up roughly 3.4% while distributed solar made up 1.4%.

U.S. Electricity Generation Mix by Fuel



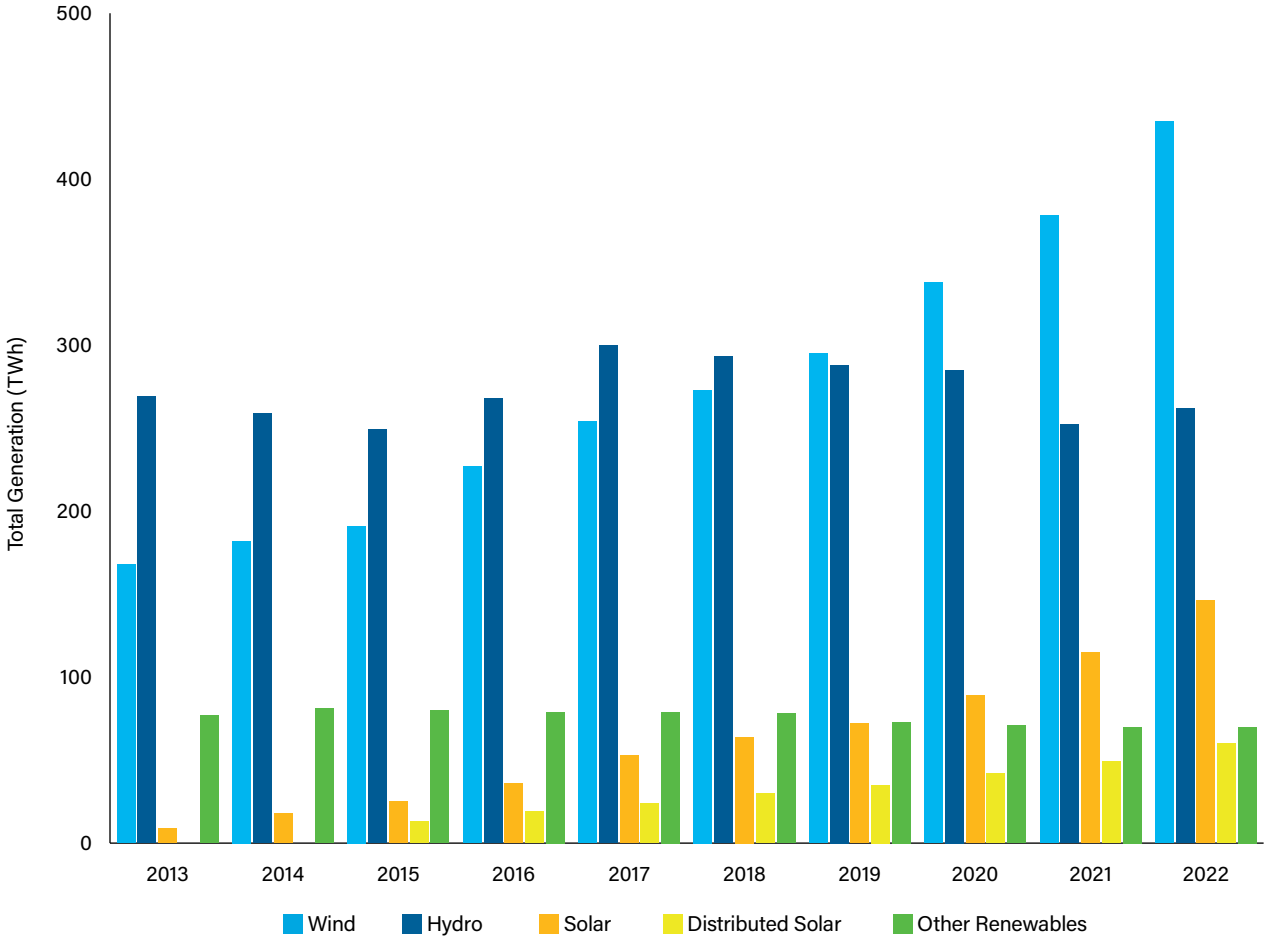
Source: EIA

U.S. Renewable Generation by Technology

Wind energy is the nation's largest source of renewable electricity generation

- Wind surpassed conventional hydroelectric as the top renewable technology in 2019. In 2022, wind made up 44.7% of renewable generation while hydro made up 26.9%. Despite an increase in total generation in 2022 (its first since 2017), hydroelectric's share in U.S. renewable generation has fallen every year since 2013 when the technology was responsible for 51.4% of renewable generation.
- Solar, both utility-scale and distributed solar, combined for 21.1% of renewable generation while other renewables like biomass made up 7.2%. Utility-scale solar and distributed solar made up 15.0% and 6.2% of renewable generation, respectively. Combined, solar's share in renewable generation has grown from just 1.7% in 2013 to 21.1% in 2022.
- Generation by other renewables such as geothermal, wood, and other biomass, has remained relatively constant over time, between 70 and 80 TWh. However, as a share of U.S. renewable generation, this has meant falling from a 14.7% share in 2013 to just 7.2% in 2022 as wind and solar have grown at a rapid rate.

U.S. Renewable Generation by Technology



Source: EIA & S&P Global

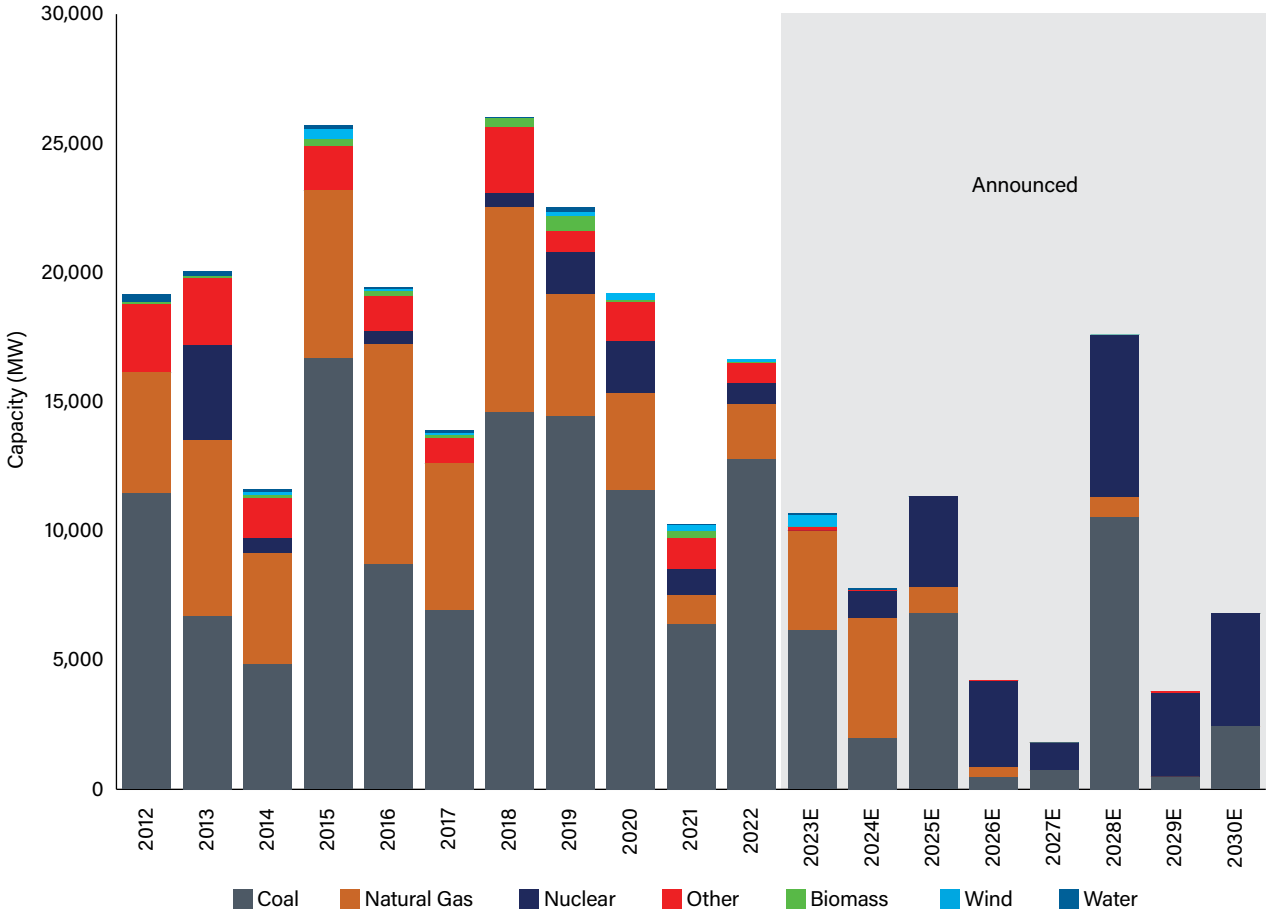
U.S. Electricity Sector

Power Plant Retirements

Over 16 GW of power capacity retired in 2022, most of it coal

- Power plant retirements hit their lowest level since 2011 with 9,839 MW taken offline. This represents a 49% decrease from the 19,198 MW retired in 2020.
- Consistent with recent history, coal retirements were the largest at 6,481 MW. Natural gas and nuclear followed with roughly 1 GW of retirements apiece.
- WH Zimmer—a 1,425 MW coal-fired power plant in Ohio—was the largest power plant retired in 2022. Closely behind was the 1,252 MW Morgantown coal plant in Maryland. The Palisades nuclear plant in Michigan represents all 812 MW of retiring nuclear capacity.
- In total, at least 92 power plants were retired in 2022. Illinois saw the most retirements with 3,367 MW going offline.
- According to S&P Global, announced retirements from 2023-2030 total 64,000 MW. Of this total, 46% are coal-fired plants and 36% are nuclear facilities. As the market continues to evolve, retirements are expected to grow and even accelerate.

Historic and Announced U.S. Electric Power Plant Retirements



Source: EIA (historic), S&P (announced)

U.S. Electricity Markets

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

U.S. Electricity Markets Highlights

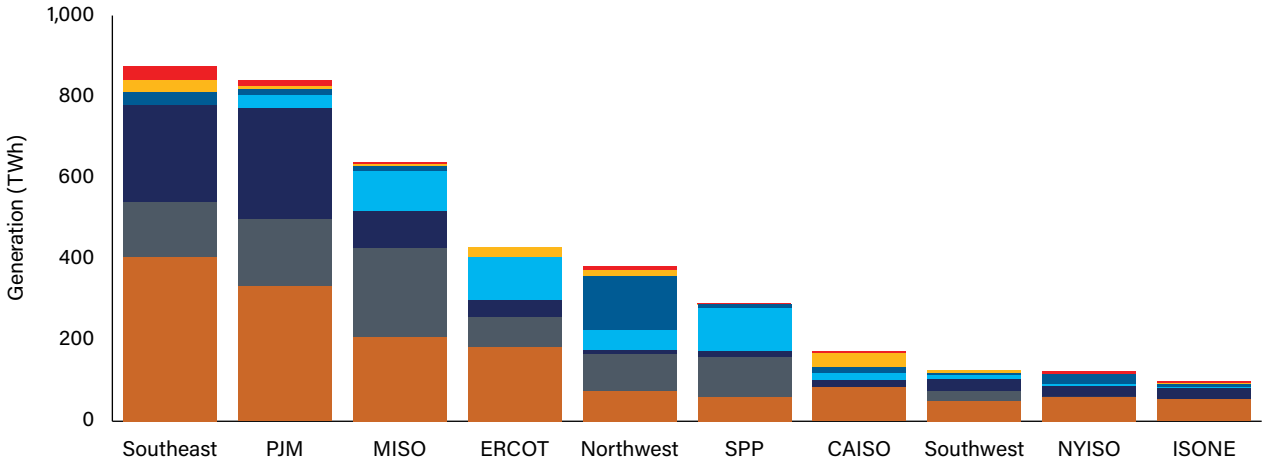
- The curtailment of clean power resources results from transmission inadequacy and other forms of grid and generator inflexibility. Curtailment results in clean power going undelivered to customers, power plants losing out on revenue, and a failure to realize lower power prices. Across all markets, wind and solar curtailment amounted to 25,400 GWh in 2022, equivalent to the annual electricity needs of 2.4 million homes.
- Wholesale power prices remain elevated in 2022 at $64/MWh after a significant increase in 2021. Natural gas prices remained elevated, while inflationary pressures persisted. Extreme weather events also shaped this increase.
- In most electricity markets, prices follow a similar daily curve. Prices are low overnight due to low demand and rise in the morning hours as most people wake up. Demand and prices both drop off in the middle of the day and then ramp up again in the evening when people return home from work. California is an outlier, with an evening peak in hourly wholesale electricity prices due to the state's high solar penetration.
- Seasons have a significant impact on monthly wholesale electricity prices. Regions with mild winters have higher prices in summer due to increased demand for air conditioning. In northern climates like New England, winter months generally have higher prices. On average, August tends to have the highest monthly prices.
- On average, prices were up just 3% across the U.S. in 2022. Retail electricity prices increased in every region except the Mountain West and Northwest.

Regional Electricity Generation Mix

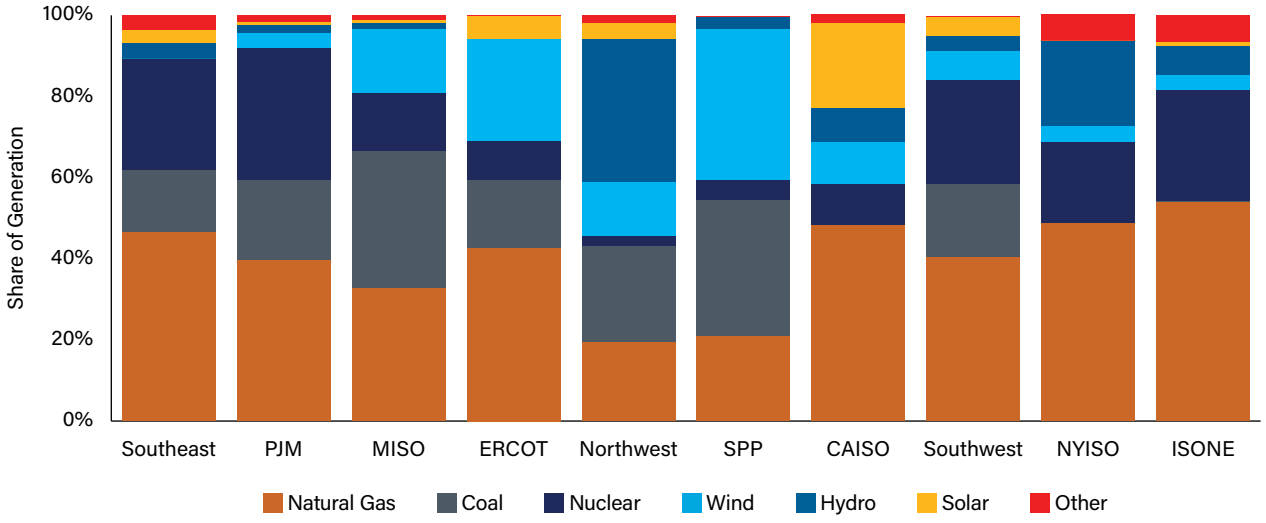
Clean energy penetration highest in SPP, ERCOT, and CAISO

- The generation mix differs in each market depending on the mix of legacy power plants such as coal and nuclear built years ago and the availability of renewable resources.
- The Plains and Texas lead in clean energy generation, with 37% wind generation in SPP and 25% in Texas, along with 6% solar. CAISO has 31% from wind and solar, while the Northwest lags at 17%. Abundant wind resources are driving the transition towards sustainable energy in these regions.
- Grids in the country's windy interior unsurprisingly lead in wind power generation. In 2022, SPP surpassed ERCOT as the region with the highest wind power generation, generating 108 TWh, representing 37% of all generation. ERCOT is now second with 107 TWh and 25%, while MISO is in third place with 100 TWh and 16% of all electricity generated. The Southeast is the only region where wind power doesn't contribute to the grid.
- Wind reclaimed its top fuel status in SPP in 2022 after briefly ceding the position to coal in 2021. With continued build-out in the region combined with ongoing coal retirements, wind is likely to hold tight to this title.
- Most solar generation occurs in CAISO where the technology provided 21% of that grid's electricity last year. ERCOT had the second highest solar penetration at 6%, followed by the Southwest (5%), Northwest (4%), and Southeast (3%). While the Southeast generates the second most solar energy, the technology is still a relatively small portion of the large grid in that region.
- Natural gas continues to be the dominant source of electricity in the country and in most regions.

Regional Electricity Generation, by Source



Regional Electricity Generation Share



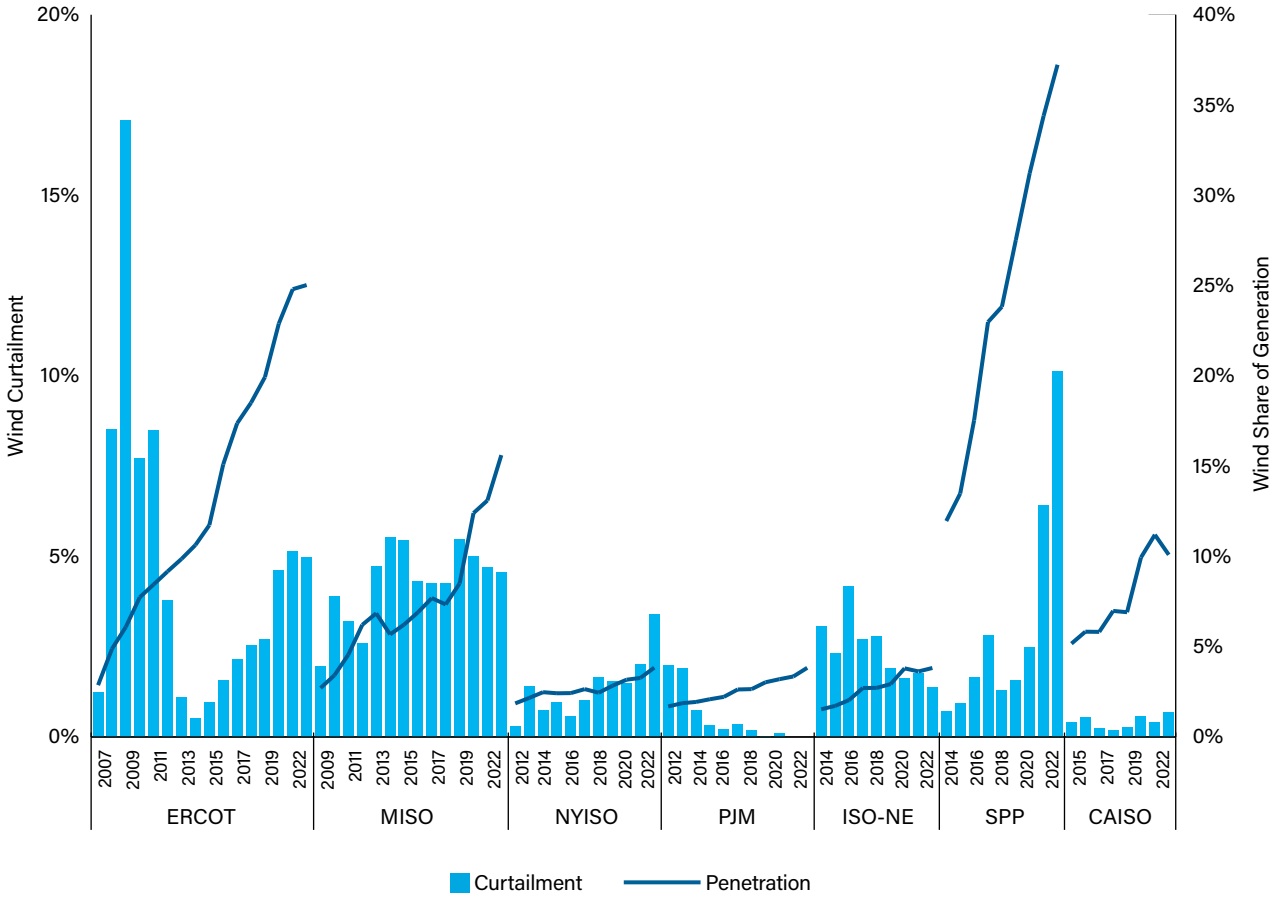
Source: EIA

Wind Penetration and Curtailment

Wind curtailment jumps in ERCOT and SPP

- Wind power curtailment results from transmission inadequacy and other forms of grid and generator inflexibility. Adding transmission capacity greatly reduces curtailment while allowing new wind development in high-quality wind resource areas. Increasing wind penetration is often associated with increasing curtailment but is not always the case.
- Wind curtailment increased in three of the seven RTOs—CAISO, NYISO, and SPP. The largest observed increase was in SPP, which saw the share of wind generation that was curtailed jump from 6.4% to 10.1% in a year.
- In a contrast to recent trends, wind curtailment fell in ERCOT, MISO, and ISO-NE. Curtailment was relatively flat in ERCOT and MISO, falling 0.1 percentage points in both markets. In New England, curtailment dropped 0.4 percentage points.
- For the second year in a row, the MISO wind curtailment rate decreased, dropping form 5.0% in 2020 to 4.7% in 2021.
- Wind curtailment in CAISO remains well below 1% even as wind penetration has surpassed 10%.

Annual wind penetration and curtailment, by RTO/ISO



Source: ACP, RTO/ISOs

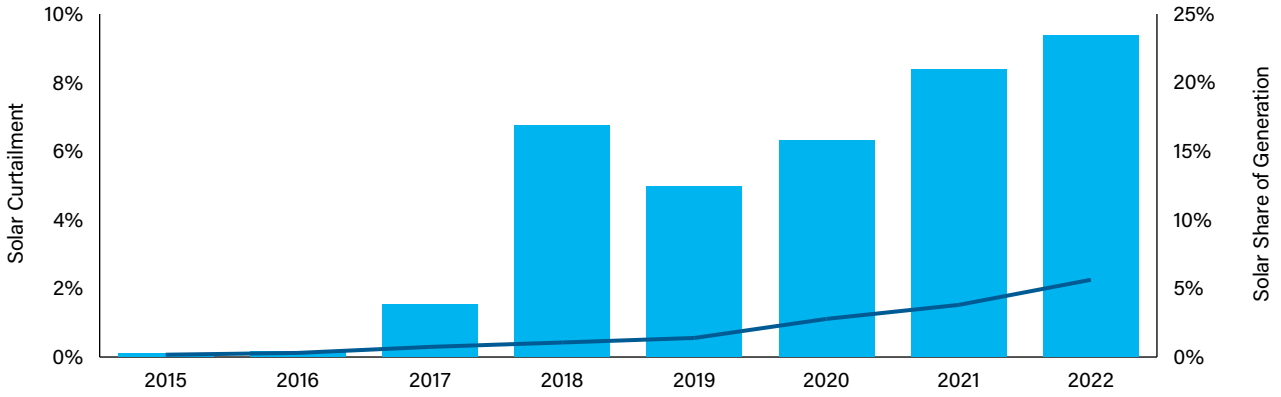
Solar Penetration and Curtailment

Solar curtailment soars in ERCOT

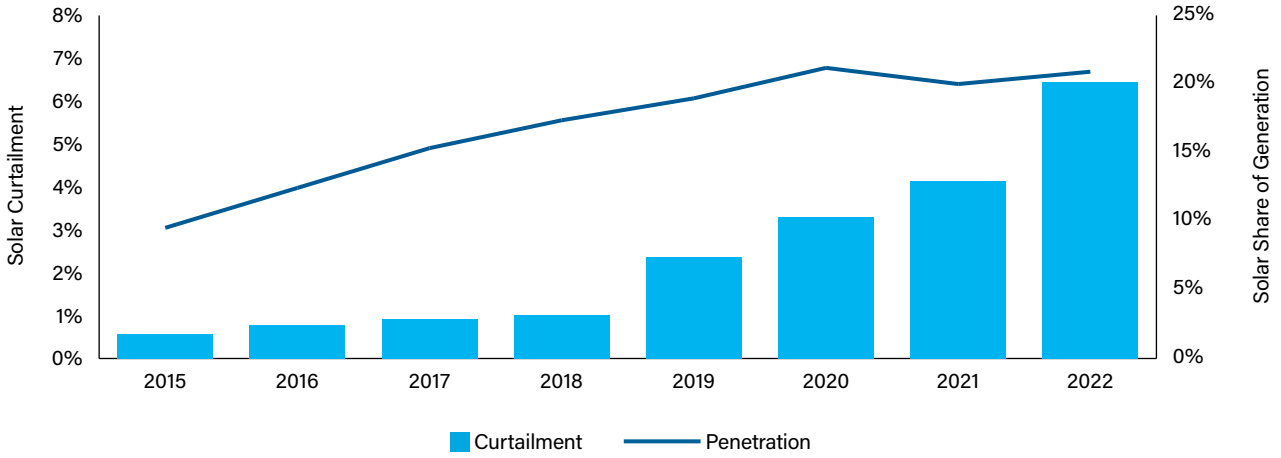
- Only two RTOs currently report solar curtailment: CAISO and ERCOT.
- CAISO and ERCOT both curtailed approximately the same volume of solar in 2022. CAISO curtailed 2,027 GWh, up from 1,426 GWh in 2021. Meanwhile, ERCOT curtailed 2,226 GW, up from 1,436 GWh in 2021. This is roughly equal to a 1,200 MW solar facility operating at an average capacity factor of 22%.
- Solar curtailment increased a full percentage point in ERCOT in 2022 to 9.4% of solar generation curtailed. This is up significantly from the 6.3% curtailed in 2020. Higher curtailments come on the heels of large solar deployments in the state. Solar now provides ~6% of ERCOT's electricity.
- Solar curtailment is less prevalent in CAISO compared to ERCOT, even though solar's penetration rate is far higher in the California market. In 2022, 6% of total solar generation was curtailed, while solar's share of total electricity generation rose to 21%.
- In both markets, curtailment is often highest in the second quarter, likely due to lower electricity demand, strong solar output, and abundant wind generation.

Solar Penetration and Curtailment

ERCOT Solar Penetration and Curtailment



CAISO Solar Penetration and Curtailment



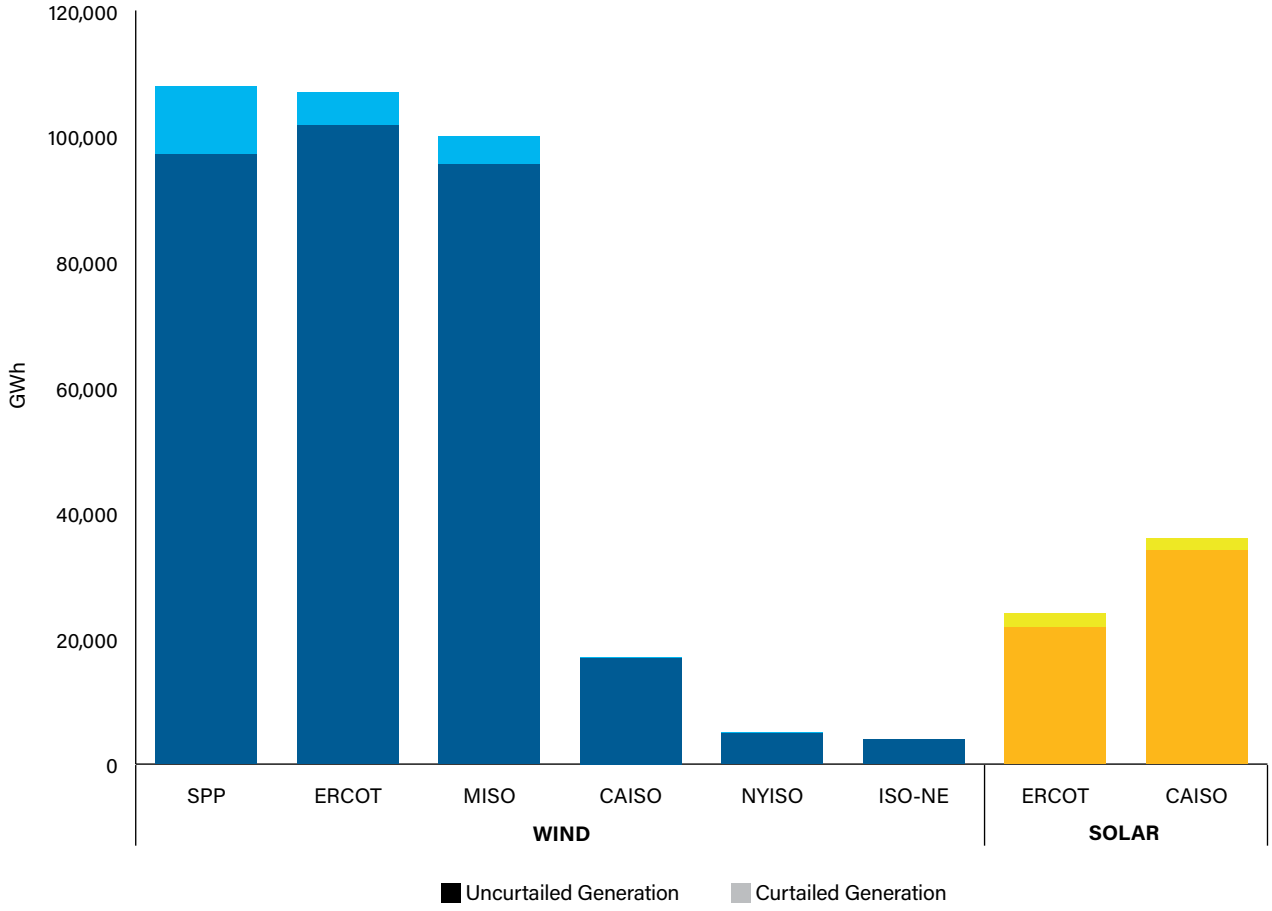
Source: ACP, RTO/ISOs

Wind and Solar Curtailment

Clean power curtailment is a growing concern

- Curtailed power is a dead-weight loss for all. Clean power goes undelivered to customers, power plants lose out on revenue for energy they were capable of generating, and low power prices cannot be realized by customers.
- The issue is most acute in the Southwest Power Pool where nearly 11,000 GWh of wind power was curtailed in 2022. For perspective, that is the same as the annual output from a 3,000 MW wind project.
- Across both wind and solar, curtailments in ERCOT totalled 7,500 GWh. That is enough to provide the entire annual electricity needs of over 700,000 households.
- MISO has the third highest volume of spilled clean energy—with curtailments totalling 4,546 GWh. In California, wind and solar curtailments totaled 2,100 GWh.
- Across all markets, wind and solar curtailment summed to 25,400 GWh in 2022. That is the same as a 7,250 MW wind project or the annual electricity needs of 2.4 million homes.

Regional Wind and Solar Curtailment in 2022



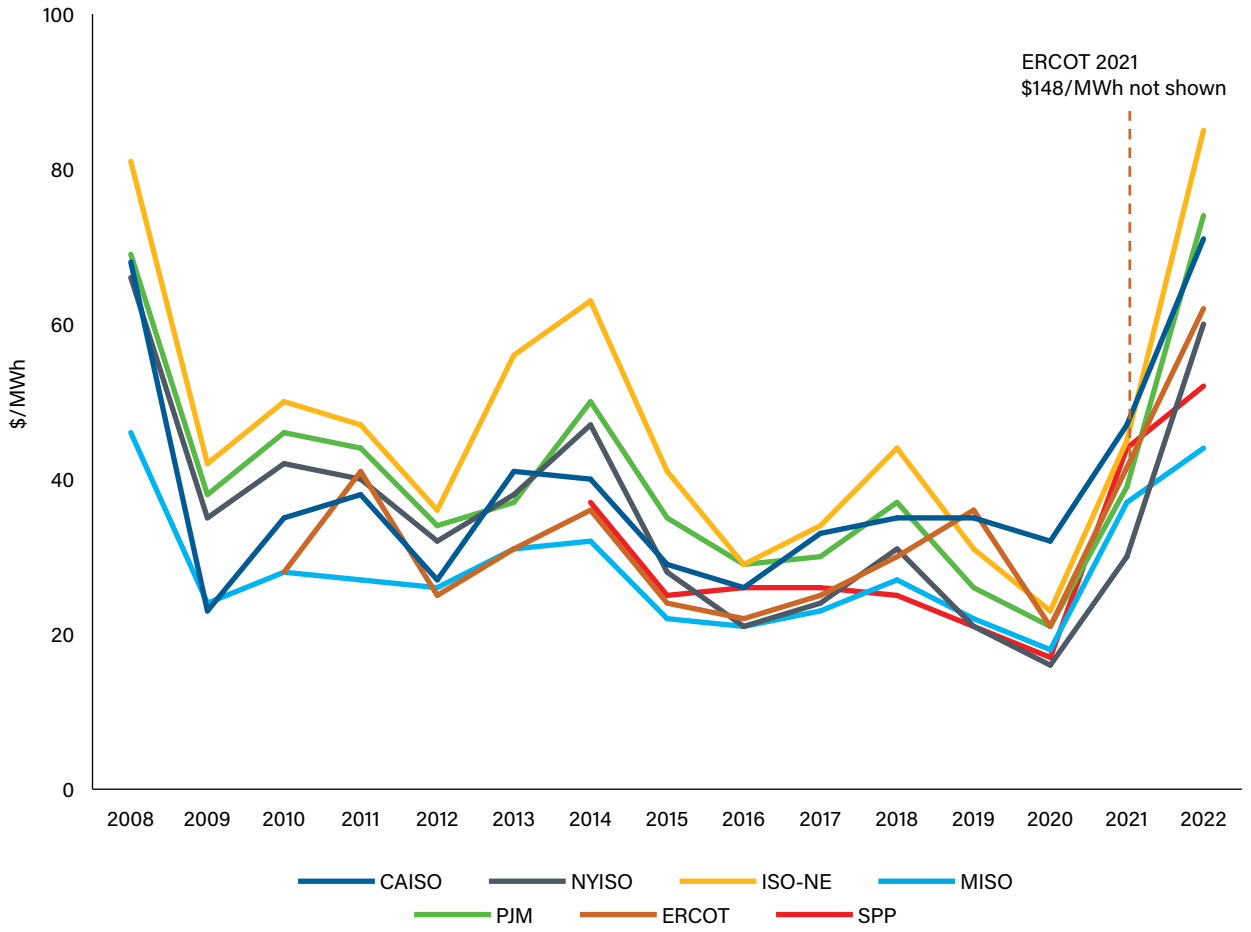
Source: ACP, RTO/ISOs

Annual Wholesale Electricity Prices

Wholesale electricity prices increased in all markets

- Wholesale power prices remain elevated after a significant increase in 2021. Across the regional markets, the average wholesale annual power price in 2022 stood at $64/MWh, up from an average of $56 in 2021. Natural gas prices remained elevated, while inflationary pressures persisted. Extreme weather events also shaped this increase. Winter storms and summer heat pushed prices high enough to affect the average for the entire year.
- Average annual wholesale power prices ranged from a low of $44/MWh in MISO to a high of $84/MWh in ISO-NE. ERCOT, the highest priced market in 2021, fell to the middle of the rank.
- NYISO experienced the largest increase, with prices soaring 102% during the year, largely influenced by higher natural gas prices. ERCOT was the only market where average annual prices fell, an artifact of the severe impact of Winter Storm Uri on 2021 prices.
- Average wholesale electricity prices are based on around-the-clock, real-time prices from a specific trading hub in each market.

Annual Wholesale Electricity Prices



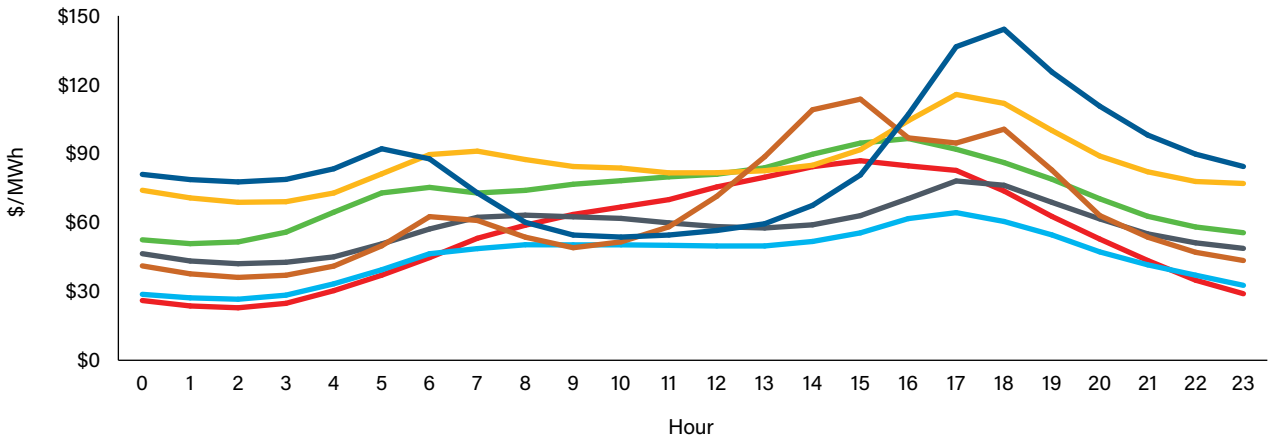
Source: S&P Global

Monthly & Hourly Wholesale Electricity Prices in 2022

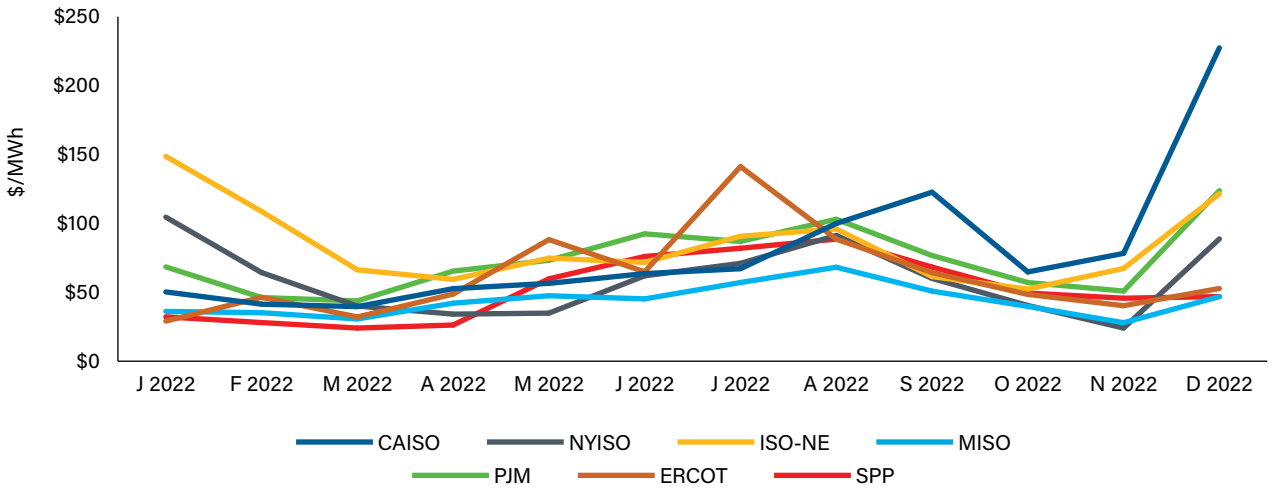
Renewables help bring down electricity costs

- Most electricity market prices follow a similar daily curve. Overnight prices are low, reflecting weak demand as most people sleep and businesses are inactive. Prices rise into the morning hours as the country wakes and commutes into work. Demand sags in the middle of the day before ramping in the evening as people return home and crank on the oven, start a load of laundry, and, increasingly, plug in their electric vehicle.
- California's evening peak is an outlier. The high penetration of solar power in the state has pushed the evening peak a few hours later. California is a leader in energy storage, which plays an important role in helping meet evening demand and supplant solar generation as the sun goes down.
- Electricity prices also vary seasonally. In parts of the country with mild winters, summers typically have the highest prices thanks to strong demand driven, in part, by air conditioning load. In northern climates like New England, power prices are generally higher in the winter. On average though, August typically experiences the highest monthly prices.
- Since renewable energy projects have zero fuel cost, they are typically the first source to be dispatched. When generating electricity, wind and solar projects displace more expensive fossil fuel generations, helping to bring down electricity costs.

Average Hourly Prices, by RTO



Average Monthly Prices, by RTO



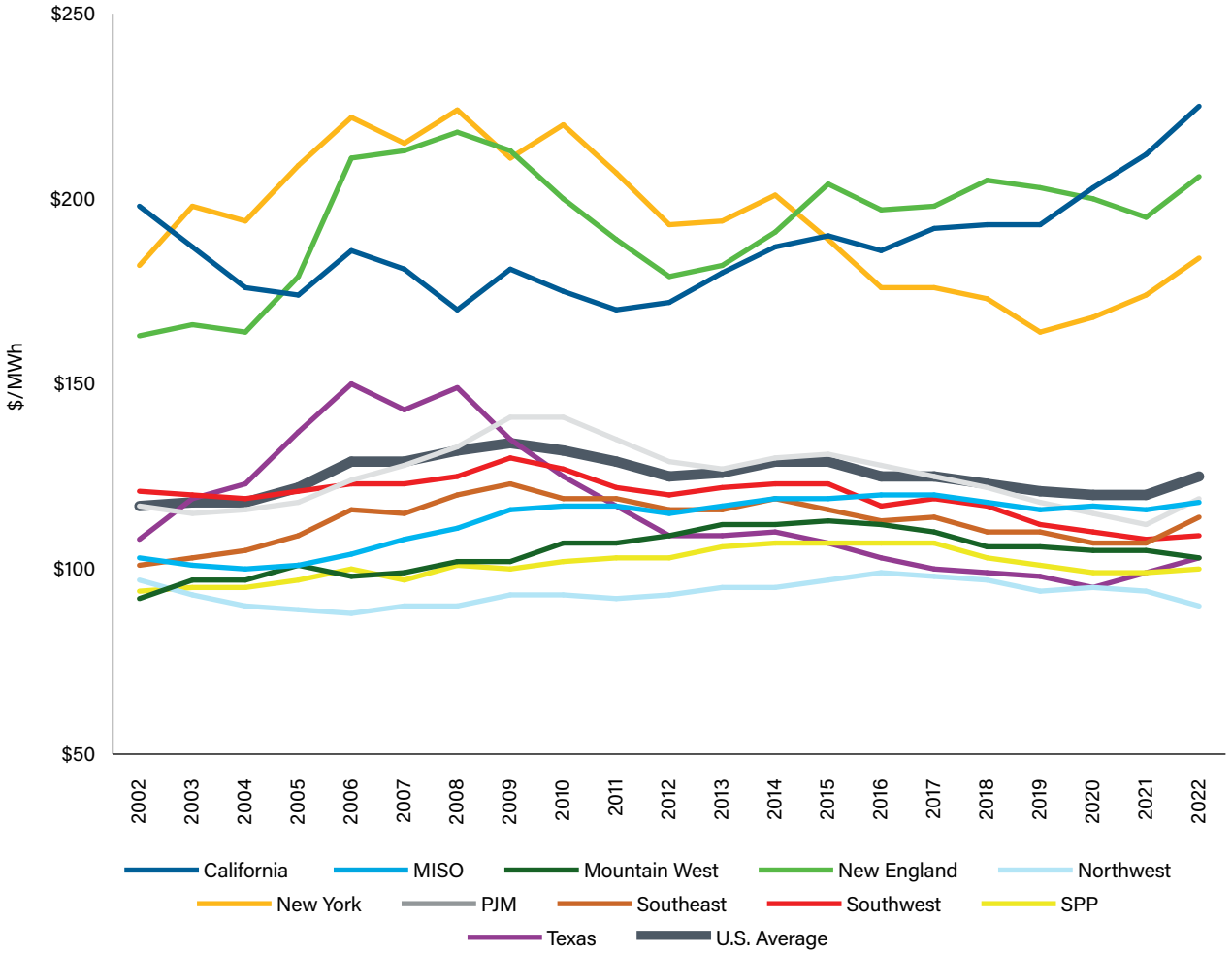
Source: S&P Global

Regional Retail Electricity Prices

Retail prices rise for second year in a row

- Retail rates did not experience the same magnitude increase as wholesale power prices, but they were up in every region except for the Mountain West and the Northwest. Fixed contracts and regulated rates helped to mitigate more significant increases.
- Across the country, retail rates rose at a moderate rate of 3%, on average.
- Southeastern ratepayers witnessed the largest price increases, relatively, as rates grew 7% in 2022. Higher natural gas prices drove most of the advance.
- California, PJM, New England, and New York customers all experienced a 6% increase in retail rates. Natural gas, the largest source of power in these regions, averaged $6.45 per million BTUs in 2022.
- California had the highest average rate at $225/MWh, followed by New England ($206/MWh) and New York ($184/MWh). The Northwest with its abundance of low-cost hydro had the lowest average rates at $90/MWh. The Mountain West, SPP, and Texas were right behind at $100/MWh.

Average Retail Electricity Prices, by Region



Source: S&P Global

U.S. Clean Power Policy

AMERICAN CLEAN POWER

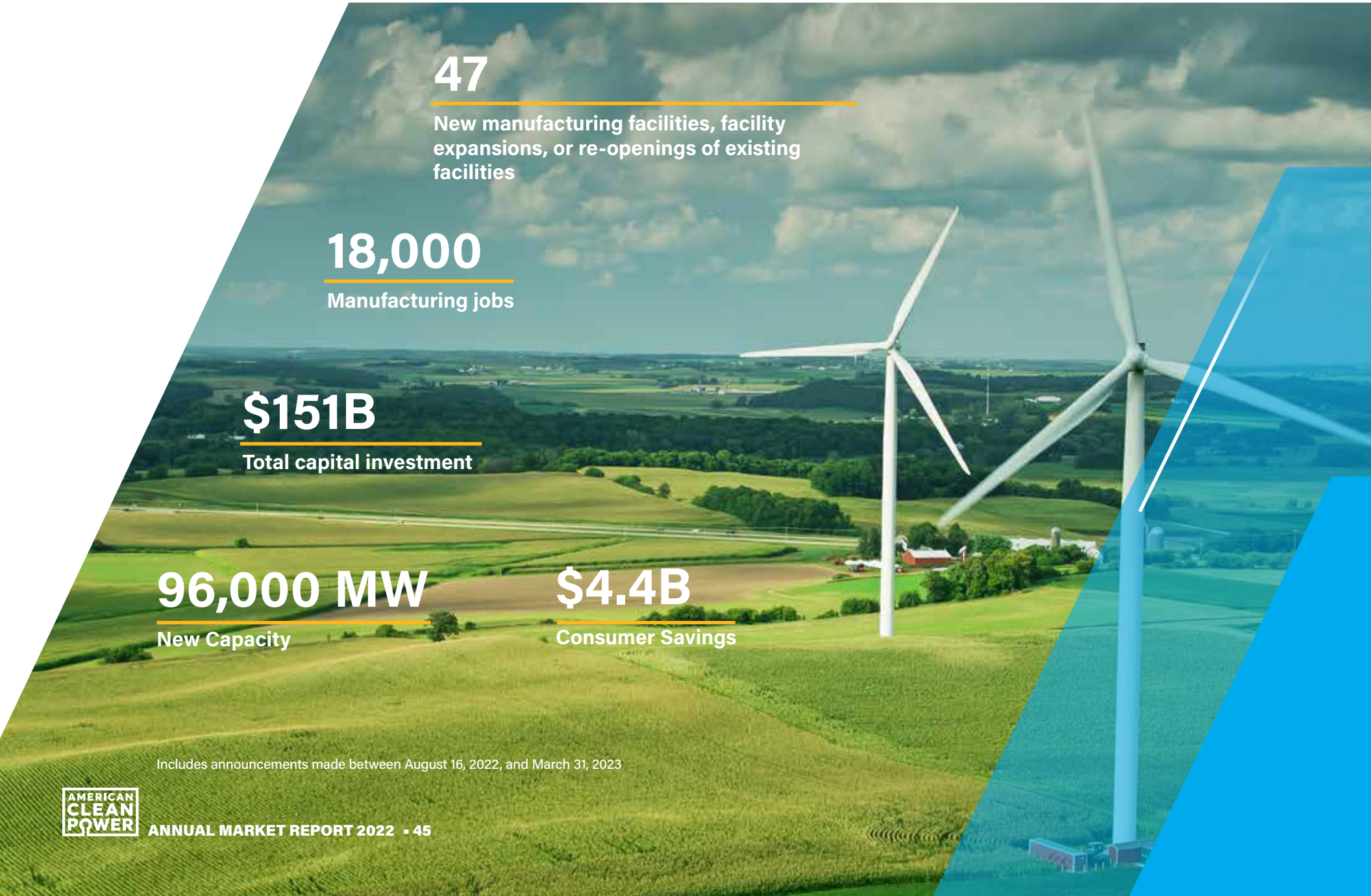
ANNUAL MARKET REPORT 2022

U.S. Clean Power Policy Highlights

- In August 2022, congress signed into law the IRA, representing the single largest investment in renewable power in the history of the U.S., and the largest investment in climate action to date.
- ACP's preliminary assessment of the IRA is that its policies will deliver an estimated 525 to 550 gigawatts (GW) of new, utility-scale clean power from 2022-2030. As a result, we now expect there will be roughly 750 GW of operating clean power capacity in 2030.
- Since the passage of the IRA through the first quarter of 2023, the U.S. utility-scale clean energy industry has announced 47 new manufacturing facilities, expansions, or reopenings that will support 18,000 jobs. Additionally, over $150 billion in domestic utility-scale clean energy investments have been announced.

Clean Energy Investment in America

Since August 16, 2022, the U.S. utility-scale clean energy industry has announced:



47

New manufacturing facilities, facility expansions, or re-openings of existing facilities

18,000

Manufacturing jobs

$151B

Total capital investment

96,000 MW

New Capacity

$4.4B

Consumer Savings

Includes announcements made between August 16, 2022, and March 31, 2023

Clean Power Policy Impact

Passage of an unprecedented national commitment to clean power – the Inflation Reduction Act

Signed into law on August 16th, the Inflation Reduction Act represents the single largest investment in renewable power in the history of this country, and the largest investment in climate action to date.

The bill extends the production tax credit and investment tax credit for wind and solar through 2024 before transitioning to a technology-neutral tax credit that will remain in place until 2032 or when electric-sector emissions fall to 75% of 2022 levels, whichever is later. Energy storage, for the first time, is made eligible to qualify for the investment tax credit, while domestic manufacturing of clean energy components is incentivized through component-specific production tax credits and an expansion of the 48(c) advanced manufacturing tax credit. ACP's preliminary assessment of the IRA is that its policies will deliver an estimated 525 to 550 gigawatts (GW) of new, utility-scale clean power from 2022-2030. As a result, we now expect there will be roughly 750 GW of operating clean power capacity in 2030. With stable policies in place, we expect annual wind, solar, and energy storage capacity installations to grow to over 90 GW by the end of the decade, more than tripling the 28 GW installed in 2021.

It is anticipated that the implementation of the IRA's regulations will accelerate the rate of clean energy installations throughout the decade. By mid-decade, it is projected that annual installations will exceed 50 GW, and they will continue to increase to more than 90 GW by the end of the decade. For comparison, the average industry forecast under business-as-usual circumstances predicts that the most productive year will generate just under 50 GW, resulting in a total addition of 335 GW to clean energy capacity.

Building 525 to 550 GW of new clean power capacity will generate $550 to $600 billion in capital investment. More broadly, construction of these projects is expected to generate over $900 billion in economic activity and add nearly $500 billion to U.S. GDP across the decade. After construction, ongoing maintenance and operations will contribute over $14 billion to U.S. GDP each year while generating nearly $29 billion in annual economic activity.

The Inflation Reduction Act *(continued)*

Investment Tax Credit
Wind, solar, energy storage

- Credits available for 30% of project cost
- Phase-out begins in latter of 2032 or when emissions fall to 75% of 2022 levels
- Projects must meet prevailing wage and apprenticeship requirements

Production Tax Credit
for renewable or zero-carbon electricity

- Available for the first 10 years of asset operating life
- $27.50/MWh for wind and solar
- Phase-out begins in latter of 2032 or when emissions fall to 75% of 2022 levels
- Projects must meet prevailing wage and apprenticeship requirements

PTC & ITC Bonus Credits

ENERGY COMMUNITIES
10% bonus for projects located on brownfield sites or fossil fuel communities with high unemployment

DOMESTIC CONTENT
10% bonus for meeting certain domestic content requirements

LOW-INCOME COMMUNITIES
10% bonus for projects <5 MW located in low-income communities or on tribal lands

Bonus credits are stackable

Manufacturing Credits
PTC for specific solar, wind, and battery storage components

Clean Hydrogen PTC
Up to $3 per kilogram depending on carbon intensity. Available for first 10 years of operating life

Transferability
Monetization of tax credits is enabled by allowing entities to sell the credits to unrelated parties

$5 BILLION
to DOE to support retooling and repowering of generation and transmission facilities

$2 BILLION
to DOE for loans financing transmission projects of national interest

$760 MILLION
to DOE for state grants targeting transmission line siting

$395 MILLION
across DOE, FERC, DOI, and NOAA to hire personnel to permit projects

$100 MILLION
to DOE to study interregional and offshore wind transmission

OCSLA extended to U.S. territories for offshore wind

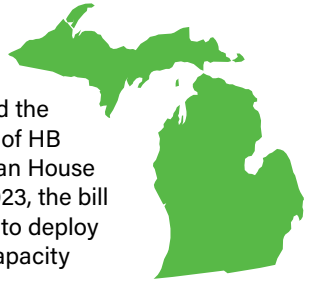
U.S. Clean Power Policy

State Policy Highlights

Illinois

Governor J.B. Pritzker signed into law the Illinois Siting and Permitting Reform Bill in January 2023. The law blocks county governments in Illinois from enacting ordinances that would serve as an outright ban on clean power projects. The law also sets standards for zoning and siting, preventing local governments from putting in place overly restrictive standards for wind and solar projects.

Michigan



Governor Gretchen Whitmer announced the MI Healthy Climate Plan, which established the framework for the introduction of HB 4256. Introduced in the Michigan House of Representatives in March 2023, the bill establishes a goal for the state to deploy 2,500 MW of battery storage capacity by 2029.

Indiana

The Indiana General Assembly passed SB 411 in March. The bill established siting standards that county governments could adopt on a voluntary basis. Adopting the standards would designate the county as a wind or solar-ready community.

California

The state of California took major strides in 2022 to advance the clean energy transition. The state capitalized on a historic budget surplus to pass a five-year climate package, authorizing $54 billion to commercialize critical clean power technologies such as long-duration storage and green hydrogen. Governor Gavin Newsom spearheaded an effort in the final month of the legislative session to codify the state's goal to reach net-zero emissions by 2045 as well as to accelerate California's zero-carbon electricity targets.

New York

In December 2022, the State of New York's Climate Action Council adopted the Climate Scoping Plan in order to implement the 2019 Climate Leadership and Community Protection Act. The Scoping Plan outlined an ambitious roadmap to help the state meet its goals to generate 70% of electricity from renewable sources by 2030 and 100% of power from zero-emissions sources by 2040. The plan would lead to a significant reduction in emissions and prime the state for the energy transition.

Massachusetts

In August 2022, Governor Charlie Baker signed into law H 5060, also known as the omnibus climate bill. The law, titled An Act Driving Clean Energy and Offshore Wind, contains provisions that would decarbonize the state's economy, encourage the deployment of clean energy, and codify Massachusetts' goal to procure 5,600 MW of offshore wind energy by 2030.

New Jersey

Governor Phil Murphy issued Executive Order No. 307 in September 2022, raising the State's offshore wind energy goal from 7,500 MW to 11,000 MW by 2040. The Executive Order also instructed the New Jersey Board of Public Utilities to conduct a feasibility study on increasing the offshore wind target, signalling that the target may expand again in the future.

Maryland

The Maryland General Assembly passed the Climate Solutions Now Act of 2022 in April 2022. The law established ambitious goals to cut greenhouse gas emissions by 60% by 2031 and to reach net-zero greenhouse gas emissions by 2045.

Clean Power + Transmission

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Clean Power + Transmission Highlights

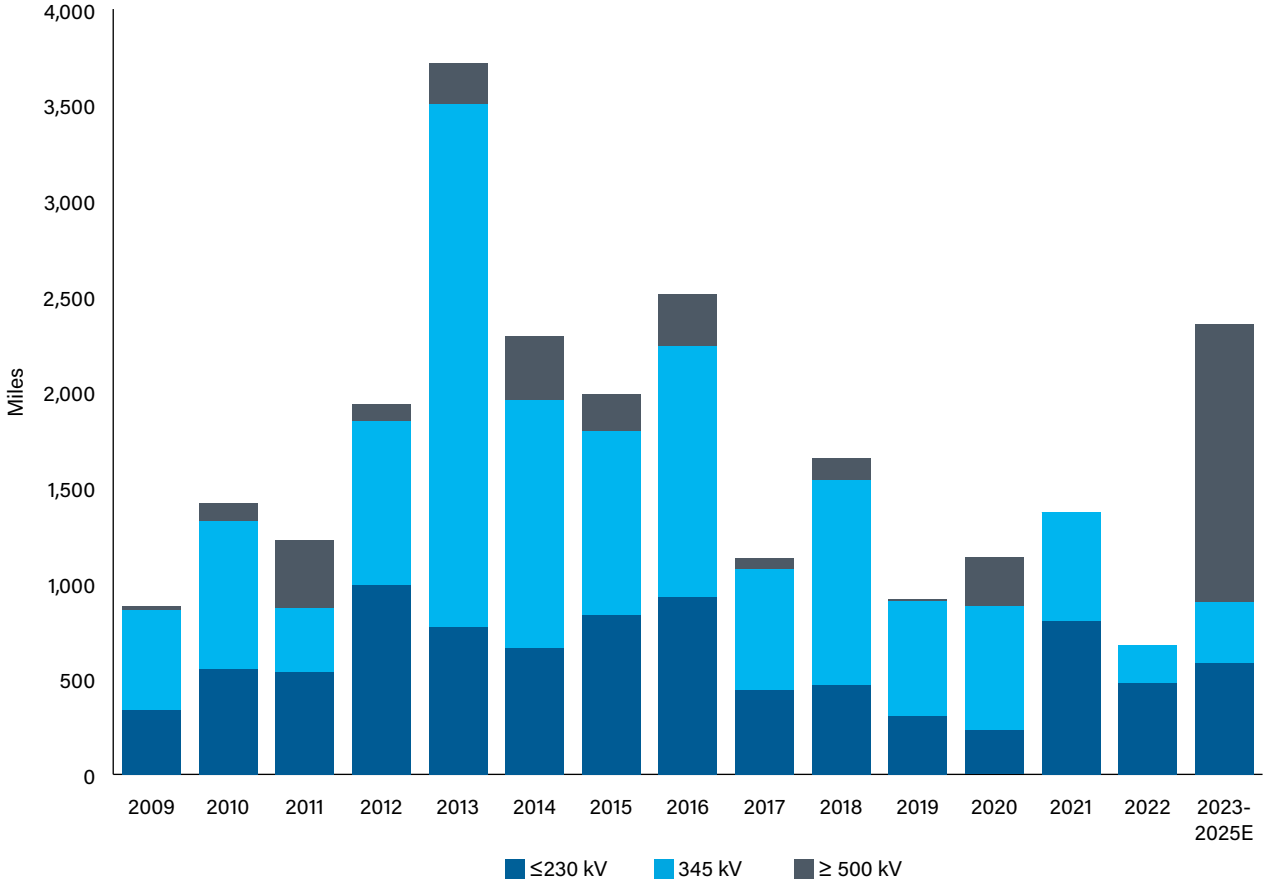
- In 2022, utilities and independent transmission developers added just 675 miles of new transmission. This is a 50% reduction from 2021 installation volumes and marks the fewest miles built in the decade.
- There are 23 major high voltage transmission lines in development totaling nearly 9,500 miles. Many of these transmission projects are being developed with the goal of connecting more renewable capacity to the grid and could support more than 41 GW of new capacity.
- Solar and hybrid projects are dominating interconnection queues. Hybrid projects make up more than a third of interconnection queues, while solar accounts for more than 25%.

Miles of Transmission Completed in the U.S.

Transmission installations reaches low point as permitting delays persist

- In the past decade, the electricity industry has deployed over 17,000 miles of transmission lines, including 11,500 miles of 345 kilovolt (kV) or greater capacity lines, to deliver generation to market and maintain grid reliability. Deployment peaked in 2013 before steadily declining over the rest of the decade.
- In 2022, utilities and independent transmission developers added just 675 miles of new transmission. This is a 50% reduction from 2021 installation volumes and marks the fewest miles built in the decade.
- Looking forward, FERC is tracking 2,350 miles of transmission projects that have a high probability of commissioning in the next three years. These projects are concentrated in MISO and WECC.
- Transmission is critical to maintain a reliable electricity grid and to more efficiently and effectively integrate renewable energy resources. Recent transmission additions are not adequate to enable the clean energy transition.

Miles of Transmission Projects Completed

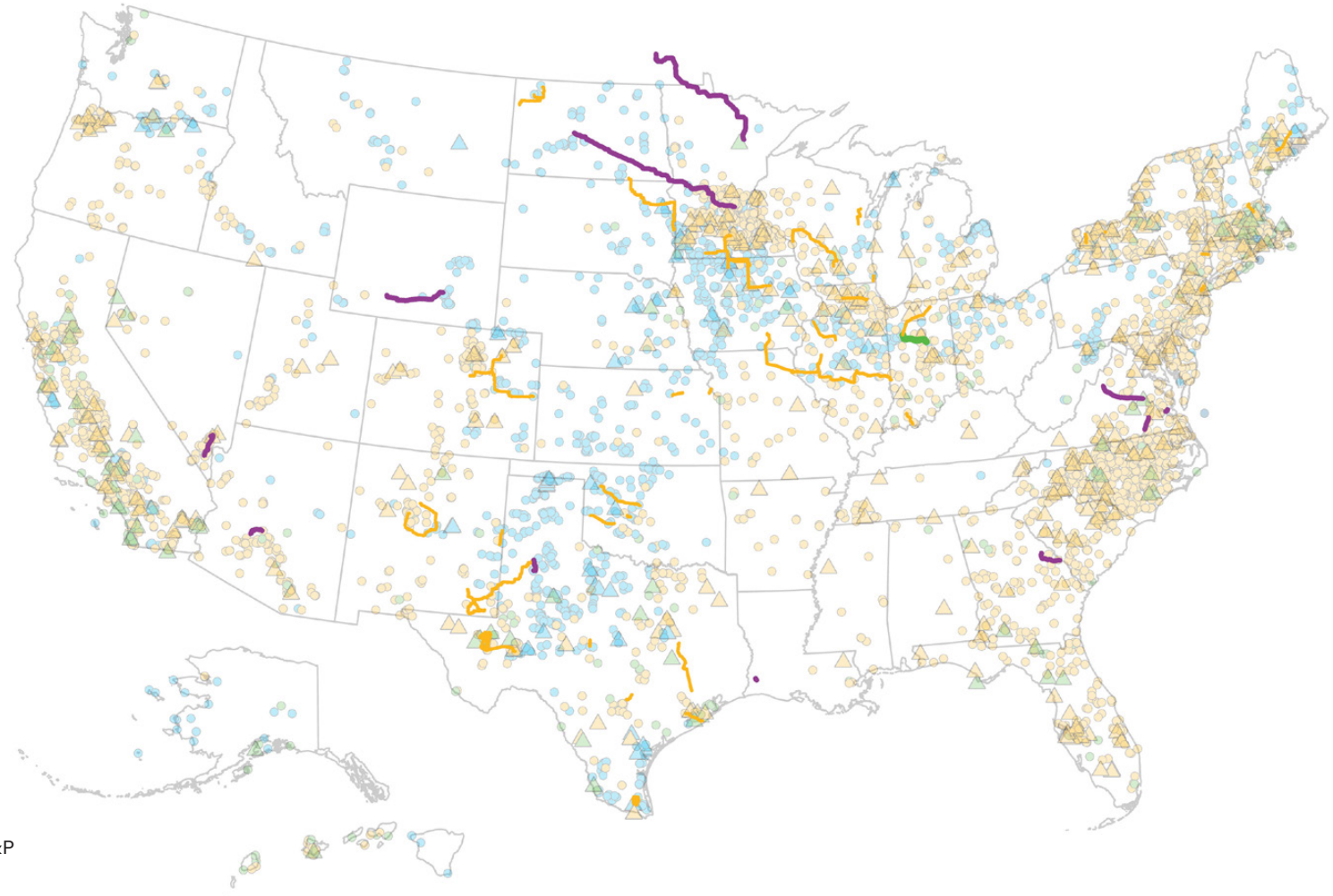


Source: FERC

Clean Power Projects and Transmission Built Since 2017

Only 675 miles of high-voltage transmission lines delivered across the U.S. in 2022—a record low

High-Voltage Transmission Lines Built 2017-2022



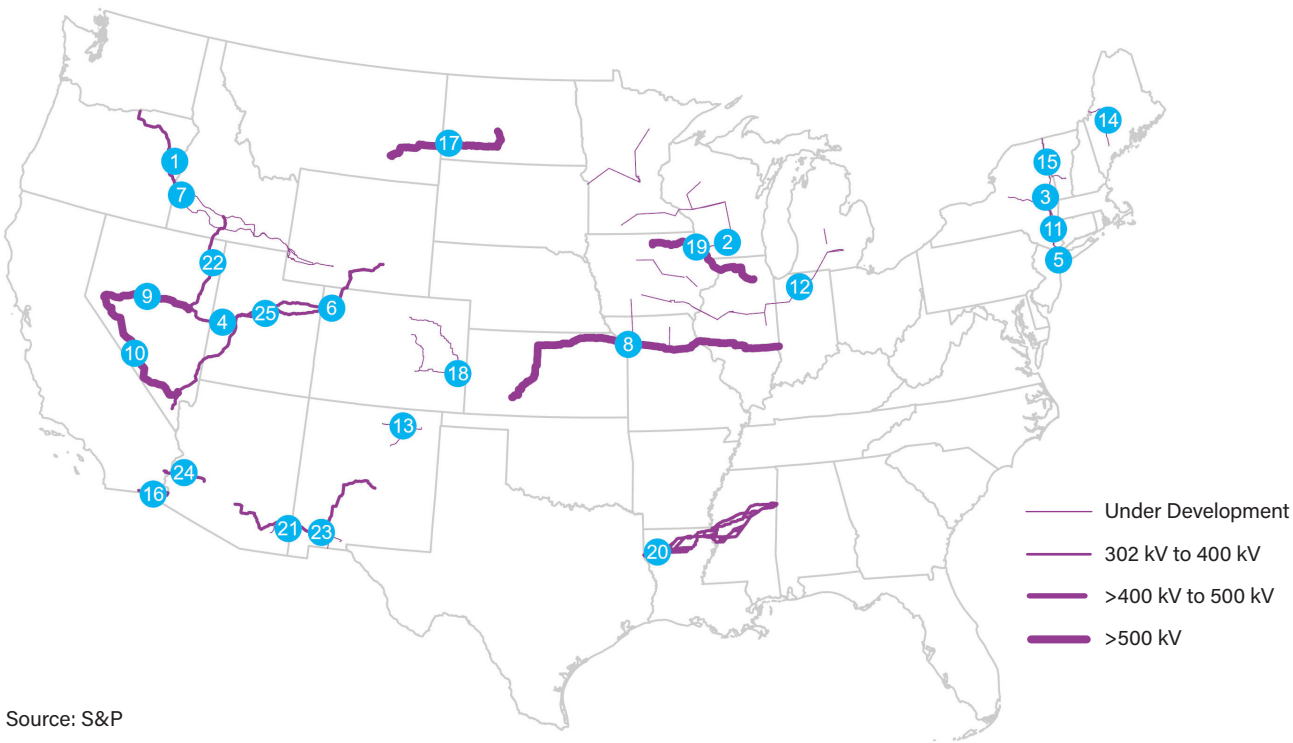
Source: S&P

Transmission Development Activity

There are over 9,000 miles of high voltage transmission lines in development across the U.S.

- High voltage (≥320 kV) transmission lines in development total 9,488 miles across 25 major projects.
- Many of these transmission projects are being developed with the goal of connecting more renewable capacity to the grid. The high voltage projects shown in the map could support over 41.2 GW of new capacity.
- For example, the SOO Green HVDC project, a proposed 350-mile 525 kV line, seeks to connect renewable resources in MISO with electricity customers in PJM. Similarly, the Grain Belt Express project would deliver renewable energy generated in Kansas to neighboring power pools that serve consumers in Missouri, Illinois, Indiana, and elsewhere across the Midwest. This would allow for greater transmission between pools, improving reliability.

High Voltage Projects Under Development



Source: S&P

Label	Project	Voltage (kV)	Miles
1	Boardman-Hemingway	500	290
2	Cardinal-Hickory Creek	345	102
3	Champlain-Hudson Power Express HVDC	345	339
4	Cross-Tie	500	214
5	Empire State Connector HVDC	320	265
6	Gateway South	500	416
7	Gateway West	500	790
8	Grain Belt Express	600	780
9	Greenlink North	525	235
10	Greenlink West	525	350
11	Knickerbocker-Pleasant Valley	345	54
12	LRTP Tranche 1	345	2,123
13	Lucky Corridor	345	179

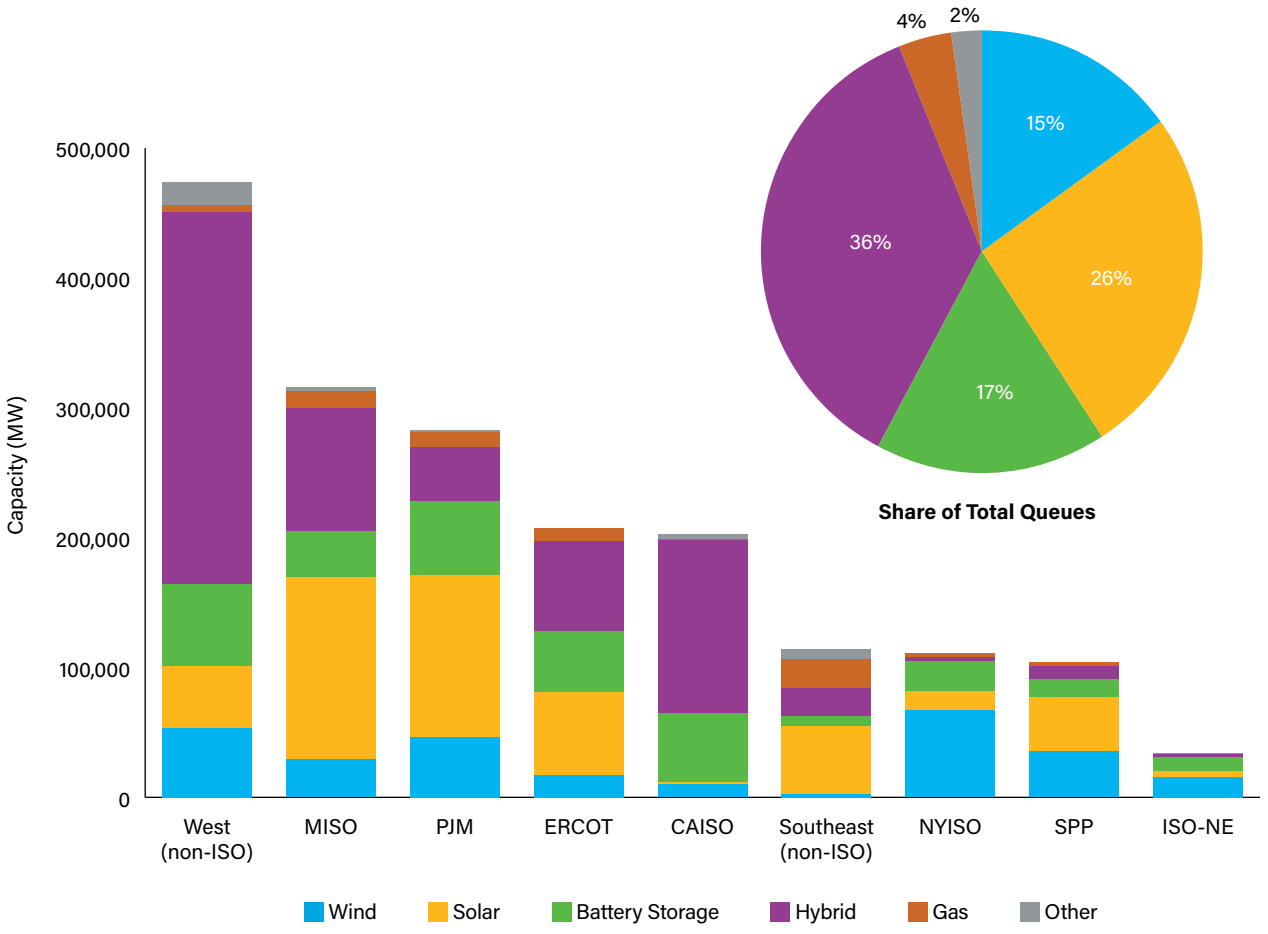
Label	Project	Voltage (kV)	Miles
14	New England Clean Energy Connect	320	145
15	New England Clean Power Link	320	152
16	North Gila-Imperial Valley #2 Green Path	500	90
17	North Plains Connector	600	385
18	Power Pathway	345	560
19	SOO Green Renewable Rail HVDC	525	350
20	Southern Spirit	500	400
21	Southline	345	275
22	Southwest Intertie	500	275
23	SunZia	500	550
24	Ten West Link	500	125
25	TransWest Express HVDC	500	405

Interconnection Queues

Hybrid and standalone solar projects continue to dominate the queues

- Interconnection queues are essentially a waiting list of proposed power projects seeking a grid connection in the coming months and years. While most projects that apply for interconnection are not subsequently built, data from these queues provides a good general indicator for mid-term trends in market, developer, and investor interest.
- Hybrid projects make up 36% of all capacity in interconnection queues across the U.S., while standalone solar projects represent roughly 26%. Solar combined with battery storage makes up roughly 85% of hybrid projects in the queues.
- Hybrid solar plus battery projects represent nearly 57% of capacity in the CAISO queue. This is most likely driven by the fact that California already has a high solar penetration rate and developers are seeking to shift electricity generated by solar to other periods of the day.
- Standalone solar makes up about 44% of capacity in both PJM and MISO's queue. Wind makes up the majority of the queue in NYISO and ISO-NE, primarily due to offshore wind projects.

Interconnection Queue Backlog



Source: LBNL

Clean Power Development and Ownership

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Clean Power Devopment and Ownership Highlights

- The top five owners of clean power in operation, ranked by capacity, remained consistent with 2021: NextEra Energy (34 GW), Berkshire Hathaway Energy (14 GW), Avangrid (8 GW), Enel (6 GW), and Clearway (6 GW). NextEra leads as the top owner across wind, solar, and battery storage.

- In 2022, NextEra, Ørsted, and American Electric Power led the nation in installing the most new clean power capacity. Together, the top 10 owners account for half of the capacity that was installed in 2022. Overall, more than 160 companies commissioned new projects in 2022.

- The development pipeline consists of projects that are either in advanced stages of development or currently under construction. ACP defines advanced development as projects that are not yet under construction but have secured a power purchase agreement (PPA), firm equipment order, or plans for utility ownership in place. This perspective on the pipeline offers valuable insight into the expected growth of clean power in the coming years. NextEra, Invenergy, and Ørsted lead the developer rankings with the most clean power in development.

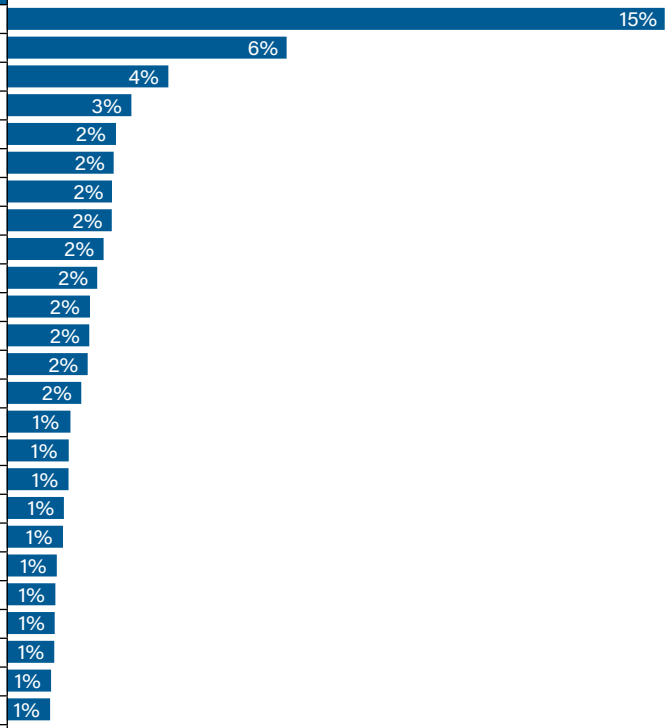
- 3.7 GW of operating clean power projects changed hands in 2022, a significant decrease from previous years. Wind accounted for 58% of acquisitions, solar 41%, and battery storage the remaining 1%.

Cumulative Clean Power Ownership

NextEra owns more than twice as much clean power as any other company

Cumulative U.S. Clean Power Capacity Ownership Market Share

Rank	Company	Wind	Solar	Storage	Total Capacity
1	NextEra Energy Inc.	23,097	8,812	1,789	33,698
2	Berkshire Hathaway Energy	12,530	1,755	13	14,298
3	Avangrid	7,966	264	0	8,230
4	Enel Green Power	5,345	937	51	6,333
5	Clearway	3,694	1,827	22	5,543
6	RWE Renewables Americas	5,029	325	70	5,424
7	EDP Renewables North America	5,083	254	0	5,337
8	Duke Energy	2,169	3,063	95	5,327
9	AES	1,718	2,806	383	4,907
10	Xcel Energy	4,577	1	1	4,580
11	Ørsted	3,043	1,125	40	4,208
12	ENGIE North America	2,915	1,253	4	4,172
13	Southern Company	2,375	1,657	58	4,090
14	EDF Renewables	3,047	632	83	3,761
15	Invenergy	2,448	634	125	3,206
16	American Electric Power Co.	2,802	298	19	3,119
17	Consolidated Edison Inc.	339	2,764	5	3,108
18	Pattern Energy	2,789	81	0	2,870
19	Brookfield Asset Management	2,162	629	32	2,823
20	Capital Dynamics	382	1,908	143	2,433
21	Dominion Energy	12	2,370	16	2,398
22	Energy Capital Partners	994	724	657	2,375
23	BP	1,017	1,189	6	2,212
24	Leeward Renewable Energy	2,013	129	20	2,162
25	WEC Energy Group	1,687	429	0	2,116
	Other	128,617	38,709	5,472	89,121

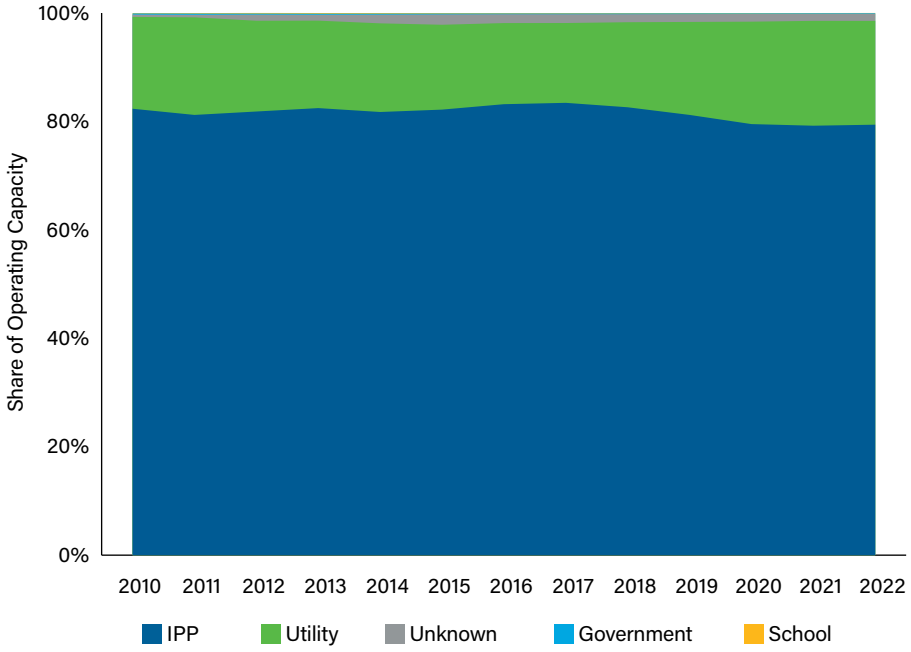


- The top 25 owners of clean power own 61% of total operating clean power. The remaining 89 GW is spread across more than 1,000 different entities.
- NextEra accounts for 15% of operating capacity, owning more than twice as much clean power as any other company across its regulated and non-regulated businesses. Berkshire Hathaway Energy ranks second with more than 14 GW of owned capacity operating, primarily under its utility subsidiaries. Avangrid rounds out the top three with more than 8 GW online.
- Most of the leading clean power stakeholders possess greater wind capacity than solar. Nonetheless, there exist six firms with portfolios that are predominantly solar-powered. Among these, Dominion Energy is the most solar-oriented, with 99% of its operating capacity derived from solar energy.
- Energy Capital Partners' portfolio has the largest battery storage share of the top 25 companies shown here. Battery storage makes up 30% of the operating clean power capacity owned by Energy Capital Partners.

Owner Type over time

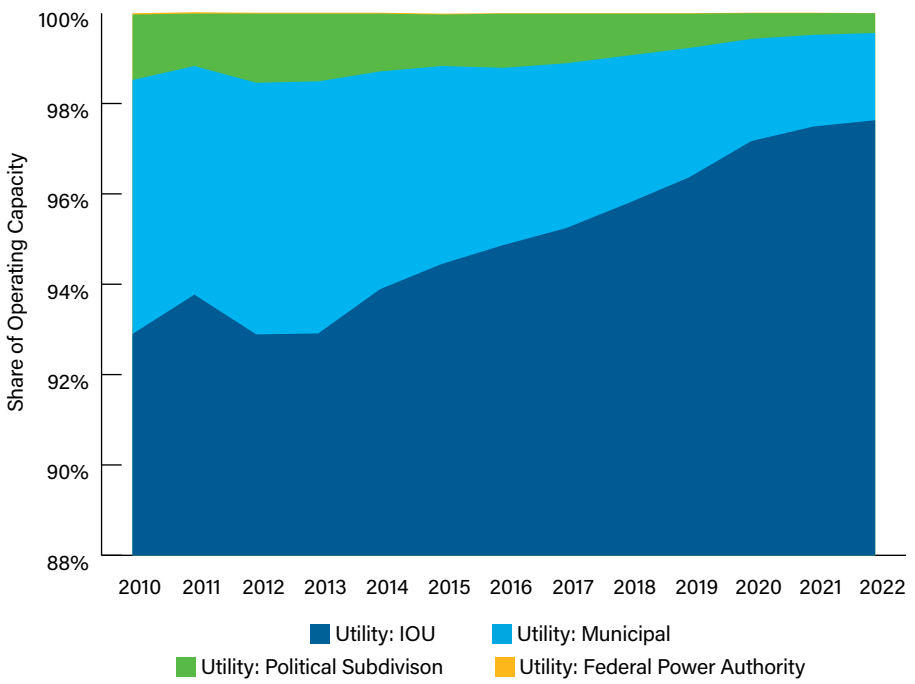
Independent Power Producers (IPPs) own dominant clean power share

Share of Operating Capacity by Owner Type



- Since 2010, utilities and IPPs have owned the largest shares of operating clean power. The relative shares of the two owner groups has remained consistent, with IPPs owning between 79% and 83% of operating power, and utilities between 15% and 19%.
- In the past three years, utility ownership share has increased slightly, reaching a high of 19%. Correspondingly IPP ownership fell to a low of 79%.

Share of Utility-Owned Operating Capacity by Utility Type

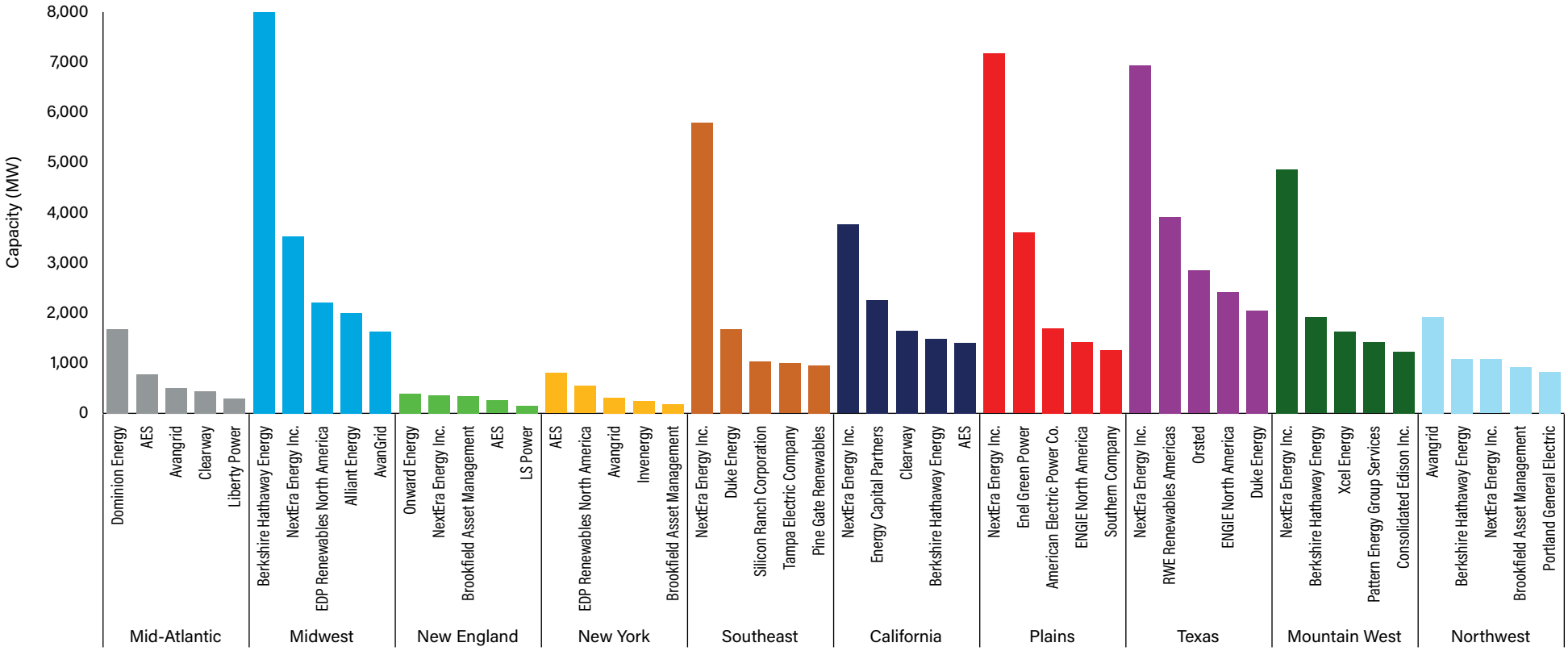


- IPPs have become an important clean power ownership group since the enactment of the U.S. Public Utility Regulatory Policies Act of 1978.
- Among utilities, investor-owned utilities (IOUs) have consistently held a significant majority of clean power ownership. In 2010, the IOU ownership share sat at 93% of utility-owned clean power, but has steadily increased in the 12 years since, reaching a peak of 97% in 2022.
- Municipal utilities have the next largest share in the utility-owned space, though the share has declined from 6% in 2010 to just 2% in 2022.

Top Regional Owners

Only nine companies rank in the top five across multiple regions

Top 5 Clean Power Owners by Region



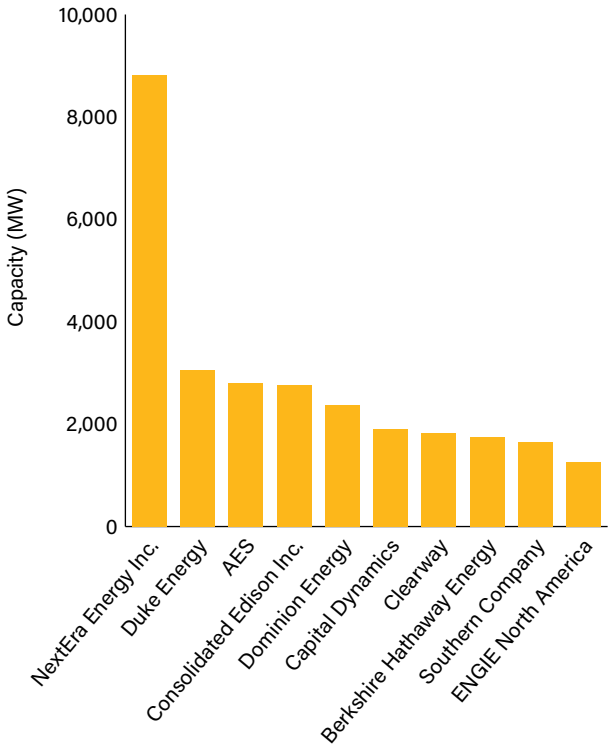
- Although some companies are present across multiple regions, there is some variation in terms of the top companies owning clean power across regions.
- NextEra Energy appears in the top five across seven regions thanks to the company's IPP subsidiary.
- AES, Avangrid, and Berkshire Hathaway Energy each rank in the top five in four regions, though Avangrid ranks just shy of the top five in two other regions.
- Almost 70% of the owners included in the chart above have clean power projects concentrated in one region and only appear once in this chart.
- Companies with wind-dominant portfolios fill the top five spots in the wind-rich Midwest and the Plains regions.

Clean Power Development and Ownership

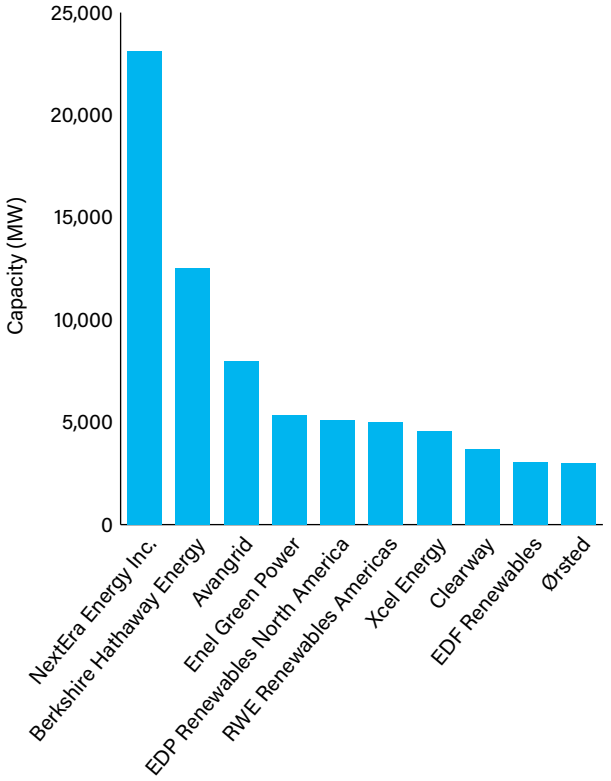
Top Owners by Technology

NextEra ranks first across all three technologies

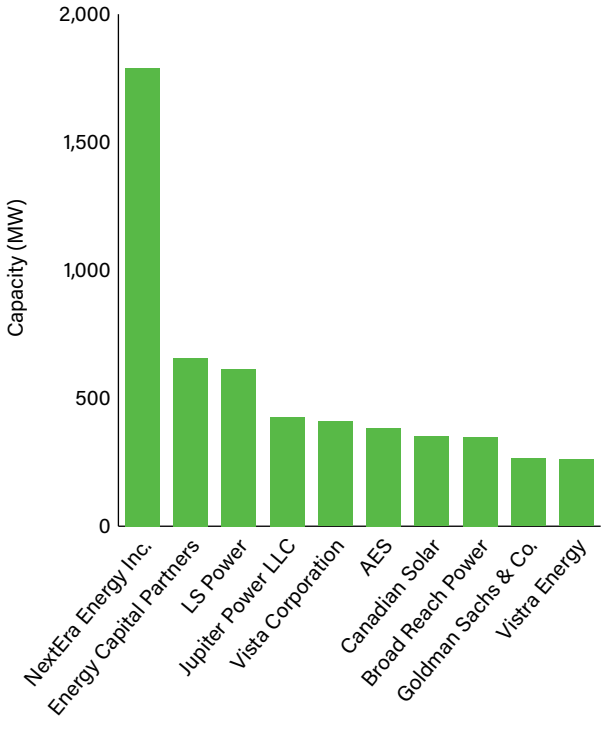
Top Solar Owners



Top Wind Owners



Top Battery Storage Owners



- In 2021, NextEra took over the top spot across wind, solar, and battery storage. The company maintained this ranking in 2022, installing new projects across all three technologies in 2022.
- In the solar space, Duke Energy ranks second after NextEra with more than 3 GW online, followed by AES at 2.8 GW.

- Long-established companies continue to lead in land-based wind ownership. Ørsted entered the top ten this year after ranking 14th in 2021.
- Many of the European companies that helped establish the U.S. wind industry, such as EDP, RWE, and Enel, continue to rank in the top ten.

- Top owners of battery storage capacity experienced the most change from 2021 after a record year for the technology in 2022.
- Canadian Solar and Goldman Sachs are new to the top ten in 2022 after each commissioning 350 MW and 140 MW of new battery storage projects in 2022, respectively.

Owners of 2022 Clean Power Additions

Half of all 2022 installations owned by the top 10 companies

U.S. Clean Power Capacity Ownership Market Share, 2022

Company	Wind	Solar	Storage	Total Capacity
NextEra Energy Inc.	2,860	1,325	547	4,732
Ørsted	681	430	0	1,111
American Electric Power Co.	996	1	9	1,007
ENGIE North America	602	351	0	953
Duke Energy	207	697	30	934
Energy Capital Partners	0	578	351	929
SB Energy	0	890	0	890
AES	67	509	264	841
RWE Renewables Americas	442	196	40	678
EDF Renewables	394	200	65	659

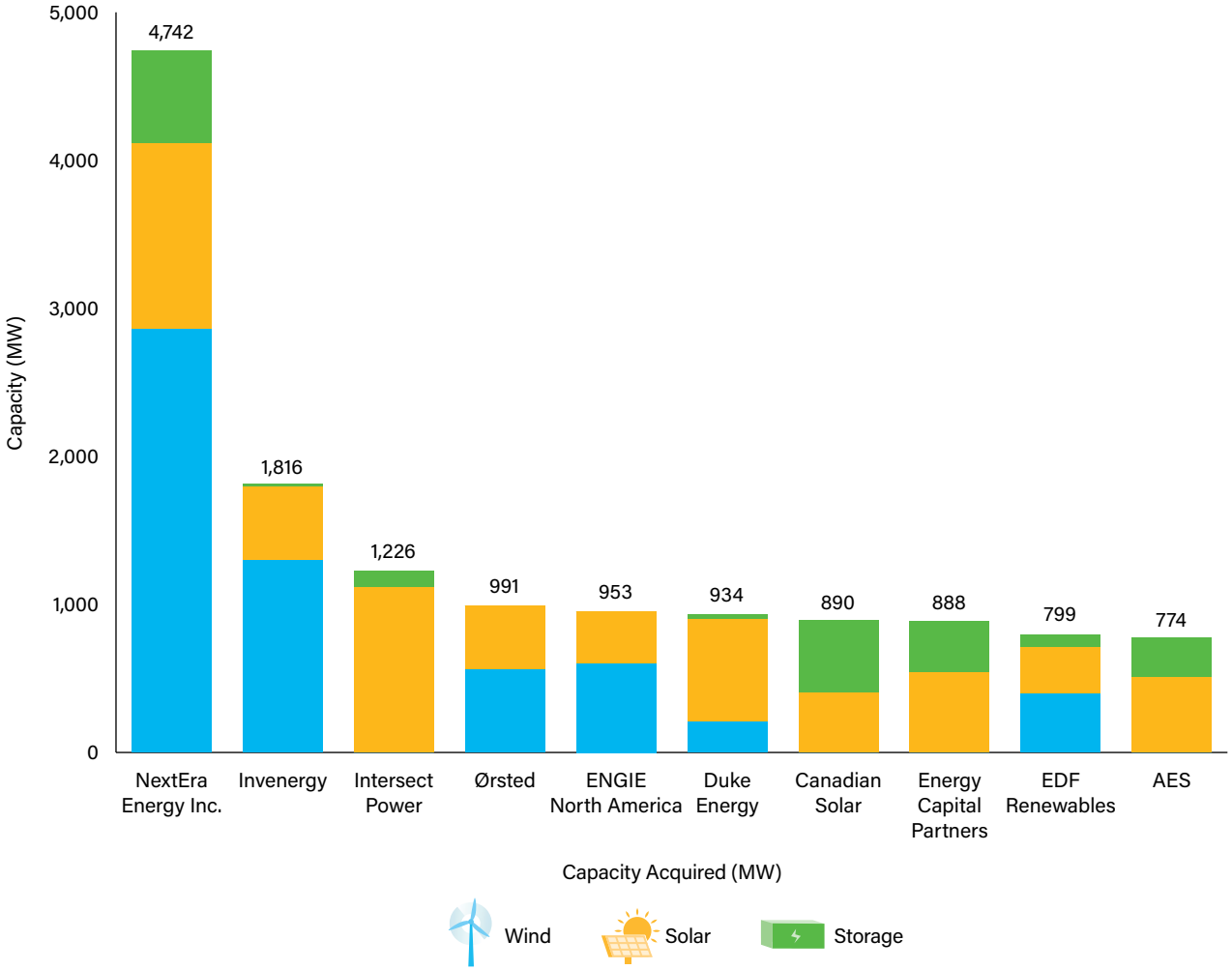
- In 2022, NextEra installed 4.7 GW of clean power, outpacing all other clean power owners by more than 3.5 GW. The majority of their installations, comprising 60% of their total annual additions, were in wind energy. This was driven in part by the successful commissioning of the Great Prairie Wind project, which added over a gigawatt to NextEra's portfolio.
- Ørsted ranks second for the year due to the commissioning four new projects in three states: Texas, Nebraska, and Illinois.
- American Electric Power rounds out the top three thanks, in large part, to the commissioning of the monumental Traverse Wind project in Oklahoma.
- Six of the top ten owners installed more wind than solar capacity, though all of them also installed solar or storage projects.
- Only two companies within the top ten, Energy Capital Partners and SB Energy, did not install any wind projects.
- Together, the top 10 owners account for half of the capacity that was installed in 2022. Overall, more than 160 companies commissioned new projects in 2022.

Top Developers of Clean Power Capacity Installed in 2022

Top ten developers account for 55% of 2022 installs

- While many companies own and develop their own projects, others rely on build-own-transfer style contracts. Therefore, the list of the top owners and developers of capacity brought online in 2022 intersect but do not fully overlap.
- NextEra develops all its own projects and in 2022 sold one of the projects the company developed as well.
- Regulated utilities, like MidAmerican, frequently utilize build-transfer contracts as a means to engage third-party developers for the construction and development of projects, which are then transferred to their ownership upon completion. This approach enables utilities and other owners of clean power projects to possess clean energy assets without having to directly oversee the development process.

Top 10 Developers of Clean Power Capacity Installed in 2022



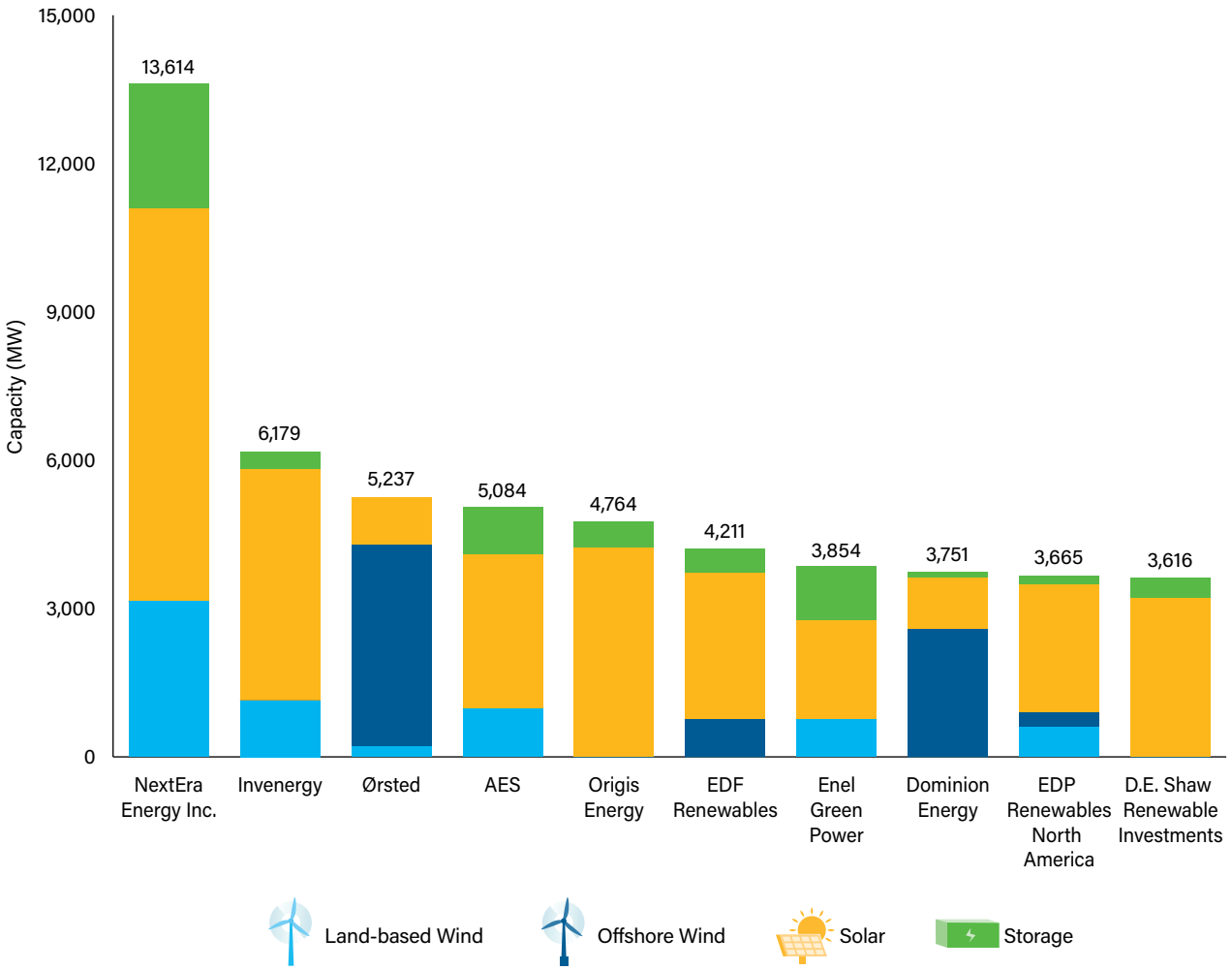
Clean Power Development and Ownership

Largest Developer Pipeline

Solar and offshore wind key technologies in development pipelines

- The development pipeline consists of projects that are either in advanced stages of development or currently under construction. ACP defines advanced development as projects that are not yet under construction but have secured a power purchase agreement (PPA), firm equipment order, or plans for utility ownership in place. This perspective on the pipeline offers valuable insight into the expected growth of clean power in the coming years.
- Solar accounts for 58% of capacity in development. Following that trend, eight out of the ten developers with the most capacity in the pipeline are developing more solar than any other technology.
- The two developers whose pipelines are not solar dominant are developing significant offshore wind projects. Ørsted has more than 4 GW of offshore wind in development, tied to seven offshore wind projects in U.S. waters. Dominion's pipeline is also offshore wind-dominant due to the Coastal Virginia Offshore Wind (CVOW) project.
- Every developer in the top ten, except for Ørsted, has battery storage capacity in development.

Top 10 Clean Power Development Pipelines, by Developer

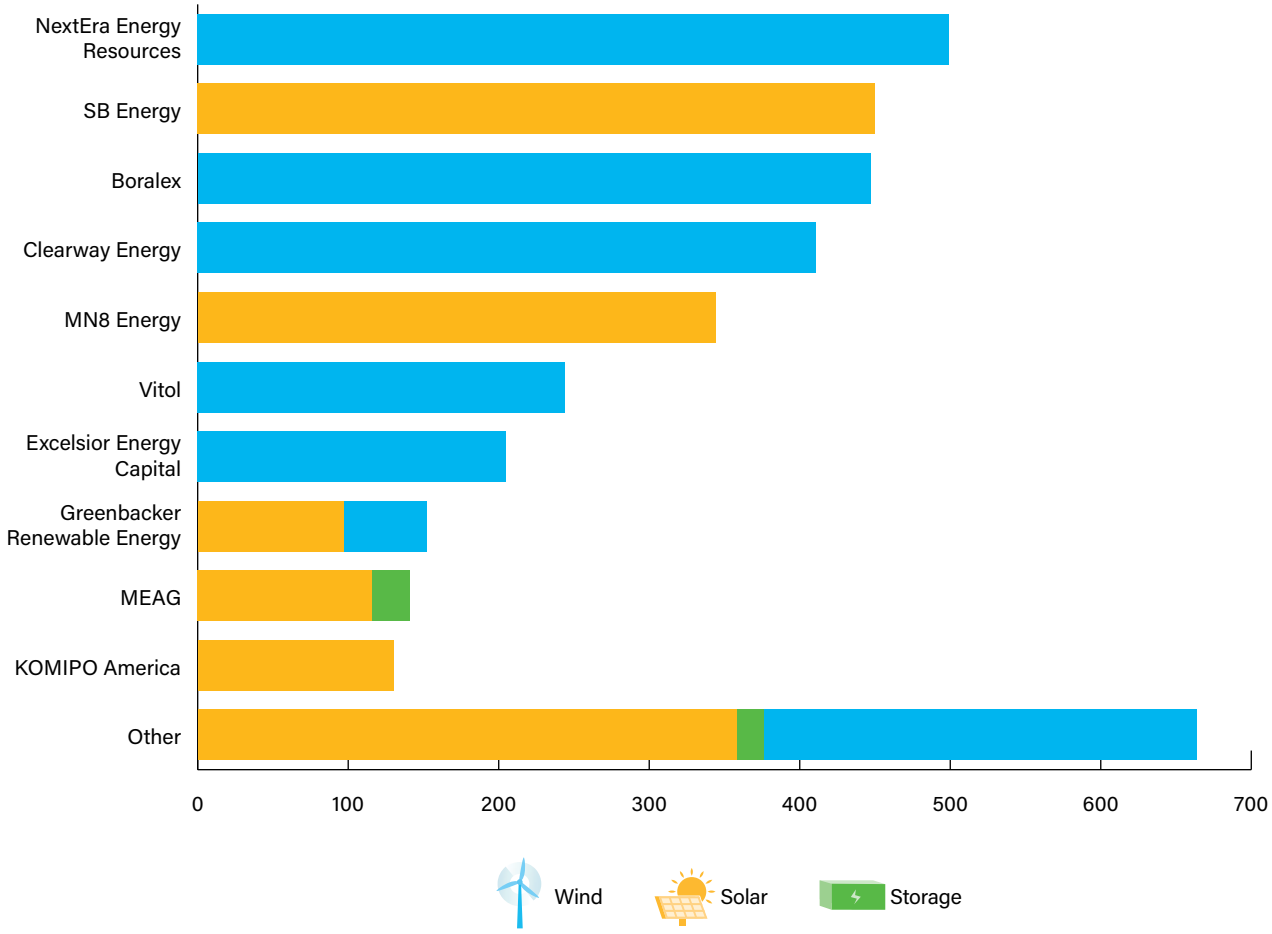


Clean Power Project Acquisitions in 2022

Nearly 4 GW of operating projects changed hands in 2022

- Acquisitions of operating projects in the U.S. decreased in 2022 compared to previous years. Approximately 3,687 MW of clean power project capacity changed ownership, down from nearly 8 GW in 2021.
- More wind projects changed hands than any other clean energy technology, accounting for 58% (2,149 MW) of acquisition activity. With 1,496 MW, solar represented 41% of acquisition activity, followed by battery storage at 1% (42 MW).
- The largest single transaction was NextEra Energy Resources' acquisition of the 499 MW Young Wind Project from Apex Clean Energy.
- In addition to project acquisitions, the clean power sector saw multiple company platform mergers/acquisitions in 2022. Brookfield Asset Management closed its $1 billion acquisition of project developer Scout Clean Energy. Under the terms of the deal, Brookfield acquired Scout's 1.2 GW portfolio of operating wind projects while Scout will continue to operate under its current name and develop its 22 GW pipeline of solar, wind, and energy storage projects.
- 2022 marked the continuation of the trend of large investment firms shifting towards clean power and its long-term revenue streams by acquiring renewable energy assets. Firms including MEAG, Greenbacker Renewable Energy, and Excelsior Energy Capital have expanded their clean power footprint with project acquisitions.

Top Companies Acquiring Operating Clean Power Assets



Clean Power Procurement

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Clean Power Procurement Highlights

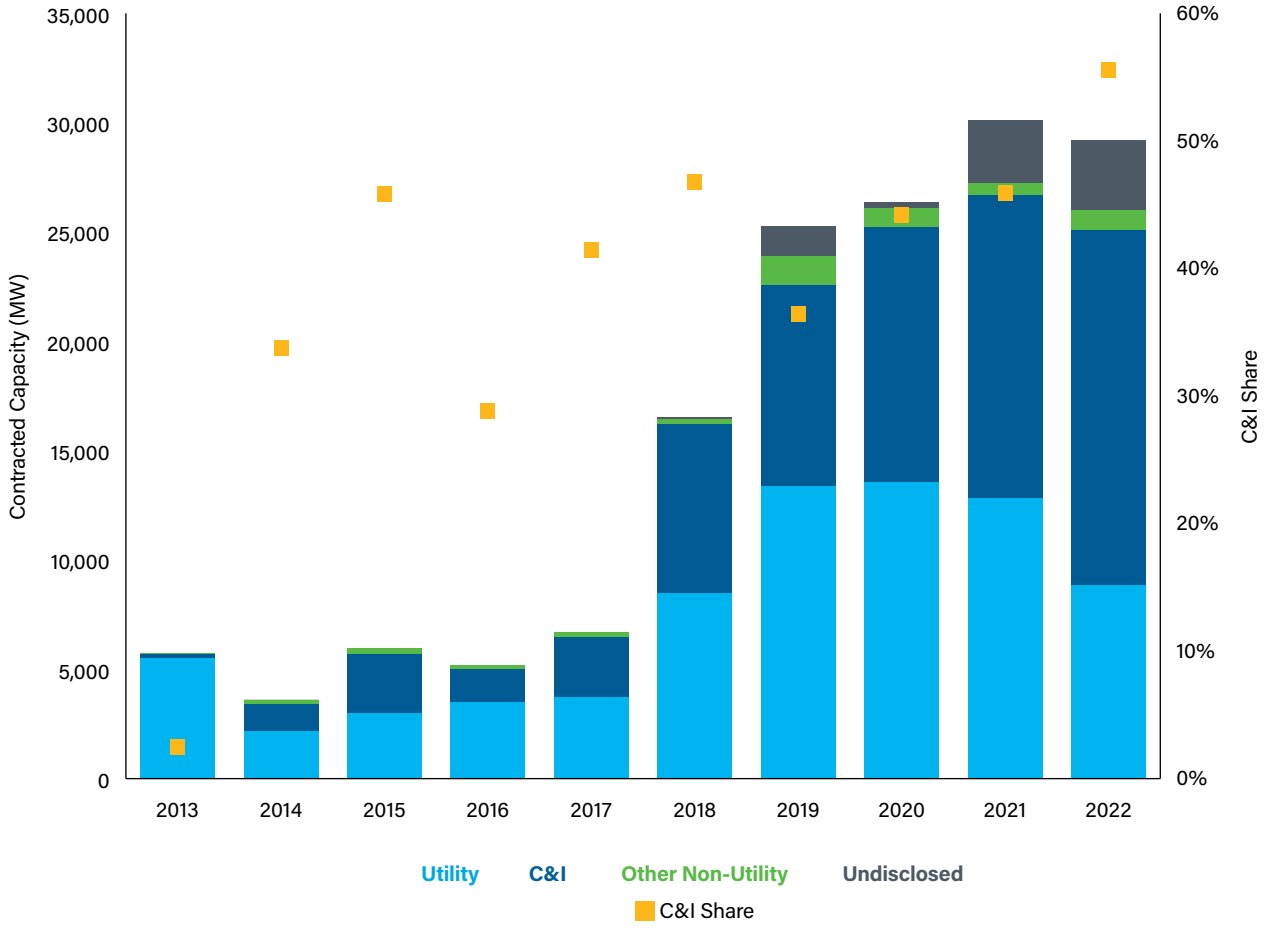
- More than 29 GW of new PPAs were announced in 2022, just shy of the record 30 GW announced in 2021. Solar made up the majority of new PPAs, though the volume of solar PPAs decreased by 1% compared to 2021. Wind PPA announcements, on the other hand, increased by 18% compared to 2021.
- Corporations are leading in new clean PPA announcements, with Amazon, Meta, and Verizon claiming the top three spots for 2022 announcements, outstripping utilities for the year.
- Utilities, specifically investor-owned utilities, maintain the top rankings in terms of operating clean power. Berkshire Hathaway Energy, Xcel Energy, and Southern California Edison have the most clean power operating on their systems and serving customers.
- Within the corporate buyer space, Amazon has contracted the most clean power to date after rapidly increasing procurement activity over the past two years. Meta and Google, who were earlier adopters of clean energy, rank second and third in terms of total operating capacity.
- Much of the C&I contracted capacity is for clean power projects still in development. Meta has the most operating clean power contracted and operating its business. Amazon ranks second for operating contracted capacity, and Google in third.

Power Purchase Agreement Announcements by Buyer Type

Corporate buyers are becoming an increasingly important clean power buyer group

- ACP monitors and analyzes the adoption of clean power offtake agreements as they are announced, as well as procurement trends for operational clean power projects. This chart displays the annual capacity of clean PPAs, categorized by the type of purchaser. It's important to note that many of the projects depicted in this chart are still in the development stage.
- Long-term PPAs have long been the dominant offtake mechanism form. The 29.2 GW of PPAs announced in 2022 falls short of the record set in 2021 by 3%. This is due to a decline in utility PPA announcements. Corporate buyers, on the other hand, set a record for PPA announcements in 2022, announcing more than 16 GW of new PPAs.
- The percentage of annual PPA announcements made by corporate buyers has fluctuated over time. In years with low overall announcement numbers, the corporate share of annual announcements is notably higher. Over the past four years, the C&I share has risen from 36% to 56% as corporations work towards sustainability goals.
- Utilities used to dominate PPA announcements, accounting for between 50% and 70% of announcements between 2014 and 2020. In recent years, the utility share has dropped, reaching a low of 30% in 2022.

Power Purchase Agreements Signed Over Time, by Power Purchaser Type



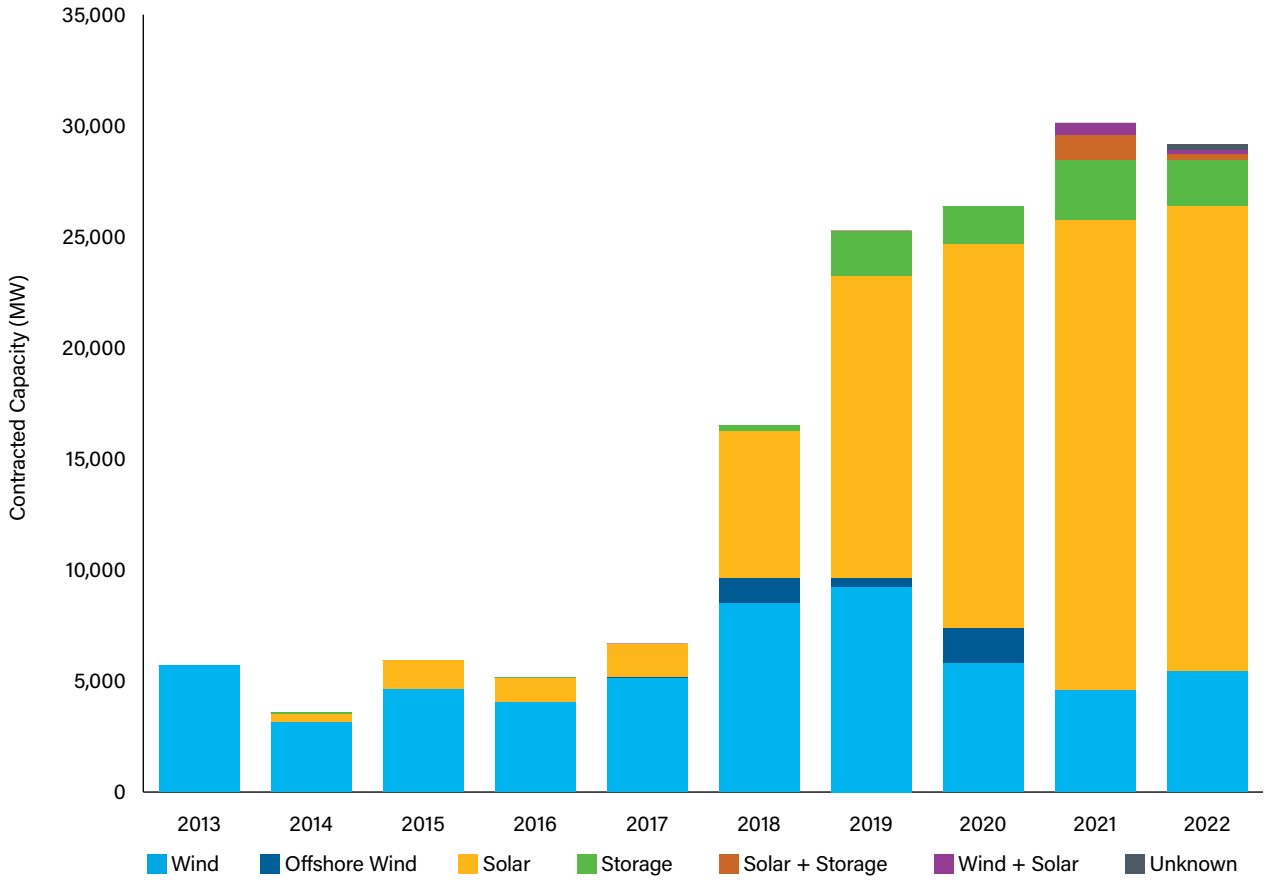
Clean Power Procurement

Power Purchase Agreement Announcements by Technology

Solar's share of announced PPAs continues to grow

- 2022 PPA announcements were just shy of the record set in 2021. Despite this, land-based wind capacity announcements experienced their first increase since 2019. Over 5.4 GW of land-based wind PPAs were announced, 18% higher than 2021 levels, but still lower than 2020.
- Solar PPA announcements fell just 1% compared to 2021, though 2022 still represents the second highest year to date for solar PPA announcements.
- Solar has been the most common technology for PPA announcements since 2019. In 2022, solar represented 72% of PPA announcements.
- In 2013 wind made up almost 100% of PPA announcements. The technology's share of announcements has steadily fallen to a low of 15% in 2021. In 2022, wind's share of PPA announcements increased slightly to 19%, though it is still the technology's second lowest share of announcements after 2021.

Power Purchase Agreement Announcements by Technology

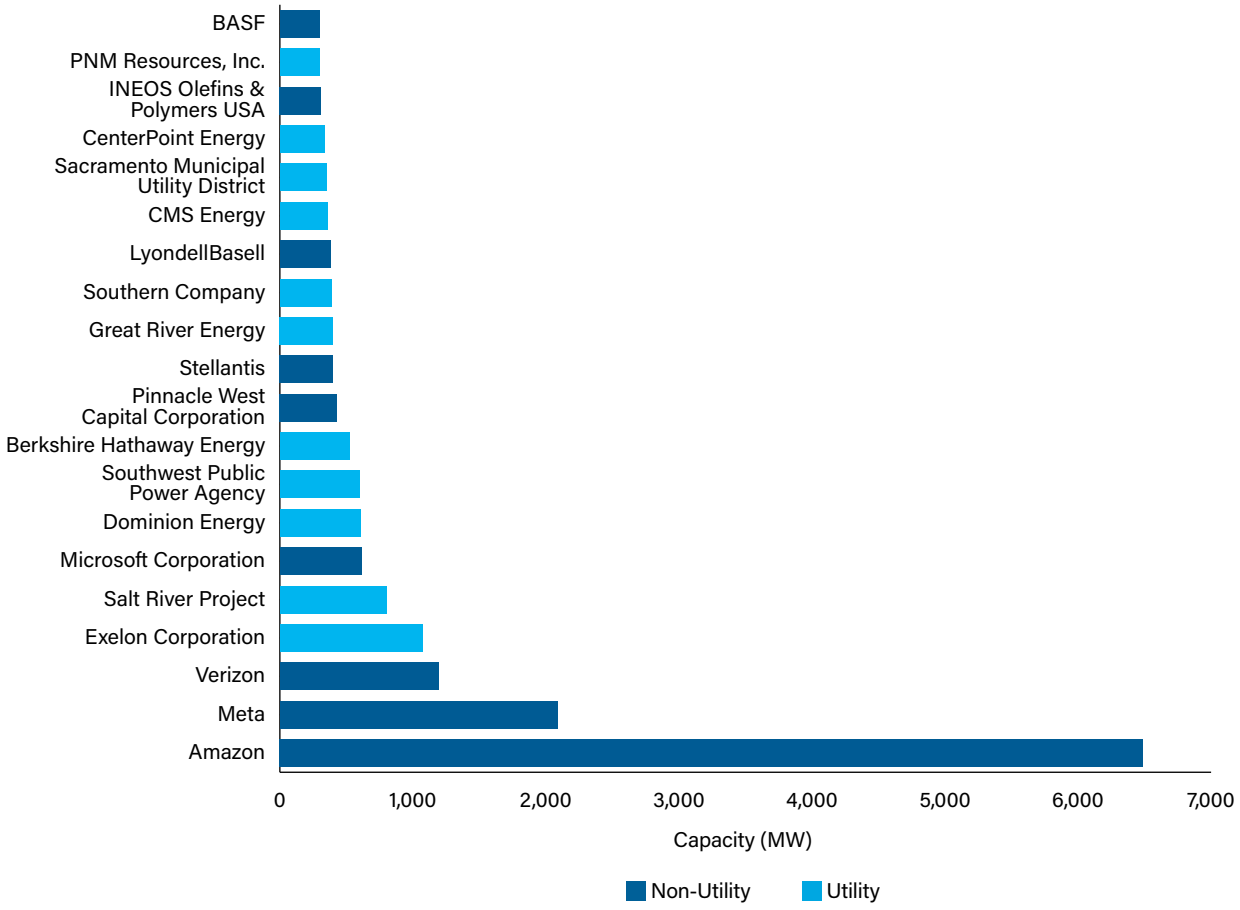


Top Companies Announcing Clean Power Purchases in 2022

Corporations make up almost half of the top companies announcing new PPAs

- The 20 companies listed here announced the most new clean PPAs in 2022. Of the top 20, 11 are utilities and nine are non-utility companies, primarily commercial & industrial buyers.
- Amazon leads the pack by a considerable margin. The technology giant announced nearly 6.5 GW of new PPAs in 2022 as the company progresses towards its goal of powering its operations with 100% renewable energy by 2024.
- Meta and Verizon close out the podium in 2022 with 2 GW and 1.2 GW of PPAs, respectively, announced in 2022.
- Exelon Corporation is the first utility on the list and the last entity to announce more than 1 GW of new PPAs.
- In total, almost 100 entities announced new PPAs in 2022, driving the industry to its second highest year of PPA announcements to date.

Top 20 Companies Announcing Clean Power Purchases in 2022

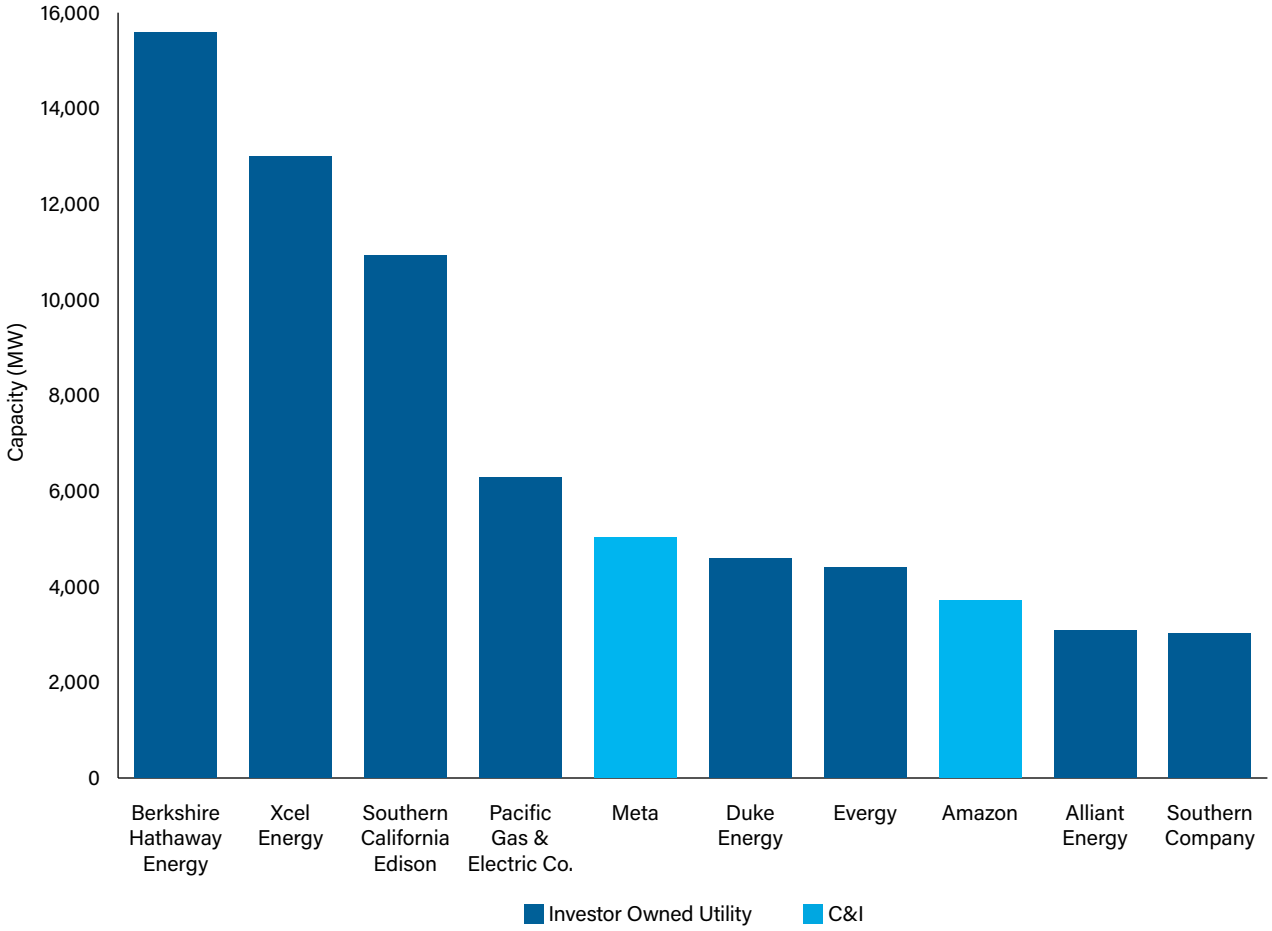


Top Buyers of Operating Clean Power

Investor-owned utilities dominate the top ten, with Berkshire and Xcel maintaining the top spots

- This chart showcases the top ten purchasers of wind and solar power capacity in the nation. These buyers obtain these clean energy resources through offtake contracts or direct ownership of the assets.
- As pressure on utility and non-utility entities alike to decarbonize mounts, demand for clean energy has risen. IOUs dominate the top buyers of operating clean power rankings, though a few corporate buyers are moving up in the ranks.
- Berkshire Hathaway Energy ranks first with nearly 15.6 GW of clean power operating and serving customers across the West and Midwest.
- Xcel Energy ranks second with nearly 13 GW operating, an approximately 1 GW increase from 2021.
- Southern California Edison maintained the third place ranking the utility held in 2021, with just shy of 11 GW of clean power online.
- Meta is the first corporation to appear in the rankings, thanks to the company's early adoption of clean power PPAs.
- Amazon is the only other corporate buyer to appear in the list. With the large volume of PPAs that Amazon has announced in recent years, it is likely to move up the rankings as those projects commission.

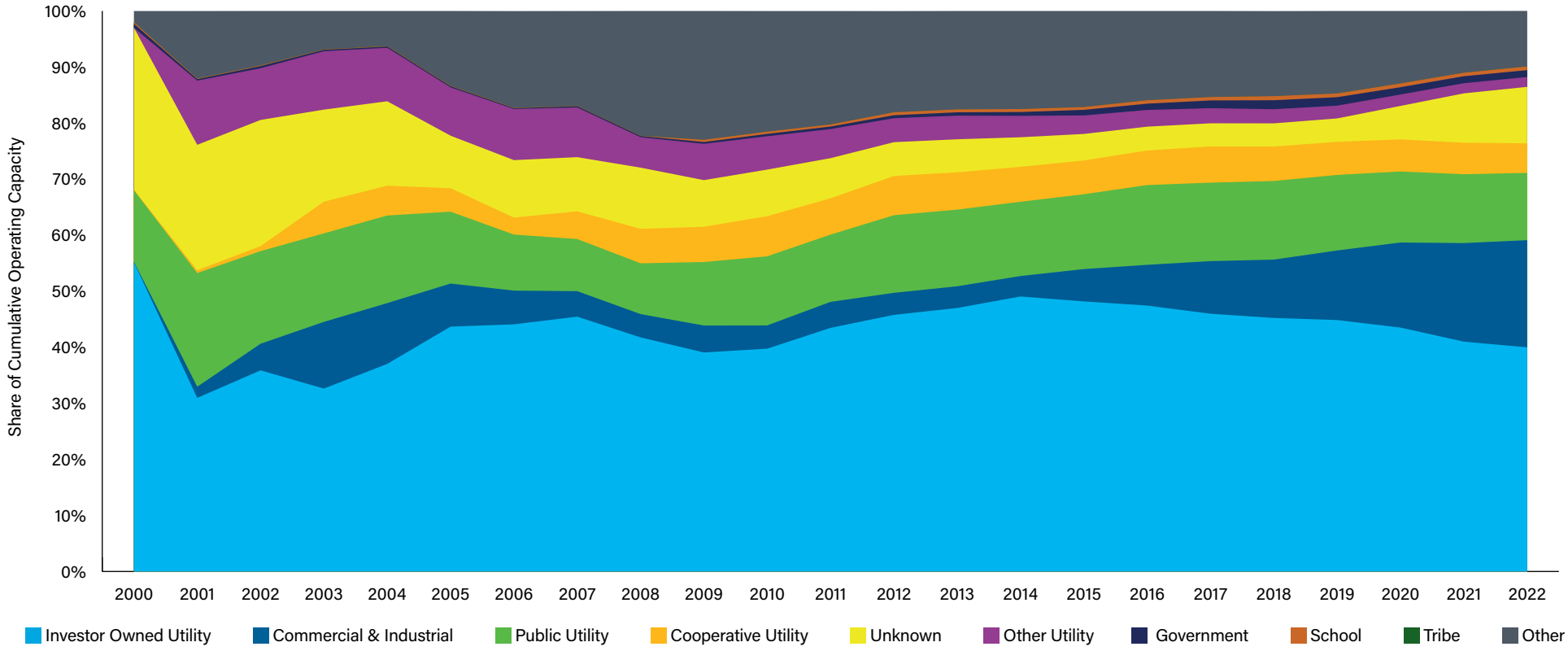
Top Purchasers with Operating Clean Power



Operating Clean Power Offtake by Purchaser Type

Corporate buyer share closes in on 20% of operating capacity

Share of Cumulative Operating Clean Power by Purchaser Type



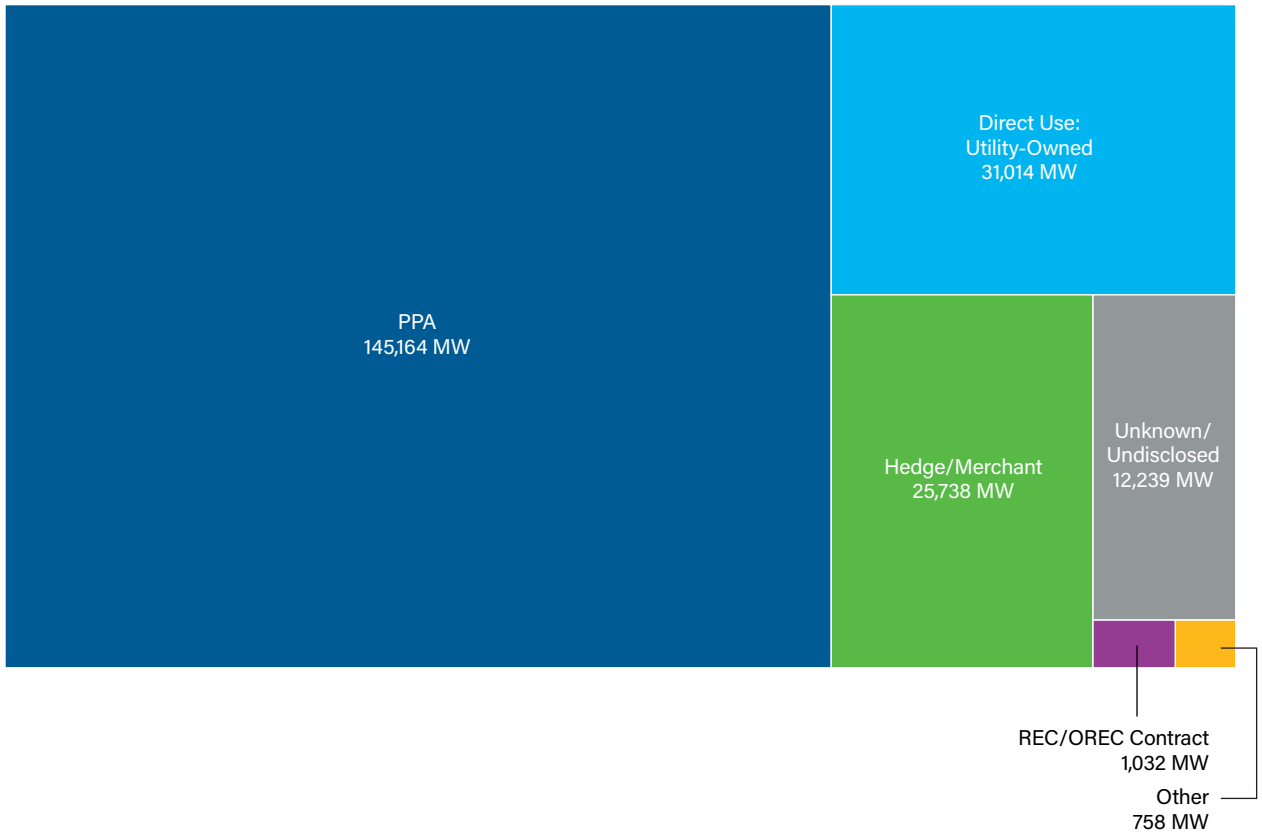
- Utilities have consistently accounted for between 60% and 70% of all operating offtake since 2000. In 2022 the utility share dropped below 60%, to 59%, for the first time.
- IOUs have been the dominant buyers of power from operating clean power projects since 2000. In 2022, IOUs own or have offtake agreements for 40% of operating capacity.
- Commercial & industrial buyers have quickly become the second most prominent buyer group. Back in 2000, C&Is were procuring less than 1% of operating capacity. Since 2015, this buyer group has increased their share of operating power by 2 percentage points each year, reaching 19% in 2022.
- Public and Cooperative utilities are the next most significant clean power buyer group, accounting for 19% and 12%, respectively, of operating clean power offtake.

Operating Offtake by offtake type

PPAs account for 67% of operating clean power offtake

- PPAs have long since been the preferred offtake mechanism used for clean power projects. A PPA is a long-term contract where an entity, such as a corporation, agrees to purchase electricity from a renewable energy generator who owns, operates, and maintains the wind, solar, or battery storage project. This allows the customer to buy electricity and renewable energy credits from a clean power project without having to deal with the risks of owning and operating the project themselves. It also provides both parties with price certainty and stability.
- Utilities owning projects and using that power to serve their customers is the second most prominent offtake mechanism, accounting for 14% of operating clean power offtake.
- Hedge and merchant agreements account for another 12% of operating clean power offtake. Hedge agreements, a type of financial contract, are typically used to manage and mitigate risks associated with the fluctuating price of electricity generated by clean power sources. Merchant agreements allow project owners to sell electricity at prevailing market prices without entering into long-term fixed-price contracts or PPAs with specific buyers.

Operating Offtake by offtake type



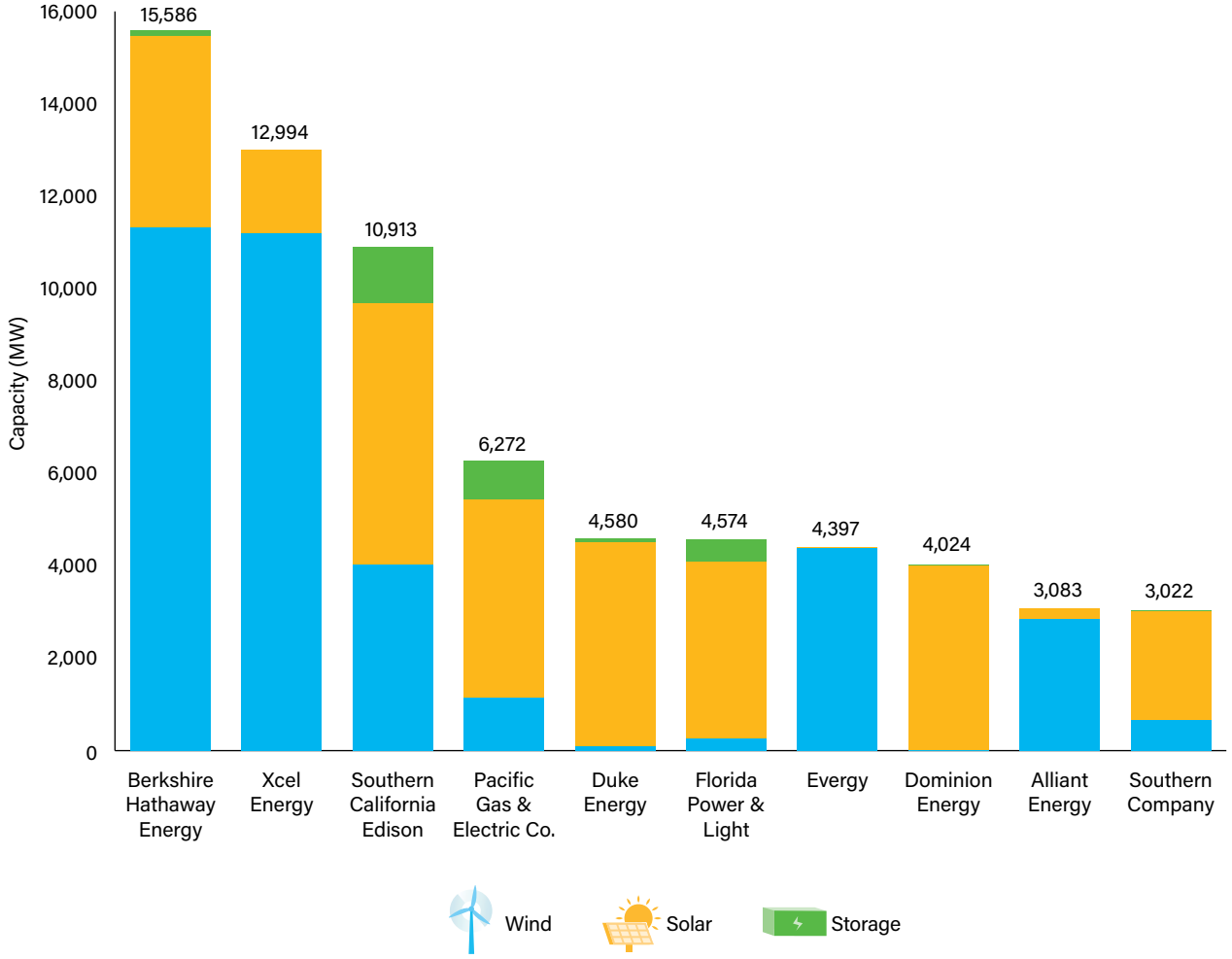
Clean Power Procurement

Top 20 Investor-Owned Utilities with Clean Power on System

Solar becomes more prominent in IOUs' operating clean power capacity

- Clean power on system includes all clean power capacity that the regulated arm of a utility has procured to serve its customers—through either PPAs or direct ownership of clean power projects.
- IOUs were among the earliest adopters of clean power and therefore have the largest amounts of operating clean power on system.
- Berkshire Hathaway Energy leads the pack with nearly 15.6 GW online, a more than 1 GW increase from 2021.
- Xcel Energy ranks second with just short of 13 GW online, also increasing operating capacity by nearly 1 GW since 2021.
- Southern California Edison is the only other IOU with more than 10 GW online. While Berkshire Hathaway Energy and Xcel Energy have wind-dominated systems, more than half of Southern California Edison's operating clean power capacity comes from solar projects.
- In 2021 more IOUs in the top ten had wind power operating than solar. In 2022, six of the top ten IOUs have more solar than wind capacity online.

Top Investor-Owned Utilities with Operating Clean Power

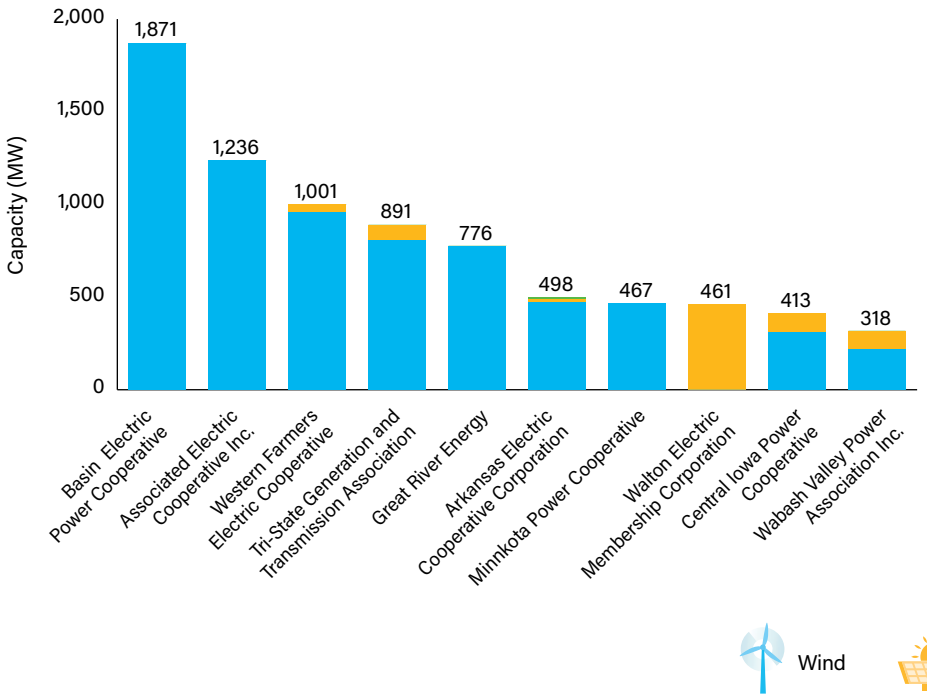


Clean Power Procurement

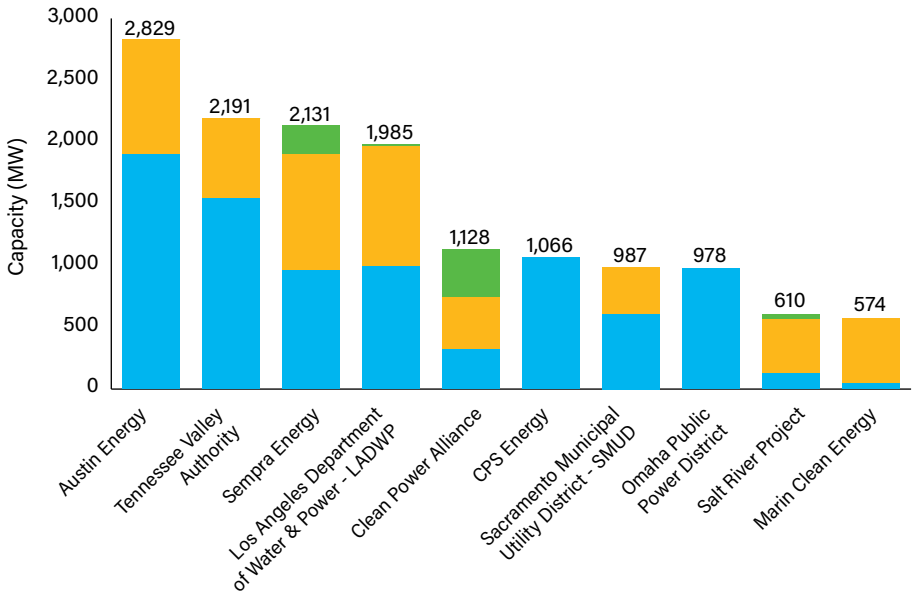
Top 10 Electric Cooperative and Public Utilities with Clean Power on System

Basin Electric Cooperating and Austin Energy lead the ranks

Top Electric Cooperative Utilities with Operating Clean Power



Top Public Utilities with Operating Clean Power



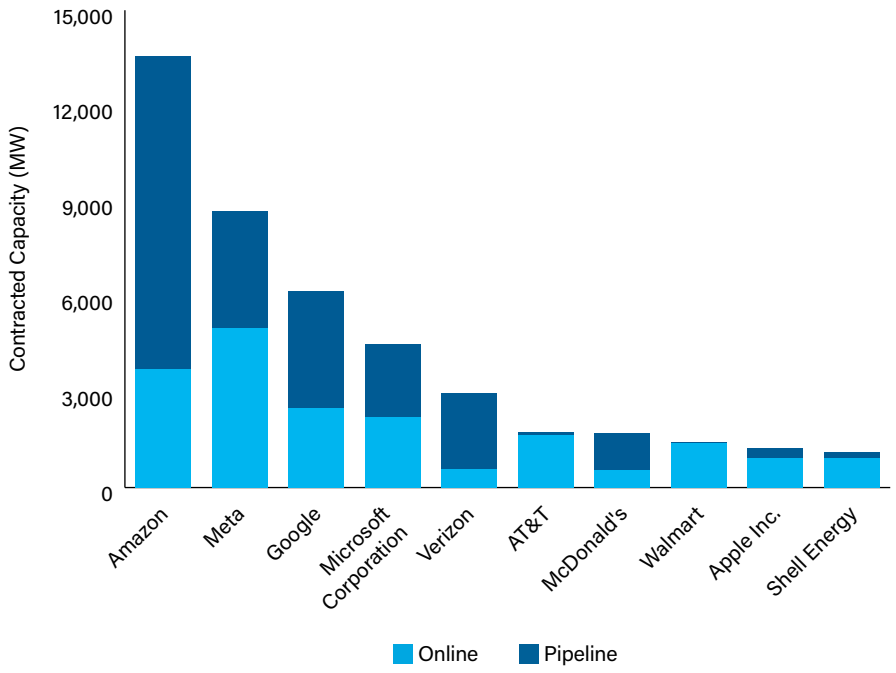
- Basin Electric Cooperative, based in North Dakota, maintains the top spot among electric cooperatives, with just over 2 GW of wind power operating. The Associated Electric Cooperative, based in Missouri, ranks second with 1.2 GW of wind operating. Walton Electric Membership Corporation, based in Georgia, is the only solar-dominant cooperative in the top ten.

- In the public utility space, Austin Energy ranks first with more than 2.8 GW of clean power online. Tennessee Valley Authority follows with nearly 2.2 GW online, and Sempra Energy, based in California, ranks third with 2.1 GW online. Many California Community Choice Aggregators appear in the top ten rankings.

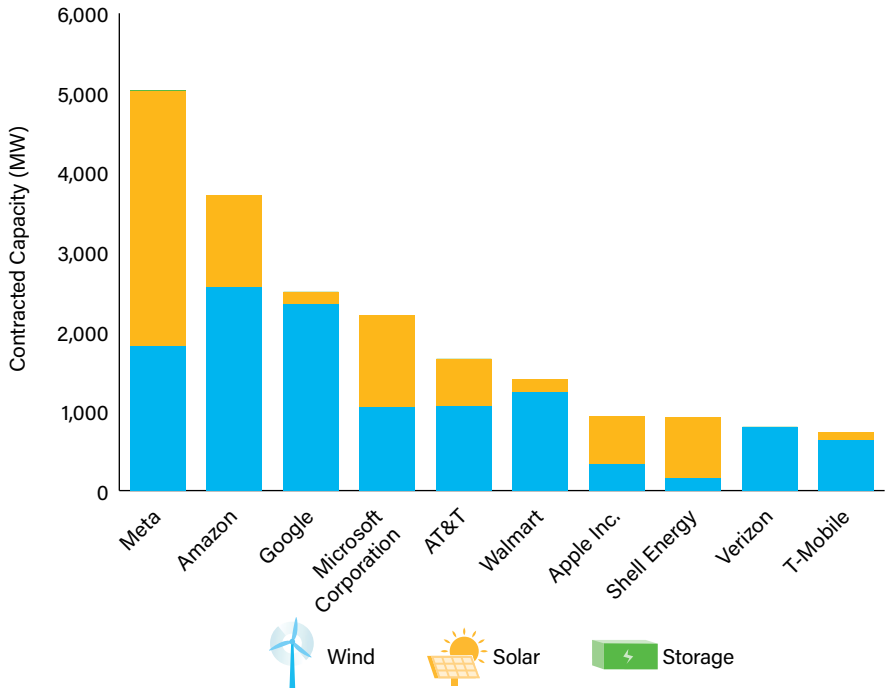
Top 10 Commercial & Industrial Buyers of Operating Clean Power

Meta leads C&I buyers with the most operating clean power, Amazon leads in total contracted capacity

Top 10 Commercial & Industrial Buyers of Clean Power



Top 10 C&I Purchasers of Operating Clean Power



- Corporations are increasingly turning to clean energy to power their business activities—delivering products, services, and experiences that are clean powered.
- Amazon has contracted the most clean power to date after rapidly increasing procurement activity over the past two years. Meta and Google, who were earlier adopters of clean energy, rank second and third in terms of total operating capacity.

- Much of the C&I contracted capacity is for clean power projects still in development. Meta has the most operating clean power contracted and operating its business. Amazon ranks second for operating contracted capacity.
- Google kicked off the modern era of large-scale C&I deals in 2010 and now ranks third for total operating contracted capacity.

Clean Power Economic Benefits

AMERICAN CLEAN POWER

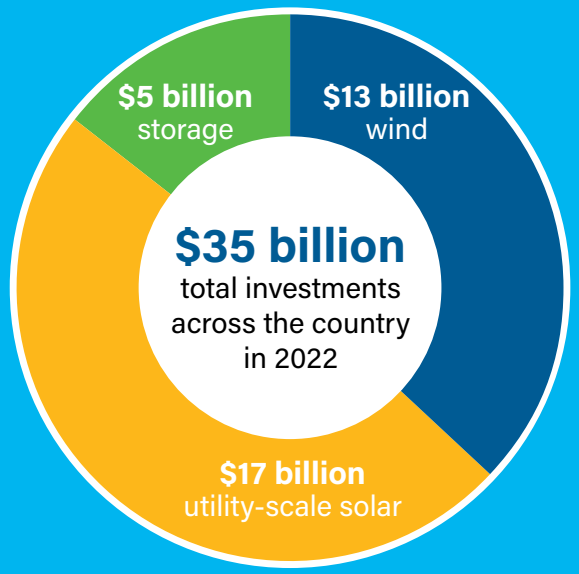
ANNUAL MARKET REPORT 2022

Clean Power Economic Benefits Highlights

- Wind, solar, and battery storage employ 443,000 Americans. There are nearly as many workers employed by U.S. clean power than in the coal extraction and generation, natural gas extraction and generation (including advanced natural gas) sectors combined.
- The clean power industry invested nearly $35 billion in renewable projects in 2022, an important catalyst for economic growth throughout the U.S.
- The industry also provided nearly $1.5 billion in annual land-lease payments, providing communities with additional income, stimulating local economies, and diversifying revenue sources.
- State and local tax payments related to clean power projects, totaling $1.4 billion in 2022, support communities by funding public services, supporting local government operations, and addressing community needs, such as affordable housing or environmental conservation efforts.
- Nearly 81% of U.S. clean power capacity is installed in low-income counties. These projects create economic opportunities in the communities that need it most, providing local employment, land-lease payments, as well as property, income, and sales tax revenue.

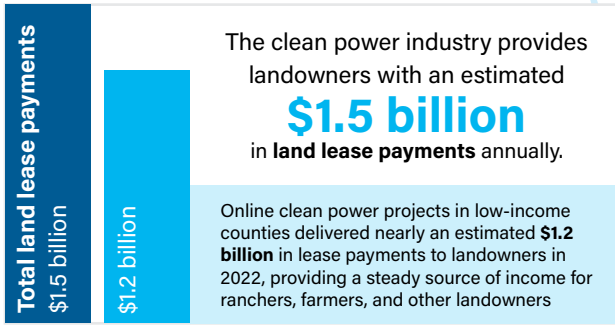
Clean Power Economic Benefits

Investing in clean power is a potent catalyst for economic growth throughout the United States, fueling new development



Clean Power Lifts Up Communities

Clean power expands the tax base in American communities and provides extra revenue from drought-proof land lease payments to landowners that host projects.



The clean power industry provides landowners with an estimated

$1.5 billion

in **land lease payments** annually.

Online clean power projects in low-income counties delivered nearly an estimated **$1.2 billion** in lease payments to landowners in 2022, providing a steady source of income for ranchers, farmers, and other landowners

The clean power industry pays an estimated

$1.4 billion

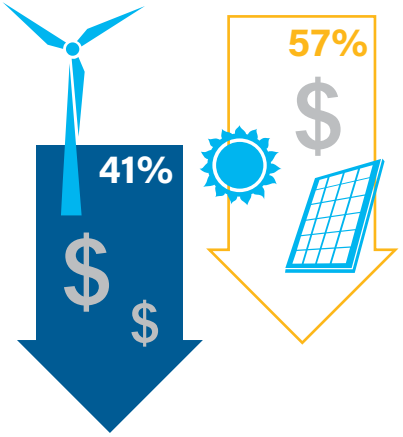
in **state and local taxes** annually.

Online clean power projects in low-income counties contribute an estimated **$1.1 billion** in state and local taxes.

Nearly 81% of U.S. clean power capacity is installed in low-income counties, or counties where the median household income falls below the national median household income of $69,717.

Clean Power is a Cost-Effective Solution to Combat Climate Change

WIND & SOLAR costs have fallen **41%** and **57%** over the last decade, making them the most affordable new electricity sources in most of the U.S.



When generating electricity, **WIND AND SOLAR power produce**

zero emissions.

Emissions avoided by operating wind and solar projects in the U.S. generate health benefits with an economic value between

$20 and $51 billion.

Clean Power Creates Climate-Friendly and Family-Sustaining Jobs

According to the Department of Energy's United States Energy and Employment Report 2022, wind, distributed and utility-scale solar, and battery storage sectors employed nearly **443,000** people supporting project development and operations, construction, maintenance, manufacturing, and other supply chain activities.*

Clean energy is set to have nearly **200,000** domestic workers in the manufacturing sector alone by 2030 as part of achieving a majority renewable electric grid

U.S. offshore wind growth will support up to **83,000 jobs** by 2030

*As of the end of 2021

Renewable energy workers are paid **25-35%** more than the national median wage and **10%** of the workforce is unionized

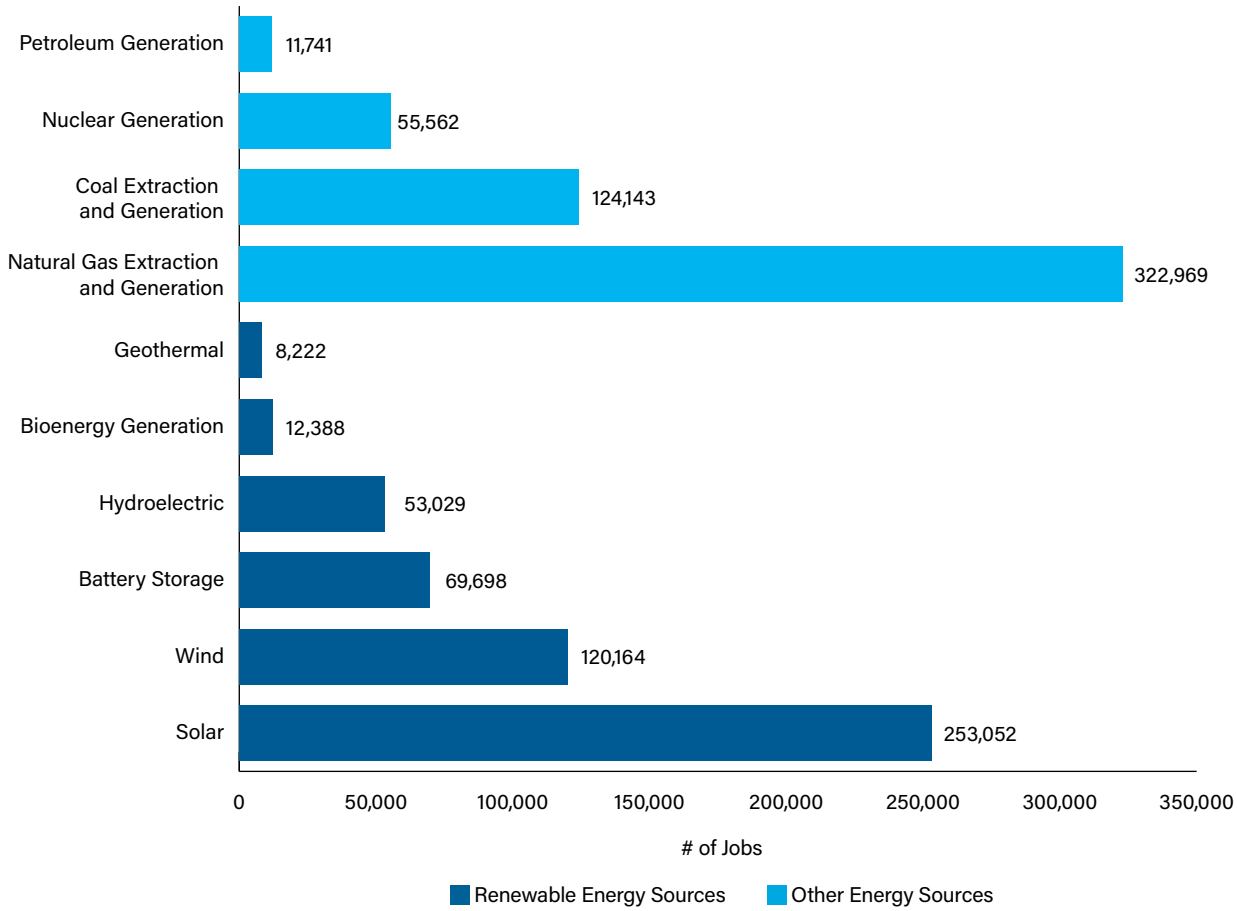
Wind turbine technician and solar installer are **2 of the fastest-growing jobs** in the country

Clean Power Jobs

Wind, solar, and energy storage employ 443,000 Americans

- According to a report issued by the Department of Energy titled *United States Energy and Employment Report 2022*, wind, distributed and utility-scale solar, and battery storage sectors employed nearly 443,000 at the end of 2021 supporting project development and operations, construction, maintenance, manufacturing, and other supply chain activities.
- The solar sector makes up the largest share of clean power employment with 253,052 estimated majority time workers. This is an increase of nearly 20,000 from 2020.
- The wind sector employed 120,164 workers in 2021, up from 116,801, while battery storage sector employment increased from 66,749 in 2020 to 69,698 in 2021. These estimates include both direct and indirect (supply chain) employment.
- The are nearly as many workers employed by U.S. clean power than in the coal extraction and generation, natural gas extraction and generation (including advanced natural gas) sectors combined.
- The 2023 update of the Department of Energy's U.S. Energy and Employment Report is due to be released in June 2023.

Energy Sector Jobs in 2021



Source: DOE USEER
Note: Jobs are as of the end of 2021; The 2023 update of the Department of Energy's U.S. Energy and Employment Report is due to be released in June 2023.

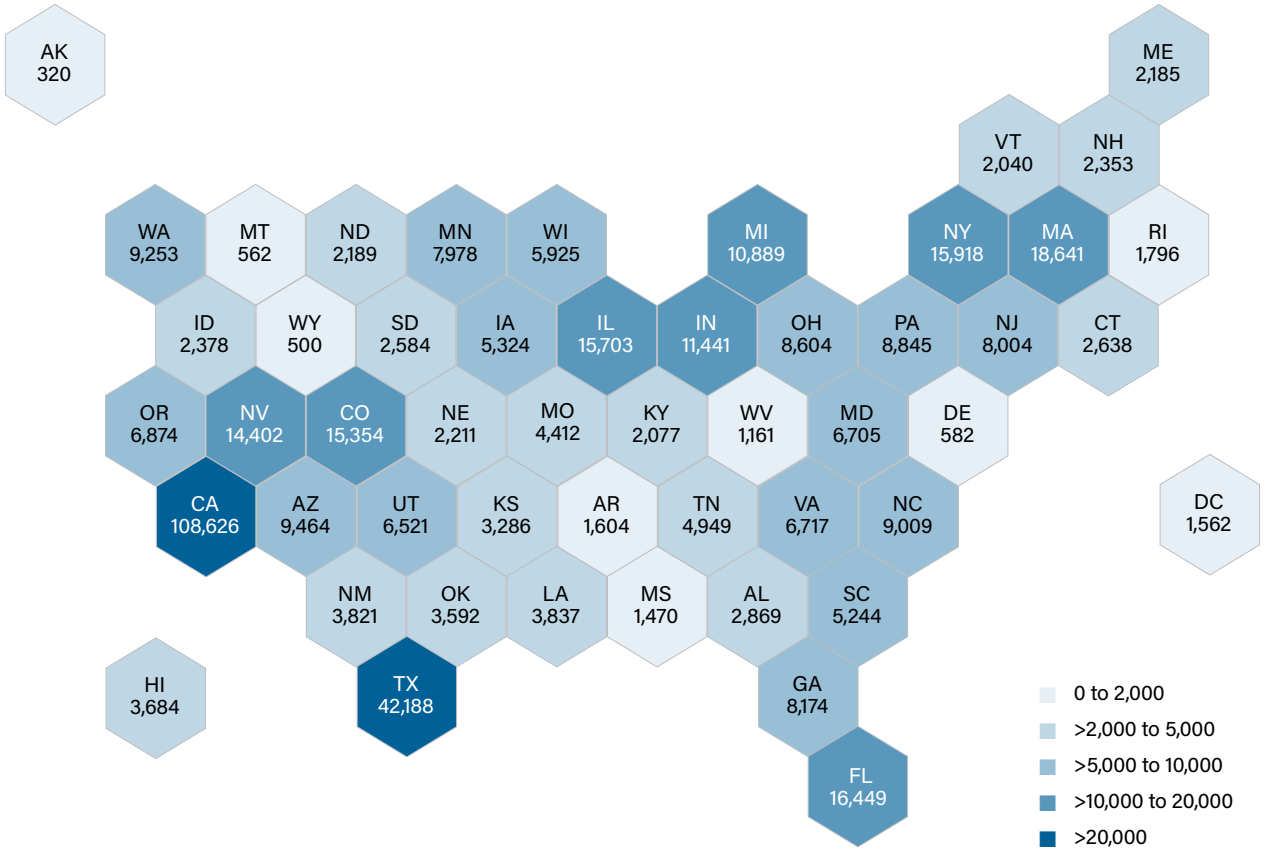
Economic Benefits

Clean Power Jobs by State

Clean power employs workers across the country in all 50 states

- American clean power is red, white, and blue with jobs spread across all 50 states.
- While jobs are often concentrated in states with high solar and wind resources, such as California and Texas, clean power employment is distributed fairly evenly across the states on a per capita basis.
- More than a third of total solar industry employment is found in California – roughly 87,200 full-time jobs. As a proportion of total state employment, solar employment in California is comparable to many other states including Hawaii, Nevada, and Vermont.
- Similarly, Texas hosts roughly 21% of total wind energy employment, or more than 25,500 jobs. However, per capita, Colorado, Indiana, Iowa, Maine, North Dakota, and South Dakota have a greater share of wind energy jobs.

Clean Power Jobs in 2021



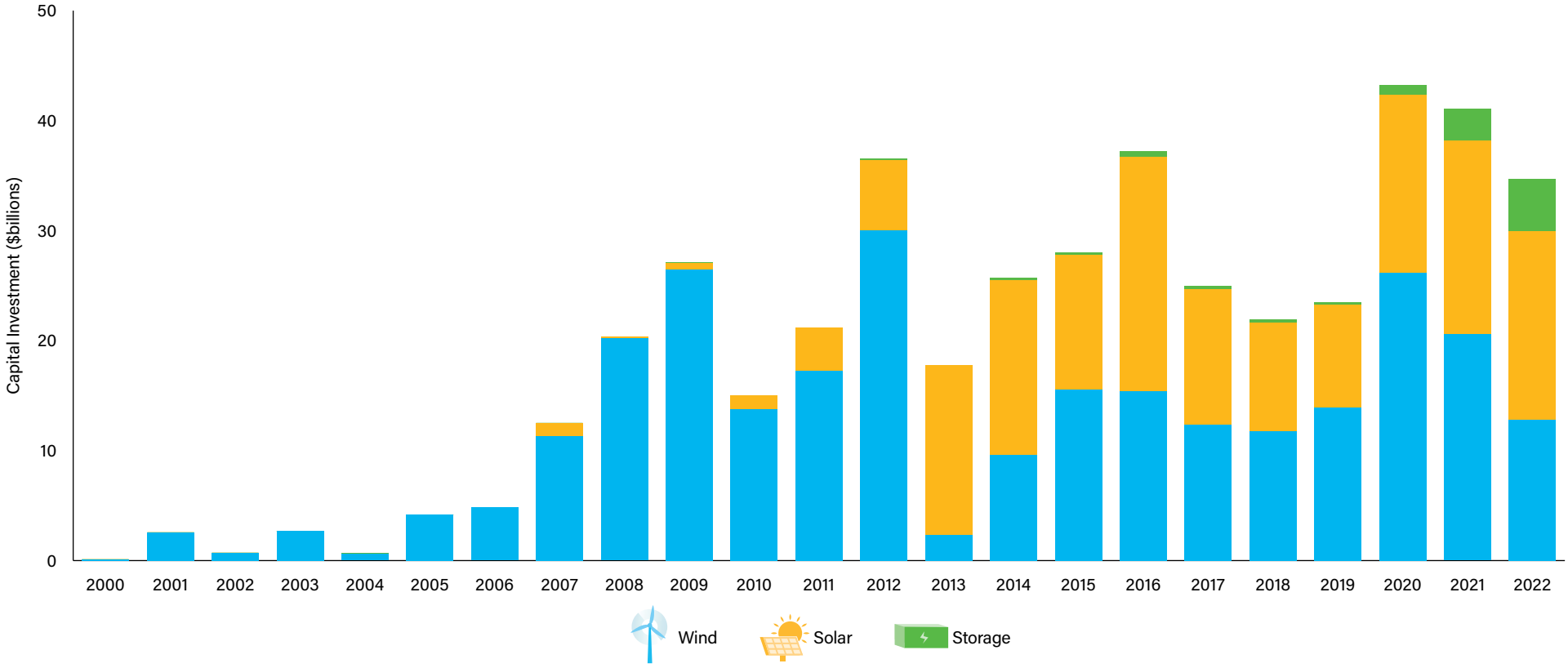
Note: Jobs are as of the end of 2021; the 2023 update of the Department of Energy's U.S. Energy and Employment Report is due to be released in June 2023.

Source: DOE USEER

Clean Power Project Capital Investment Over Time

The clean power industry invested nearly $35 billion in renewable projects in 2022

Clean Power Capital Investment Over Time



- Investing in clean power is a potent catalyst for economic growth throughout the United States, particularly in rural communities. Beyond the direct benefits of project investment and job creation, the clean power industry also generates substantial revenue through land lease payments and property, state, and local taxes, amounting to billions of dollars each year. This financial infusion not only fuels economic development but also contributes to the well-being of local communities by bolstering their tax base and supporting vital public services.
- In 2022, the wind industry invested nearly $13 billion in projects across the country. Utility-scale solar and battery storage developers invested a further $17 billion and $5 billion, respectively, bringing total 2022 investments to nearly $35 billion.

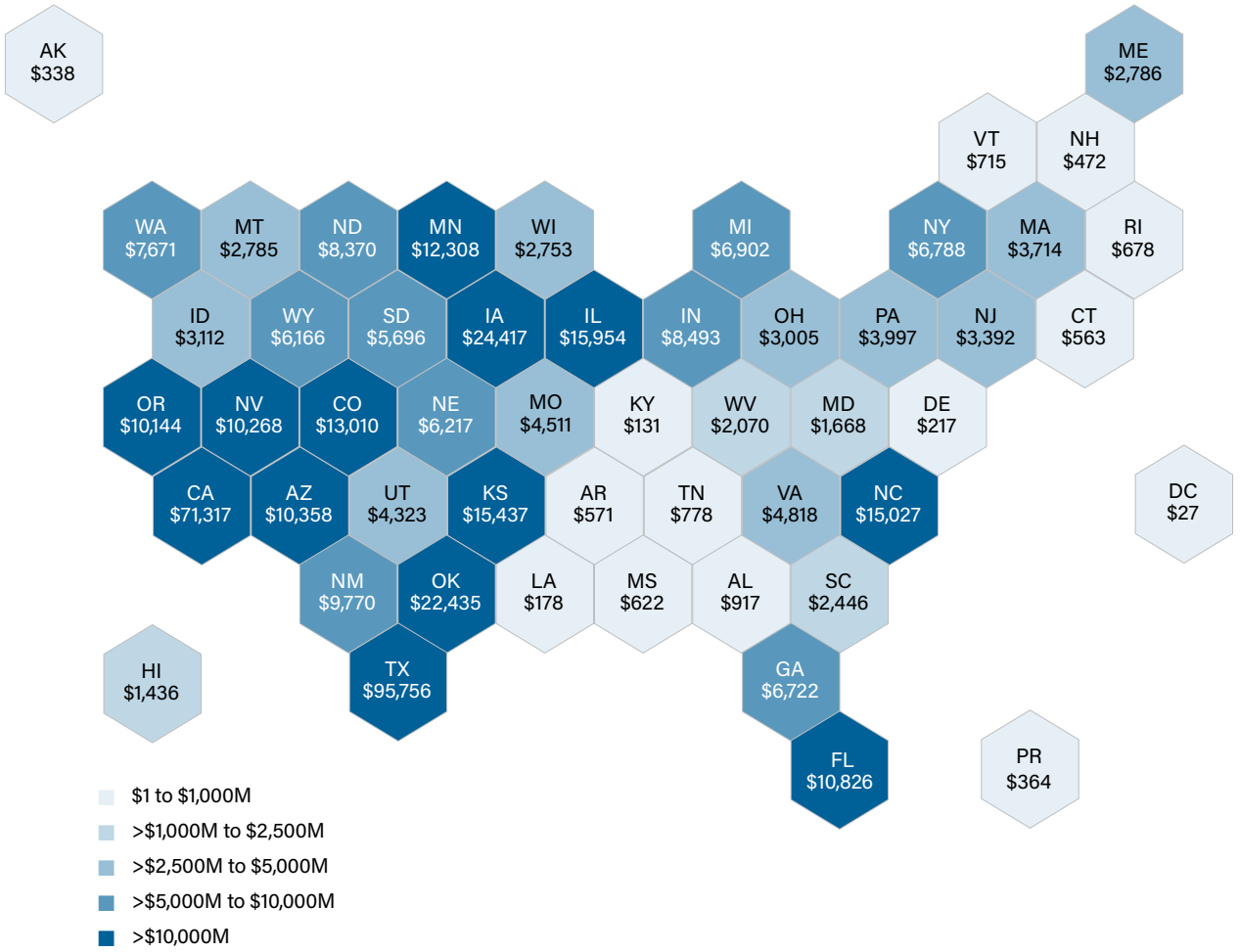
Economic Benefits

Capital Investment by State

Texas leads with nearly $96 billion in cumulative clean power project investment, followed by California

- Developers in Texas installed a nation-leading 9.2 GW of clean power in 2022, representing over $12.7 billion in project investment. Nearly half of this was driven by wind development with $6.3 billion of total project investment in that state. Solar project investment was slightly lower at $5.2 billion, while storage project investment came it at $1.2 billion. The 54.5 GW of clean power operating in Texas represents a total capital investment of nearly $95.8 billion.
- California, at nearly $5.9 billion of total clean power investment in 2022, follows Texas. This was driven largely by solar and storage capacity. Just under $3.0 billion worth of storage projects and just over $2.8 billion worth of solar projects came online in California in 2022. Wind projects represented over $100 million in capital investment in the state. Total capital investment in California surpassed $71.3 billion in 2022.
- Three other states had more than $1 billion worth of clean power projects come online in 2022.

Cumulative Capital Investment ($millions)



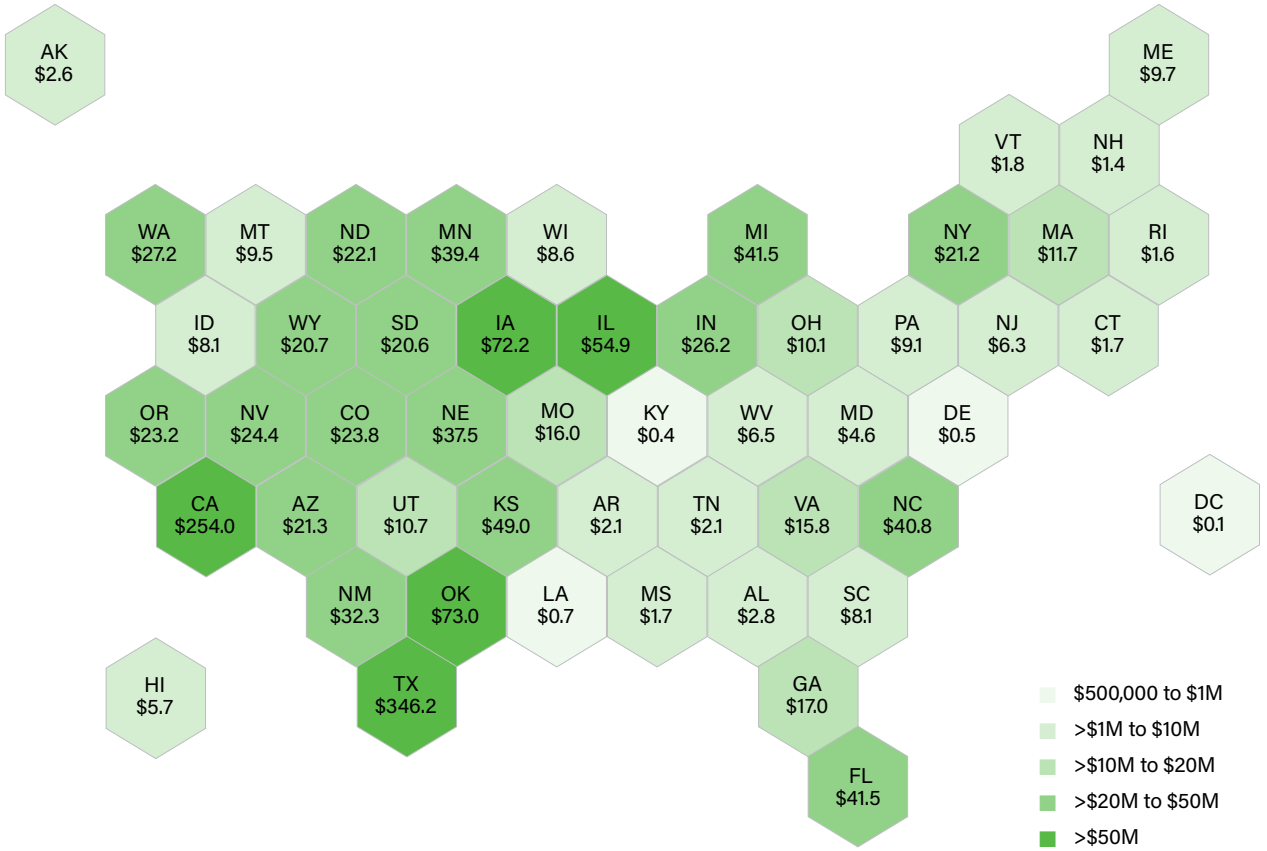
Economic Benefits

Annual Land Lease Payments

The clean power industry provides nearly $1.5 billion in annual land lease payments

- Clean power projects contribute directly to local communities through annual tax payments and landowner lease payments. Land lease payments from clean power projects provide communities with additional income, stimulate local economies, diversify revenue sources, and support public services, all of which contribute to the overall well-being and sustainability of the community.
- In 2022, the clean power industry paid an estimated $1.4 billion in state and local taxes and nearly $1.5 billion in land lease payments to landowners across the U.S. That means that each year, the industry contributes at least $2.9 billion to local communities.
- With the most clean power capacity installed, Texas leads the U.S. with an estimated $346 million in annual land lease payments, followed by California with an estimated $254 million.

Estimated Land Lease Payments in 2022 ($millions)



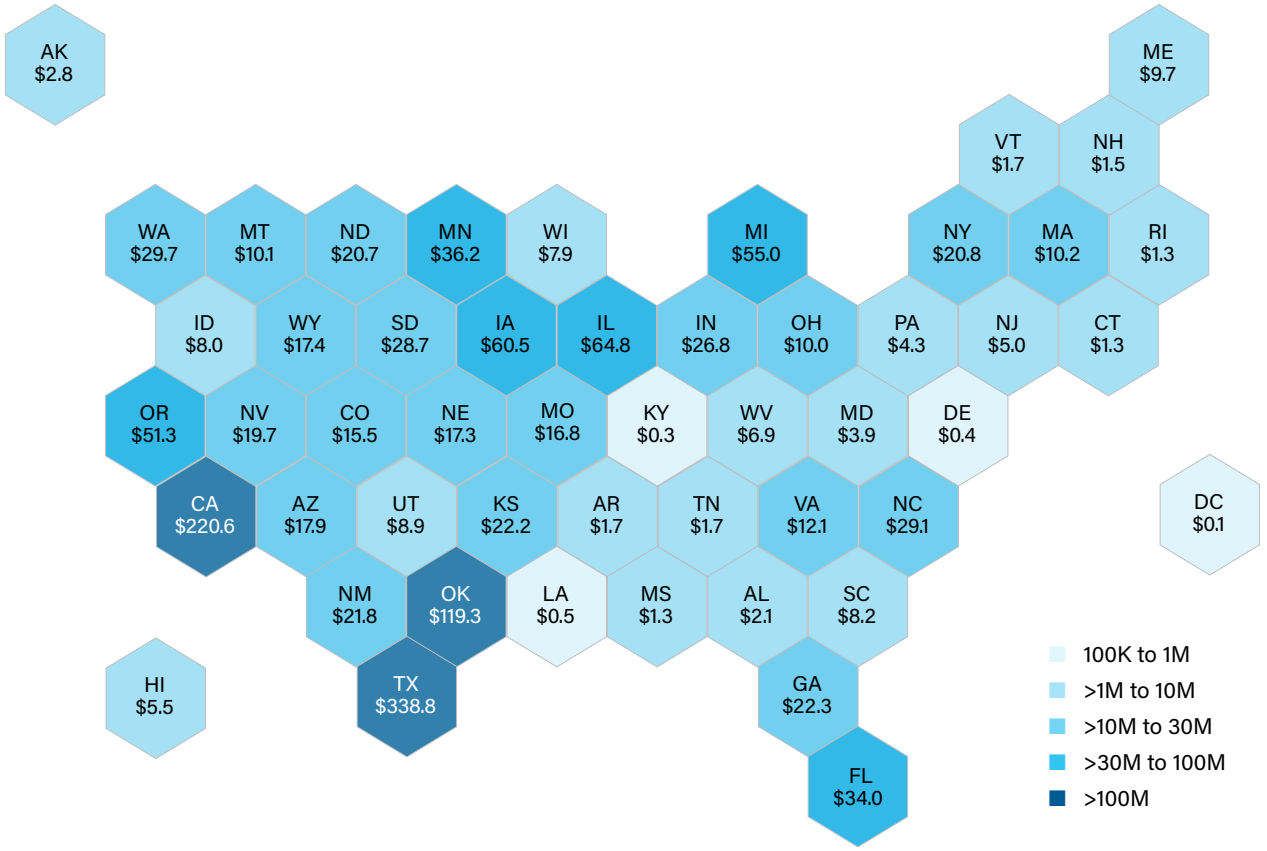
Economic Benefits

State and Local Tax Payments

In 2022, the clean power industry paid an estimated $1.4 billion in state and local taxes

- Texas leads all states with an estimated $339 million in state and local taxes paid in 2022. California follows with an estimated $221 million.
- There are five other states with estimated state and local tax revenues from clean power exceeding $50 million.
- In addition to capital investment and lease payments, annual property, income, and sales tax payments provide valuable revenue for local school districts and other government services.
- For example, in Minnesota, where there is a wind production tax, Murray County has put revenue from wind projects to good use. In 2020-21, the county replaced the HVAC system in the courthouse using $750,000 of wind production tax revenue. In 2019, the county contributed $100,000 of wind revenue to help bring broadband internet to roughly 100 previously unserved locations.

Estimated State and Local Taxes Paid in 2022 ($millions)

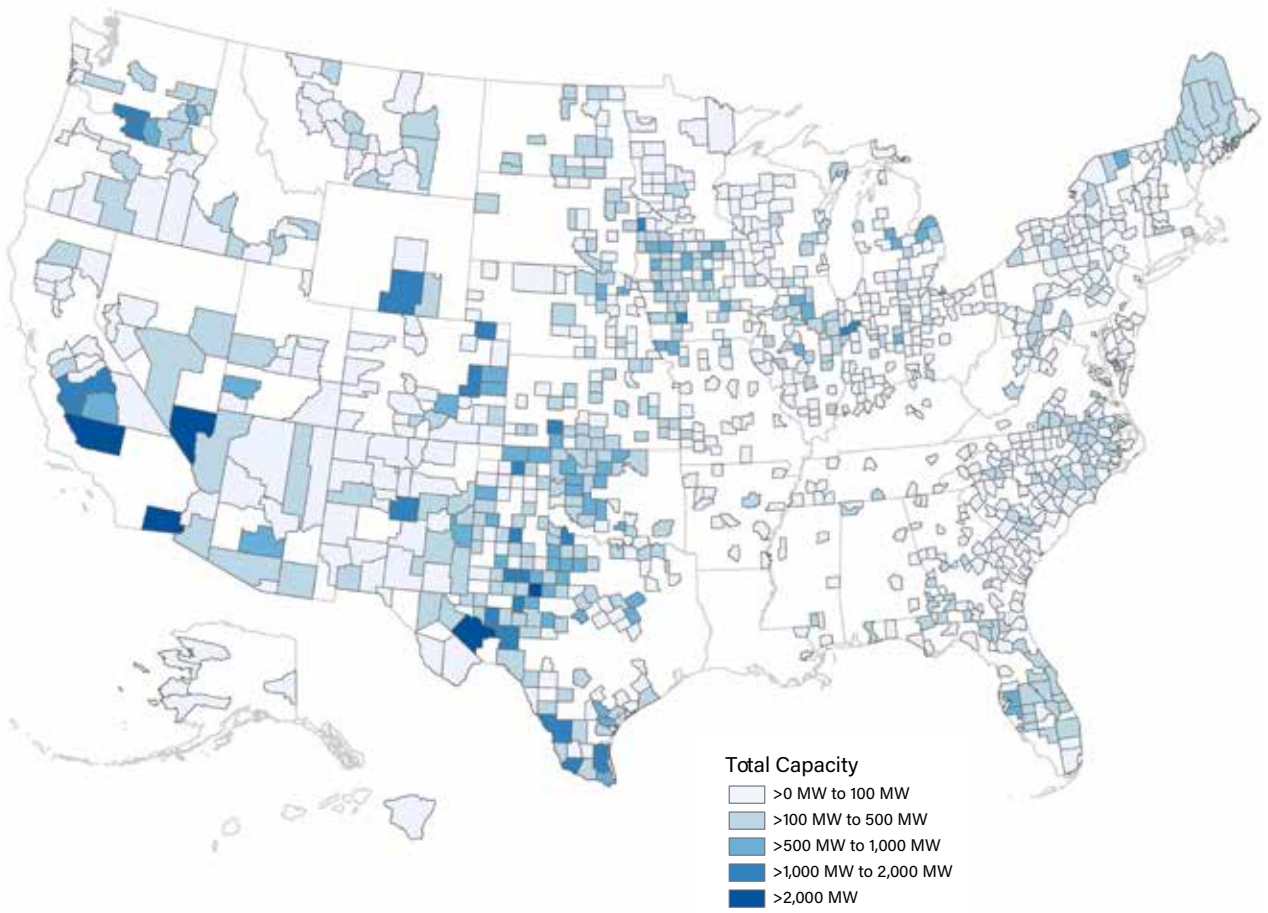


Clean Power Installed in Low-Income Counties

Nearly 81% of U.S. clean power is installed in low-income counties

- Nearly 81% of U.S. clean power capacity is installed in low-income counties, or counties where the median household income falls below the national median household income of $69,717. These projects create economic opportunities in the communities that need it most, providing local employment, land-lease payments, as well as property, income, and sales tax revenue.
- Online clean power projects in low-income counties delivered nearly an estimated $1.2 billion in lease payments to landowners in 2022, providing a steady source of income for ranchers, farmers, and other landowners.
- In addition, online clean power projects in low-income counties contribute an estimated $1.1 billion in state and local taxes.
- These projects represent a cumulative $356 billion in private capital investment. Approximately 57% of land-based wind, solar, and battery storage capacity under construction or in advanced development is in low-income counties, representing an additional $109 billion in new project investment.

Clean Power Installed in Low-Income Counties



Clean Power Environmental Benefits

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Clean Power Environmental Benefits Highlights

- Thanks to the increase in clean power resources, among other factors, the carbon intensity of the U.S. electric grid has fallen by 38% compared to 2005.
- Wind and solar capacity operating in the U.S. can reduce CO2 emissions by an estimated 426 million metric tons, or roughly 93 million cars' worth of carbon emissions.
- Additionally, operating wind and solar power can prevent the release of roughly 13,400 metric tons of PM2.5, 321,000 metric tons of NO_x and 282,000 metric tons of SO_2.
- The health benefits relating to decreased air pollution due to operating clean power have an economic value estimated between $20 and $51 billion.

Clean Power Technologies Help Our Economy and our Planet

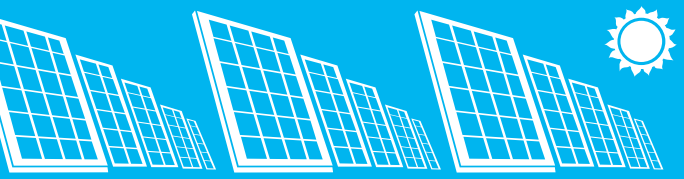
Clean energy sources like **WIND & SOLAR** are critical parts of reducing greenhouse gas emissions and combating climate change.

Transitioning to majority zero-carbon energy sources like land-based wind, offshore wind, and solar will help drive the clean energy economy forward while benefiting our planet.

When generating electricity, **WIND & SOLAR power produce zero carbon emissions,** the greenhouse gas primarily responsible for climate change

The carbon footprint of a typical **SOLAR** pv plant is **11x smaller** than a natural gas plant and **21x smaller** than a coal plant

A typical **WIND** project repays its carbon footprint from construction in **six months or less**, providing decades of zero-emission energy



Clean Power Reduces Carbon Emissions

WIND & SOLAR power avoid emitting **426 million** metric tons of carbon dioxide per year.

That amount is the emissions equivalent of:

Taking more than **93 million** cars off the road each year

435 million one-way trips down scenic Route 66

Would equal the amount of carbon sequestered by planting **20 billion** trees

The carbon emissions saved is equivalent of not using more than **48 billion** gallons of gasoline

The carbon emissions savings can prevent over **$22 billion** in future climate-related damages each year

Driving **1 trillion** miles in your average car.

That's the equivalent of:

43 million trips around the Earth

19 trillion football fields long

16 trillion trips around the bases on a baseball diamond

Clean Power Makes Communities Healthier by Improving Air Quality

Generating electricity using clean power provides public health benefits. **WIND & SOLAR** power cut significant amounts of harmful air pollutants that impair the respiratory system and exacerbate asthma, like **sulfur dioxide (SO2)** and **nitrogen oxides (NOx)** from entering the Earth's atmosphere.

Decreasing these pollutants helps to reduce smog and the rates of asthma attacks and other respiratory issues

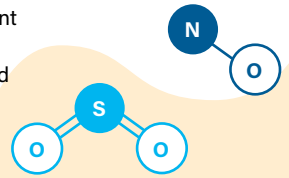
Emissions avoided by clean power generate health impacts with an economic value between $20-$51 billion

WIND & SOLAR power avoid **321,000 metric tons** of nitrogen oxides from being emitted into the Earth's atmosphere

That's the same amount of NOx emitted by an average tractor trailer driving nearly **35 billion** miles

11.7 million tractor trailers driving across the country

WIND & SOLAR power prevent **282,000 metric tons** of sulfur dioxide from being emitted into the Earth's atmosphere



Clean Power Saves Water

Because clean power does not require water for cooling like conventional power plants, **WIND & SOLAR** projects save **210 billion** gallons of water each year.

That amount of water is enough to fill:

318,000 Olympic-sized swimming pools

1.6 Trillion bottles of water

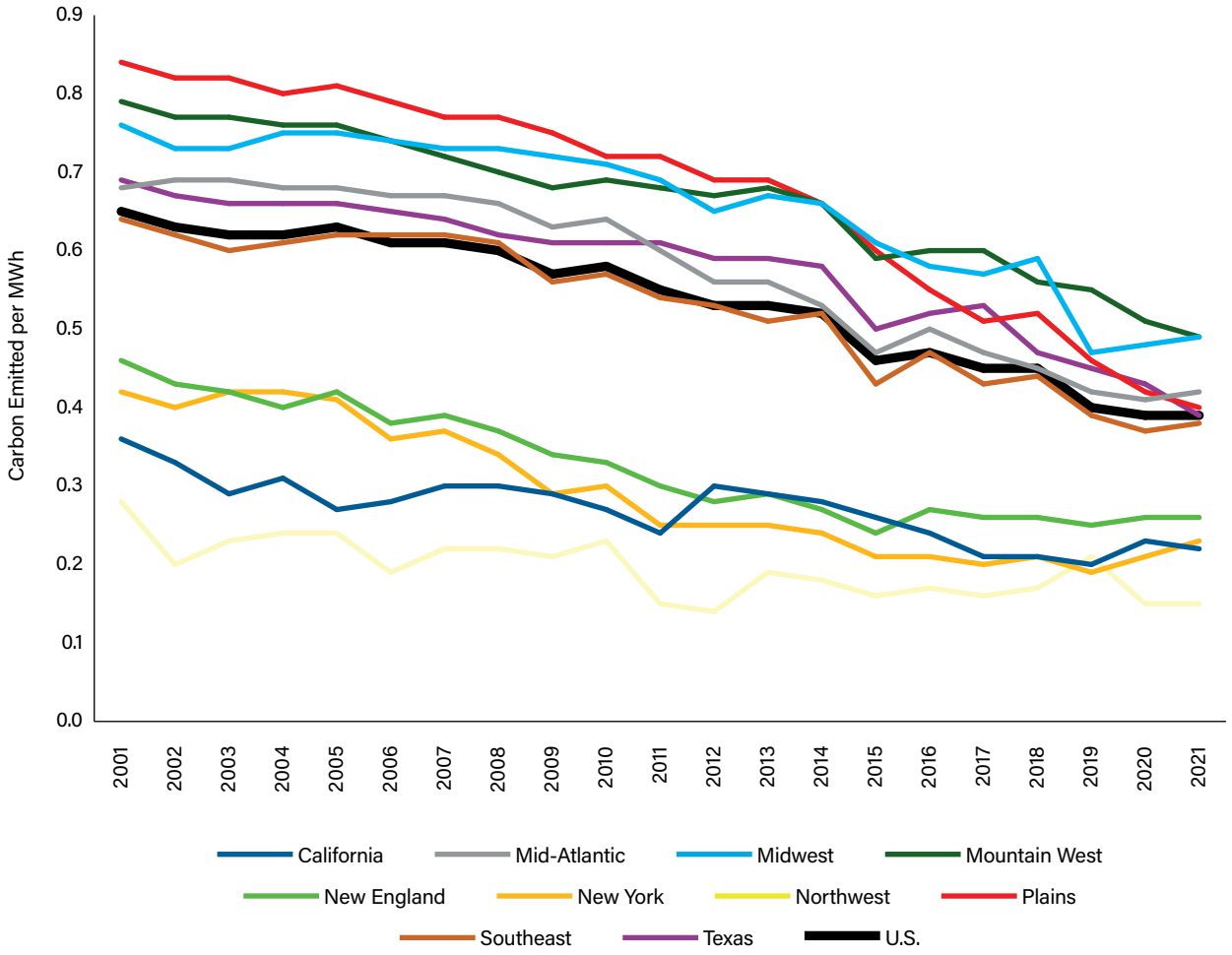
Clean Power Environmental Benefits

Carbon Intensity of Electricity Markets

The grid is cleaner than ever before with carbon intensity down 38% from 2005 levels

- The carbon intensity of the U.S. electric grid—the amount of carbon emitted per megawatt-hour of electricity generated—has fallen 38% since 2005, from 0.63 metric tons of CO_2 per MWh to 0.39 MT/MWh in 2021. The growth of renewable energy, as well as more stringent environmental regulations, the use of natural gas-fired generation, and a decreased use of coal generation has contributed to this reduction in overall emissions and emissions intensity.
- Increased coal generation in 2021 led to a small increase of less than 1% in carbon intensity compared to 2020. This was expected given the abnormal circumstances of 2020 across the economy.
- The Northwest is the least carbon intensive electricity region in the country thanks to abundant hydropower and renewables. The region emits just 0.15 MT/MWh. New York is the next cleanest grid followed by California and New England.
- Despite growing renewable generation, the Mountain West and Midwest are the most emissions-intensive grids in the country. These regions continue to generate much of their electricity from coal plants.

Regional Carbon Intensity of Power Markets



Source: EIA

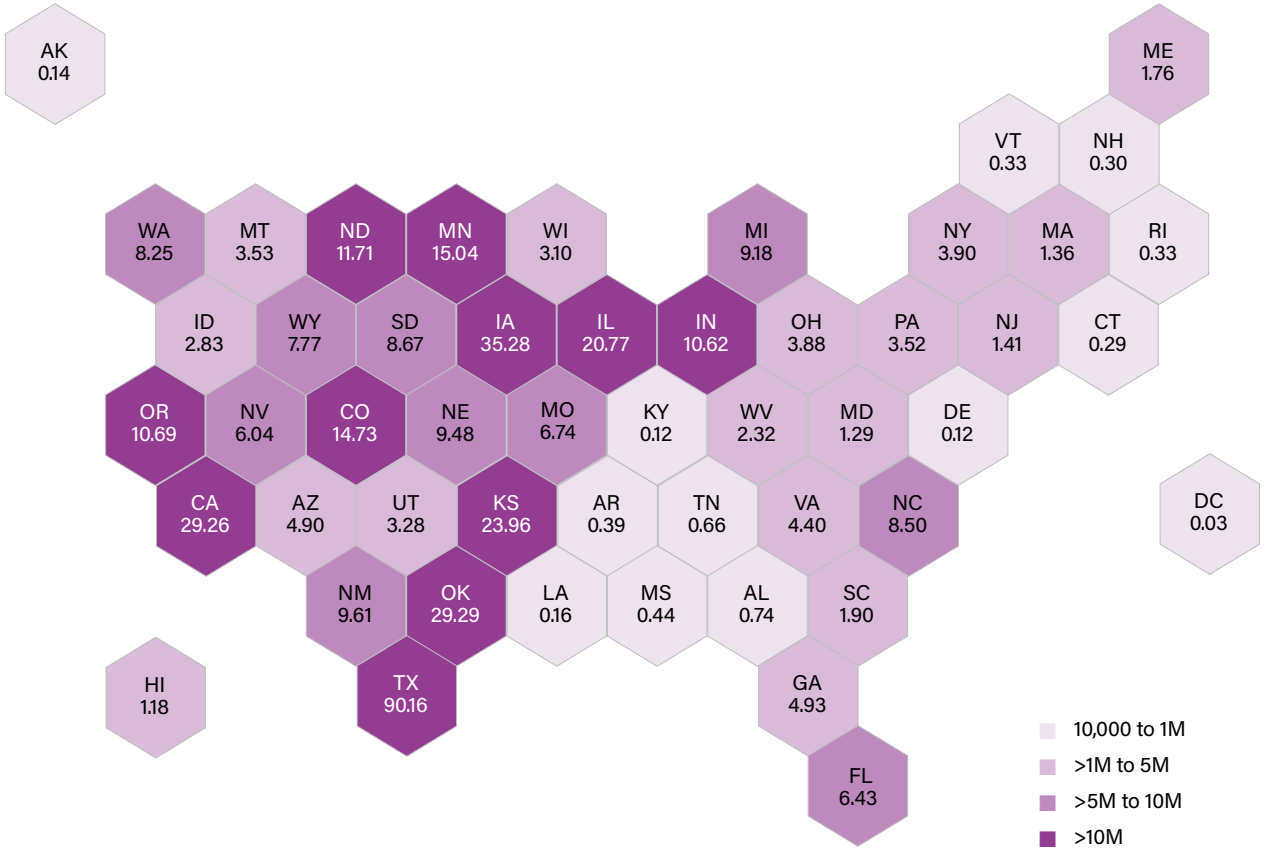
Clean Power Environmental Benefits

Carbon Dioxide Emissions Avoided by Wind and Solar Power in 2022

Installed wind and solar capacity can avoid the equivalent of 93 million cars' worth of carbon emissions

- Wind and solar power have some of the lowest environmental impacts of any source of electricity generation. These technologies do not burn fuel and therefore do not emit any air pollution such as carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrogen oxides (NO_x) or particulate matter (PM2.5).
- Wind and solar power generation often leads to a corresponding decrease in electricity production from other power plants, as the low marginal costs of wind and solar energy make them competitive and capable of displacing generation from fossil-fuel powered plants.
- Based on 2021 emissions rates from the Environmental Protection Agency's (EPA) Emissions & Generation Resource Integrated Database (eGRID), wind and solar capacity installed through 2022 can reduce annual CO_2 emissions by an estimated 426 million metric tons, or roughly 93 million cars' worth of carbon emissions.
- The roughly 37 GW of wind, offshore wind, and solar power capacity under construction at the end of 2022 can reduce CO_2 emissions by an additional 61 million metric tons once operational. That would bring total emissions reductions from U.S. wind and solar energy to around 487 million metric tons per year.

Avoided CO_2 Emissions (Million Metric Tons)



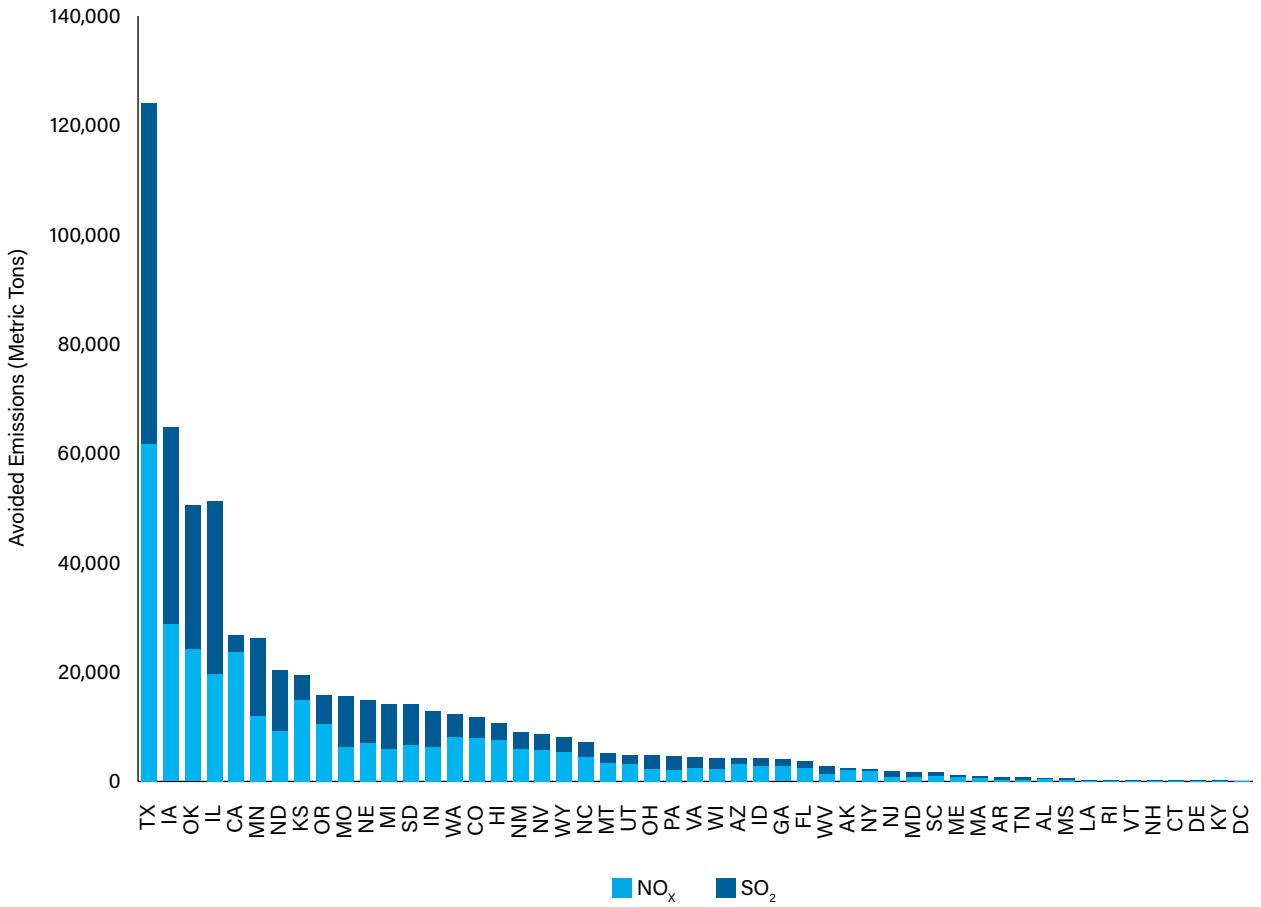
Clean Power Environmental Benefits

NO_x and SO_2 Emissions Avoided By Wind and Solar Power in 2022

Over 600,000 metric tons of NO_x and SO_2 emissions can be avoided by installed wind and solar

- Installed wind and solar capacity as of 2022 can prevent the release of roughly 13,400 metric tons of PM2.5 on an annual basis.
- PM2.5, as defined by the EPA, refers to tiny particles that are 2.5 micrometers or smaller, and can be easily inhaled. These fine particles not only contribute to haze, but can also penetrate deep into the lungs and, in some cases, even enter the bloodstream.
- Additionally, wind and solar power can prevent the release of roughly 321,000 metric tons of NO_x and 282,000 metric tons of SO_2.
- According to the EPA, NO_x and SO_2 emissions undergo chemical reactions in the atmosphere, resulting in the formation of small solid particles that can travel over long distances. Both NO_x and SO_2 are known to have detrimental effects, including contributing to respiratory illnesses like asthma and chronic bronchitis. Additionally, these emissions can lead to acidification of surface water, leading to fish mortality, and can also damage forest ecosystems by causing soil acidification and depletion of vital soil nutrients.

Avoided NO_x and SO_2 Emissions (Metric Tons)



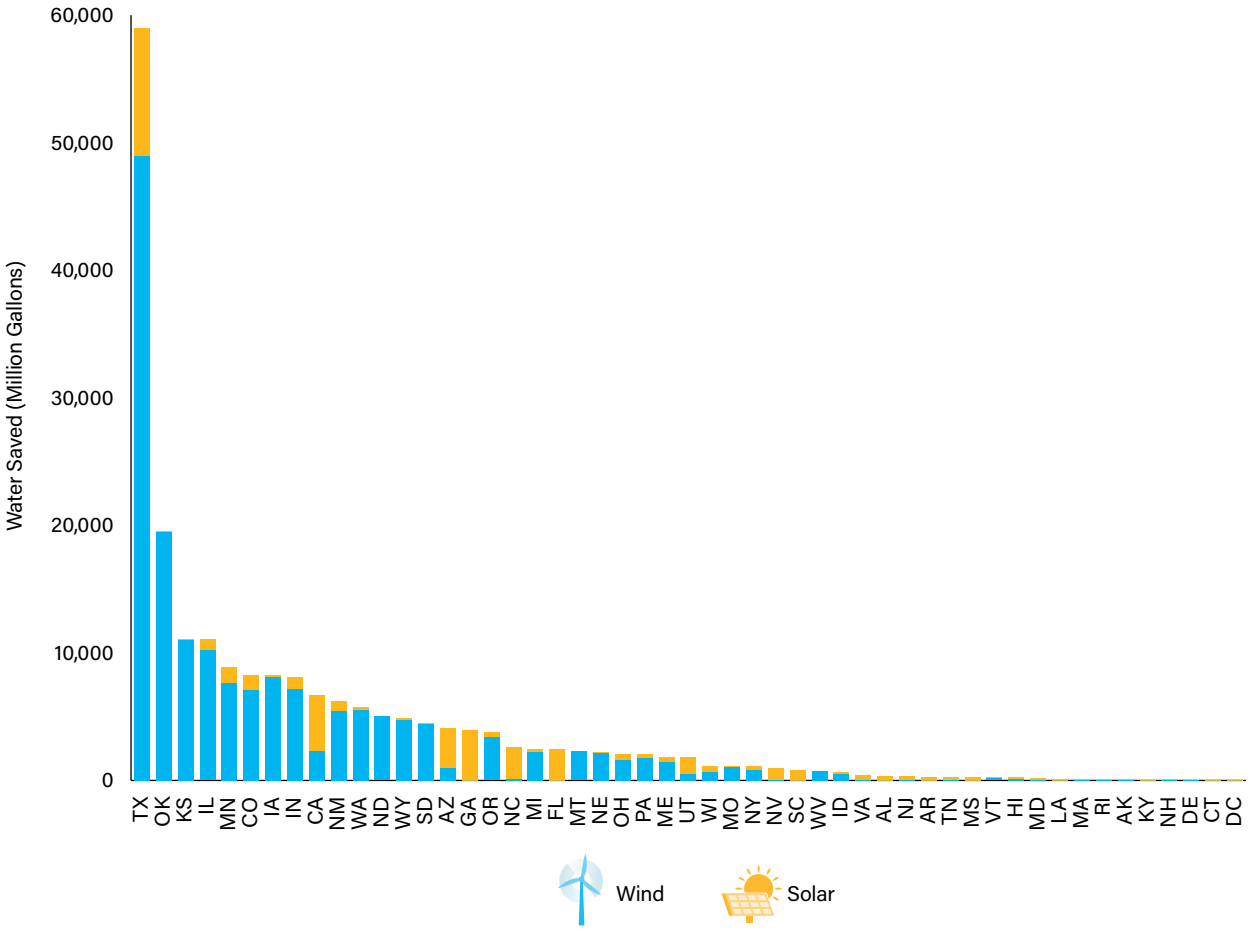
Clean Power Environmental Benefits

Water Saved by Wind and Solar

Wind and solar energy displace water usage at thermal power plants

- Thermal power plants such as natural gas and coal generating units typically use large amounts of water for cooling. As wind and solar power displace natural gas, and to a greater extent, coal-fired generation, water use is avoided.
- Wind and solar capacity installed through 2022 can avoid the use of 208 billion gallons of water, nearly 59 billion gallons of which is avoided in Texas.
- In Texas, higher than average water use per MWh of thermal generation and large amounts of wind and solar installed put that state well above others in terms of water use avoided by renewables.

Annual Water Savings From Installed Wind and Solar Power



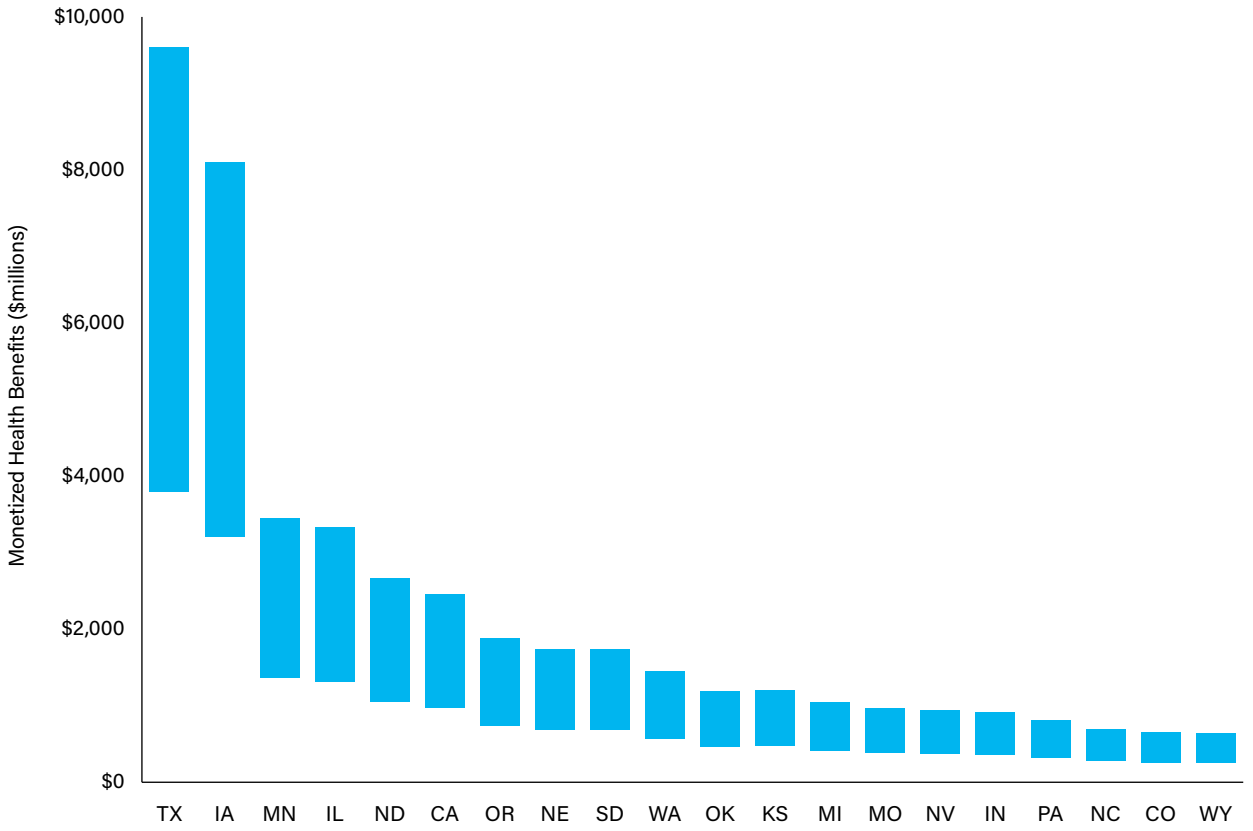
Clean Power Environmental Benefits

Health Benefits

Emissions avoided by clean power generate health impacts with an economic value between $20-$51 billion

- The EPA's CO-Benefits Risk Assessment (COBRA) model estimates the economic value of the health benefits associated with reductions in PM2.5, SO_2, and NO_x, among other pollutants. These health benefits encompass various factors such as avoided deaths, reduced asthma-related emergency room visits, fewer work loss days, and other health impacts associated with pollution. The model estimates the present value of these benefits over a 20-year period resulting from a single-year reduction in emissions.
- Emissions of PM2.5, SO_2, and NO_x that can be avoided due to the total wind and solar capacity installed through 2022 are expected to generate health benefits with an economic value between $20-$51 billion, based on EPA COBRA modeling using a 3% and 7% discount rate.
- As part of the monetized benefits, the model predicts a decrease in mortality between 2,100 and 4,800 cases, as many as 3,300 fewer non-fatal heart attacks, 60,000 fewer cases of asthma exacerbation, and 282,000 fewer work loss days.

Estimated Range of Annual Health Benefits from Emissions Reductions, 2022 Installed Capacity



Source: ACP, EPA COBRA

Clean Power Manufacturing and Trade

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Clean Power Manufacturing and Trade Highlights

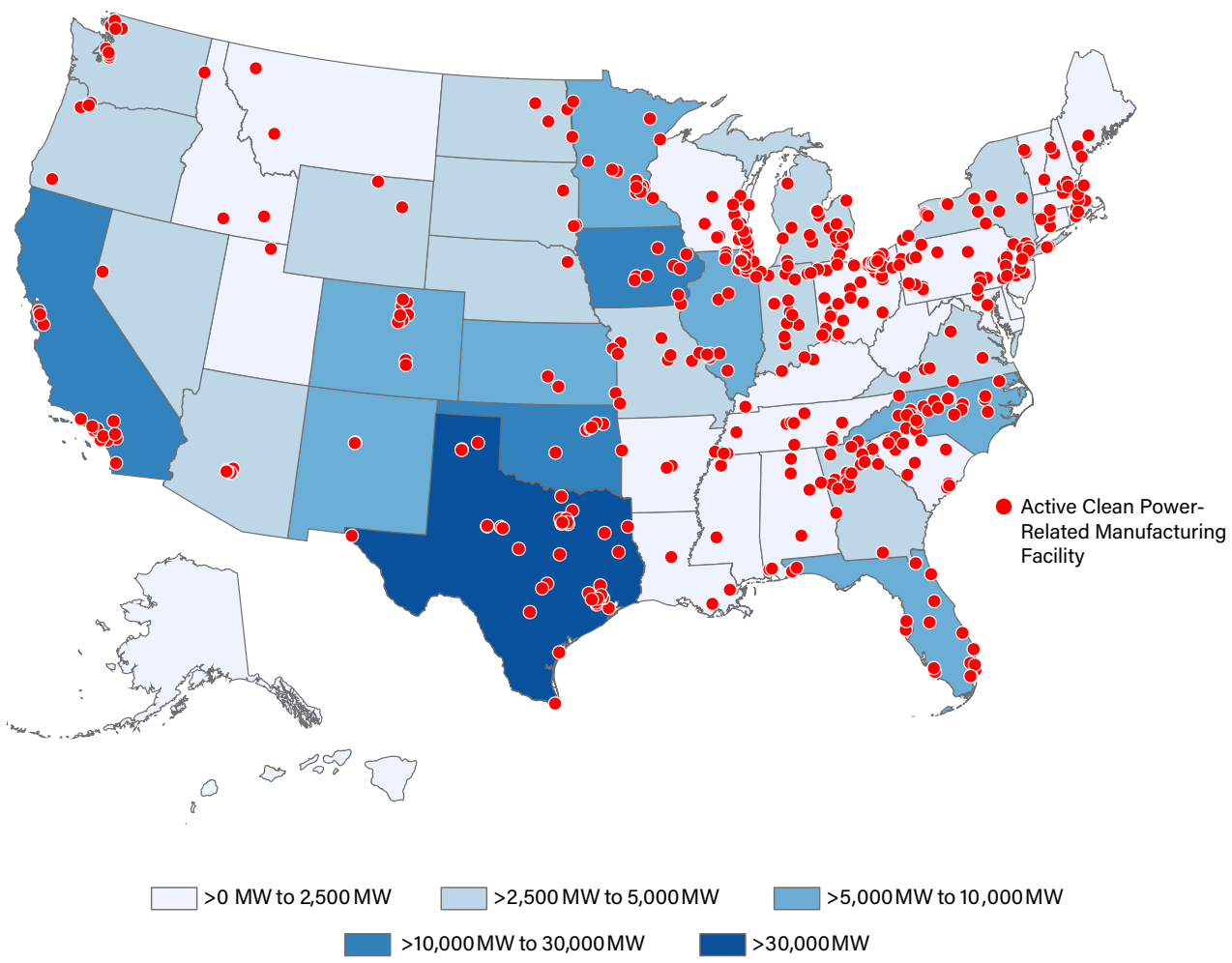
- There are more than 550 active clean power-related manufacturing facilities across the U.S., including 450 wind-related facilities, more than 90 utility-scale solar-related facilities, and 10 major battery manufacturing facilities.
- Domestically, the three active blade plants can produce 3,700 MW annually, and tower production capacity rose to the equivalent of 11,400 MW in 2022.
- In the utility-scale solar space, the U.S. can produce 3 GW of thin-film and 4.4 GW of C-Si solar modules annually.
- Battery energy storage production capacity has steadily increased from just 600 MWh in 2010 to 71 GWh at the end of 2022.
- In 2022, the wind industry imported $2 billion of wind equipment, a 34% decline from 2021.
- America's top wind trading partners include Mexico, India, Spain, Denmark, and Canada. Combined, these five countries account for 80% of wind turbine component imports.
- Due to insufficient domestic supply, the U.S. solar industry must source most modules and cells from other countries, primarily Southeast Asia. In 2022, the solar industry imported $9.3 billion of solar modules, a 48% increase from 2021.
- Plans for increased domestic clean power manufacturing capacity is on the rise as the result of a combination of strong market demand, international trade risks, and the Inflation Reduction Act. From the beginning of 2022 through the end of the first quarter of 2023, the industry has announced 59 new, expanded, or reopened manufacturing facilities that will support at least 18,000 new manufacturing jobs.

Clean Power Manufacturing and Capacity

There are over 550 active clean power-related manufacturing facilities across the U.S.

- As the most mature clean power sector in the U.S., there are nearly 450 wind-related manufacturing facilities in the U.S. Aside from providing major components such as blades, towers, and nacelles, there are hundreds of smaller manufacturers providing other components such as coatings, lubricants, power transmission components, and other raw materials to the wind sector.
- There are over 90 utility-scale solar-related manufacturing facilities in the U.S. including 10 module manufacturers, 20 racking manufacturers, and dozens more manufacturers of other components. In addition, there are 10 major battery manufacturing facilities across the country.
- The Inflation Reduction Act has unleashed a wave of investment in domestic clean power manufacturing. As of March 31, 2023, companies have announced 47 new or expanded manufacturing plants serving wind, solar, and energy storage technologies.

Operating Clean Power Capacity & Manufacturing Facilities by State



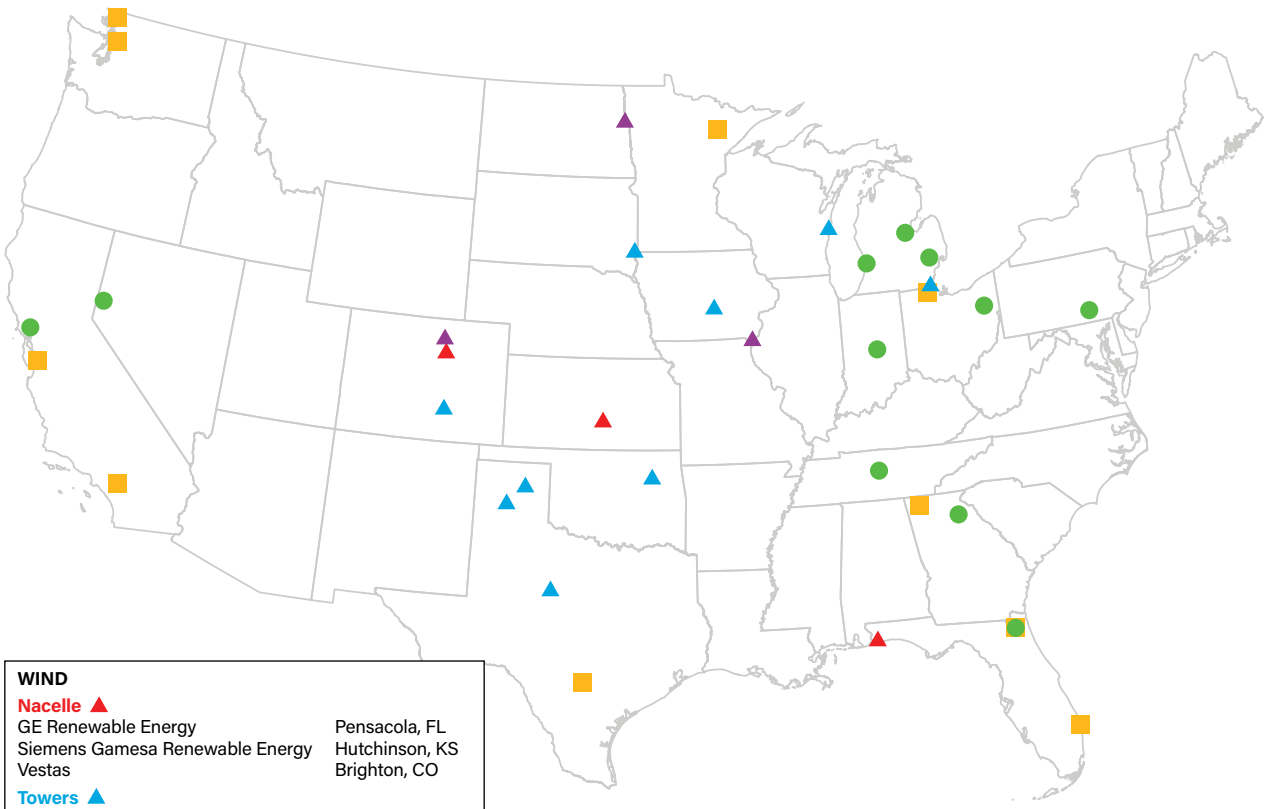
Clean Power Manufacturing and Trade

Major Wind, Solar, Or Storage Manufacturing Locations

Major clean power components are manufactured across the U.S.

- There are at least 35 major clean power manufacturing facilities that make primary components for wind, solar, and battery storage plants. These include 15 wind-related plants, 10 solar module facilities and 11 battery manufacturers.
- In 2022, the iM3NY battery manufacturing plant in Endicott, NY began commercial production. The factory has a production capacity of just 1 GWh a year but the firm has plans to increase capacity to 38 GWh by 2030.
- Also in 2022, Keystone Towers began commercial production of the first utility-scale spiral-welded towers at its new factory in Pampa, TX. This factory is at the site of a former oil and gas facility.

Major Clean Power Component Manufacturing Facilities



WIND

Nacelle

GE Renewable Energy	Pensacola, FL
Siemens Gamesa Renewable Energy	Hutchinson, KS
Vestas	Brighton, CO

Towers

Arcosa	Newton, IA
Arcosa	Tulsa, KS
Broadwind Energy	Abilene, TX
Broadwind Energy	Manitowoc, WI
CS Wind	Pueblo, CO
GRI Renewable Industries	Amarillo, TX
Keystone Towers	Pampa, TX
Marmen Energy	Brandon, SD
Ventower	Monroe, MI

Blades

LM Wind Power	Grand Forks, ND
Siemens Gamesa Renewable Energy	Fort Madison, IA
Vestas	Windsor, CO

SOLAR

Auxin Solar	San Jose, CA
First Solar	Perrysburg, OH
Hanwha Q Cells	Dalton, GA
Heliene	Riviera Beach, FL
Heliene	Mountain Iron, MN
Jinko Solar	Jacksonville, FL
Mission Solar Energy	San Antonio, TX
Silfab	Bellingham, WA
Silfab	Burlington, WA
SunSpark Technology	Riverside, CA

STORAGE

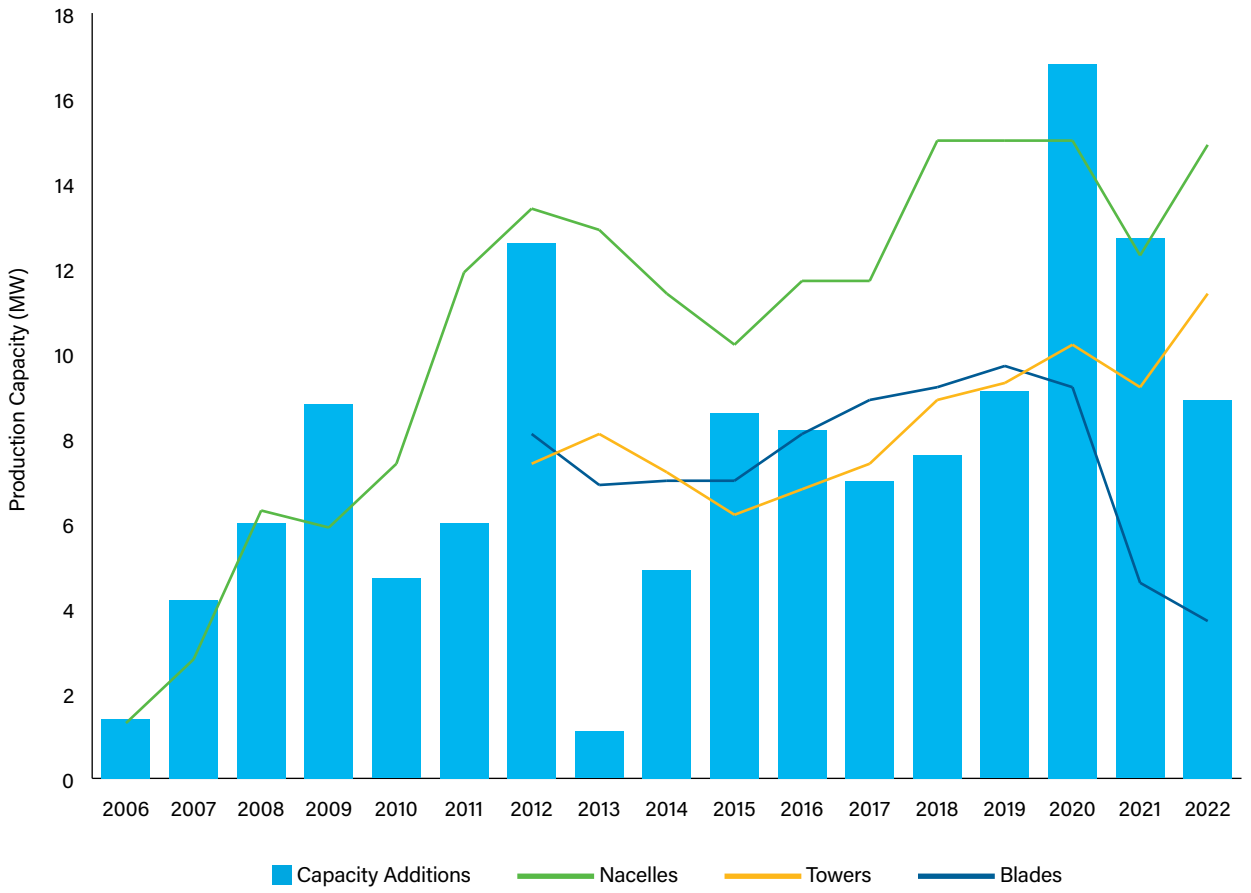
Clarios	Holland, MI
EnerDel	Indianapolis, IN
Envision Energy	Smyrna, TN
iM3NY	Endicott, NY
Saft America	Jacksonville, FL
Samsung SDI	Auburn Hills, MI
SK Battery	Commerce, GA
Tesla, Panasonic	Sparks, NV
Tesla	Freemont, CA
Ultium Cells	Warren, OH
Xalt Energy	Midland, MI

Wind Component Production Capacity

Domestic wind manufacturing steadies as IRA brings incentives and increased demand

- U.S.-based factories make everything from blades, towers, and nacelles to internal components such as bearings, slip rings, brake systems, fasteners, power converters, and sensors. There are over 450 wind-related manufacturing facilities in the U.S. supporting 23,664 manufacturing jobs.
- There are 15 wind-related manufacturing plants located in 10 states that produced wind blades, towers, or nacelles. These plants include three blade facilities, nine tower plants, and three turbine nacelle assembly facilities.
- The transition to manufacturing larger capacity wind turbines led to an increase in estimate production capacities across the three operational nacelle plants in the U.S. GE, Siemens Gamesa, and Vestas combined have the capacity to assemble approximately 15,000 MW annually.
- Wind blade manufacturing capacity held steady in 2022 after a sharp decline in 2021, following three plant closures. The three active blade plants can produce 3,700 MW annually.
- Tower production capacity rose to the equivalent of 11,400 MW as Keystone Towers came online and as turbine capacities have grown.

Domestic Production Capacity of Major Wind Components

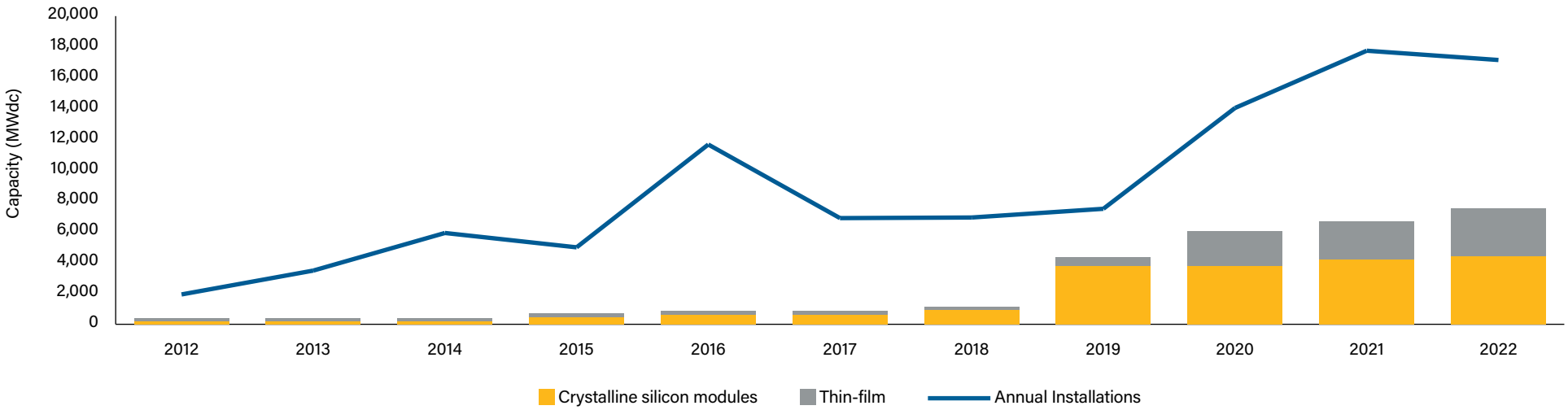


Source: BNEF, ACP

Solar Component Manufacturing Production Capacity

The U.S. can produce 3 GW of thin-film and 4.4 GW of C-Si solar modules annually

U.S. solar module manufacturing capacity, over time



Note: Estimates include excess plant capacity and does not reflect exact annual production estimate

Source: BNEF, ACP

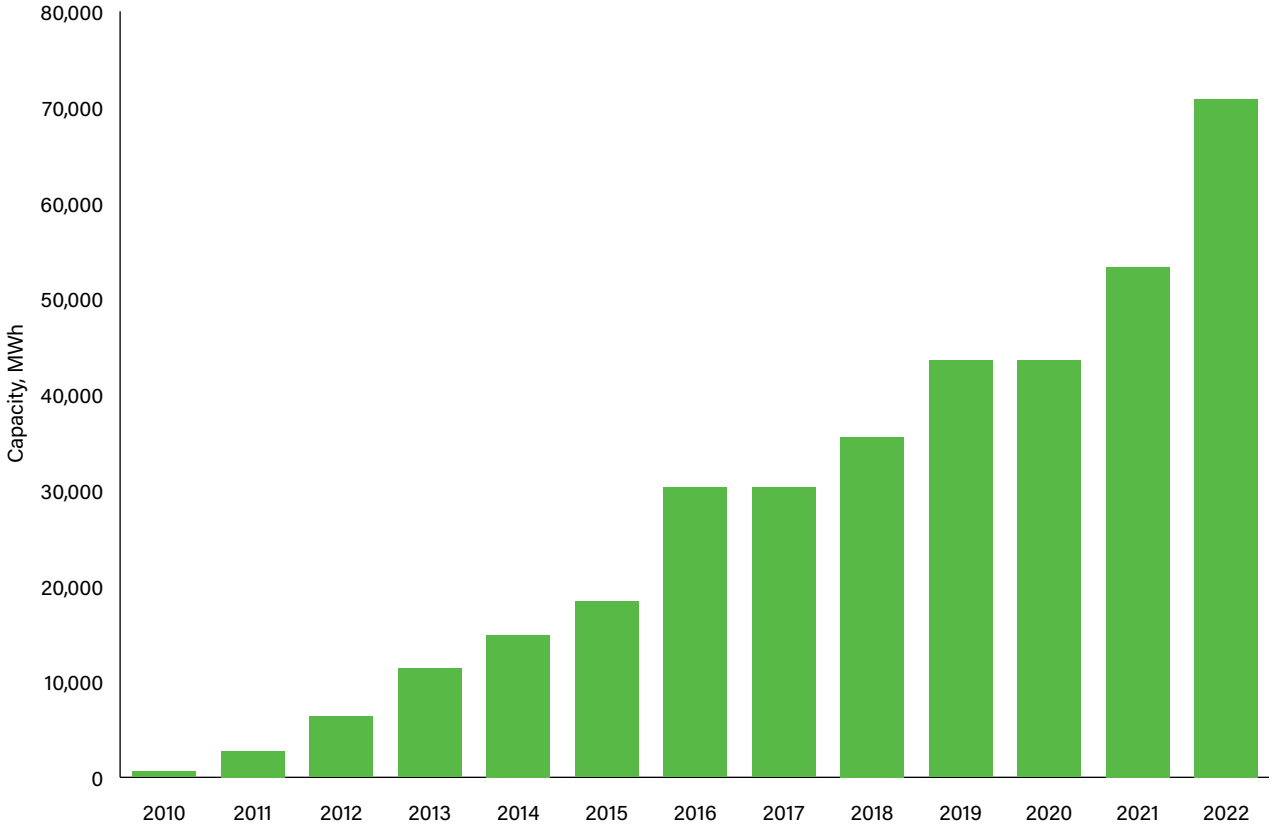
- U.S. solar module manufacturing capacity stood at 7,500 MW at the end of 2021. There are 10 major facilities in the country that can manufacture solar modules, though most of these plants primarily serve the distributed solar market.
- Crystalline silicon (C-Si) module manufacturing capacity stood at 4,400 MW. The largest facility is Hanwha Q-Cells' plant in Georgia which can produce roughly 1,700 MW per year. The next largest manufacturer is Silfab, which can produce ~800 MW per year from its two Washington State plants.
- Thin-film module production capacity is concentrated in Ohio where First Solar currently can produce 3,000 MW per year. The company is expanding its footprint—adding another 3,300 MW of production capacity in Ohio that is expected online in 2023. In 2022, First Solar also announced plans to build a 3,500 MW production facility in the Southeastern United States. That plant is expected online in 2025.
- Plans for increased domestic solar manufacturing are on the rise as the result of a combination of strong market demand, international trade risks, and the Inflation Reduction Act. Through March 31, 2023, companies have announced plans to build 27 solar manufacturing facilities.
- Nonetheless, domestic solar module production is, and will likely remain, insufficient to meet U.S. demand by a sizable margin. Total solar module production capacity stood at 7,500 MW-dc at the end of 2022 compared to utility-scale installations of 17,000 MW-dc. Moreover, the U.S. does not have any solar wafer or solar cell manufacturing facilities. However, in December of 2022, Cubic PV announced the construction of a new wafer manufacturing facility in Massachusetts, demonstrating the move to on-shore solar manufacturing.
- There are two active solar polysilicon producers in the US—Wacker in Tennessee and Hemlock Semiconductor in Michigan. A third, REC Silicon in Washington, is inactive but restarting operations.

Battery Cell Production Capacity

Domestic battery cell manufacturing jumps to 71 GWh

- Battery energy storage production capacity has steadily increased from just 600 MWh in 2010 to 71 GWh at the end of 2022.
- Battery manufacturing in the U.S. is primarily set up to serve the electric vehicle market, with most focusing on nickel manganese cobalt chemistries. Battery storage facilities typically utilize lithium iron phosphate chemistries.
- There are ten battery cell manufacturing facilities spread across five states, including three new facilities commissioned in 2022. Tesla in California, iM3NY in New York and Ultium Cells in Ohio are the latest additions to the manufacturing fleet.
- The Tesla/Panasonic plant in Nevada has, by far, the largest production capacity at 32 GWh, tripling the size of the next largest facility. In 2022, the company added 10 GWh of capacity at its Freemont, CA facility.
- ACP is tracking 10 announced battery storage manufacturing plants with intentions to serve the grid storage market. Spread across seven states, these plants will deliver the first grid storage-focused manufacturing capabilities to the U.S. market.

U.S. Battery Manufacturing Capacity



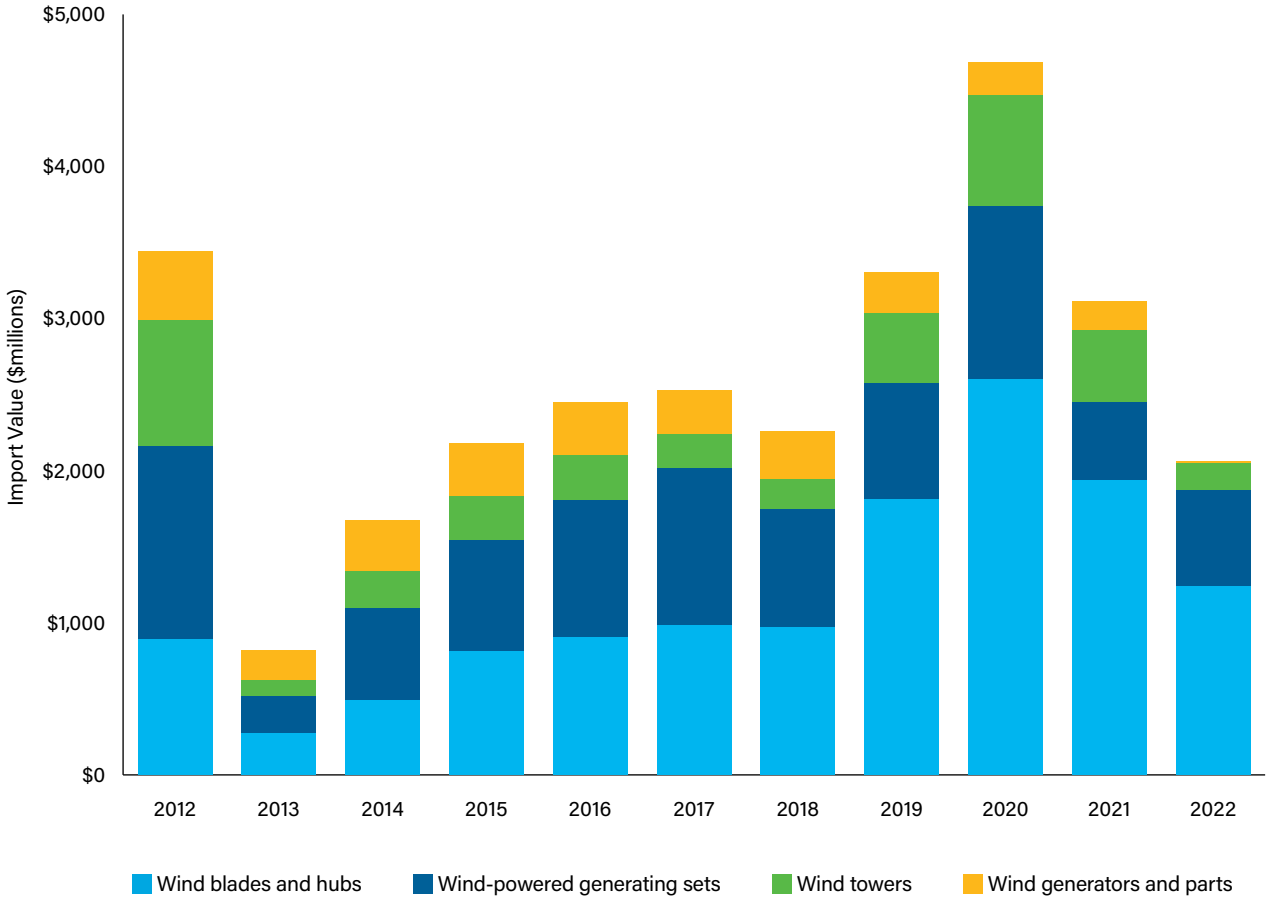
Source: BNEF

Imports of Major Wind Components

Wind imports fell 34% in 2022 as market slowed

- The U.S. wind industry has a robust domestic manufacturing footprint with over 450 facilities supplying parts and components. Nonetheless, the industry does require imports to fully service demand.
- In 2022, the wind industry imported $2 billion of wind equipment across four categories of tracked products: wind generating sets, wind towers, wind blades and hubs, and wind generators and parts. Imports fell 34% in 2022 after falling 33% in 2021. Import volumes were at their lowest level since 2015.
- Wind equipment import levels typically follow deployment trends. Significant imports in 2012 gave way to minimal volumes in 2013. Slow to recover, imports reached a record level in 2020 alongside record installation volumes. Since then, imports have fallen as the market has slowed. Blade and hub imports account for most wind equipment imports.
- Imports of wind generators and parts fell to just $16 million in 2022, the lowest level on record. Tower imports have fallen to volumes not seen since 2013.

Major Wind Component Imports

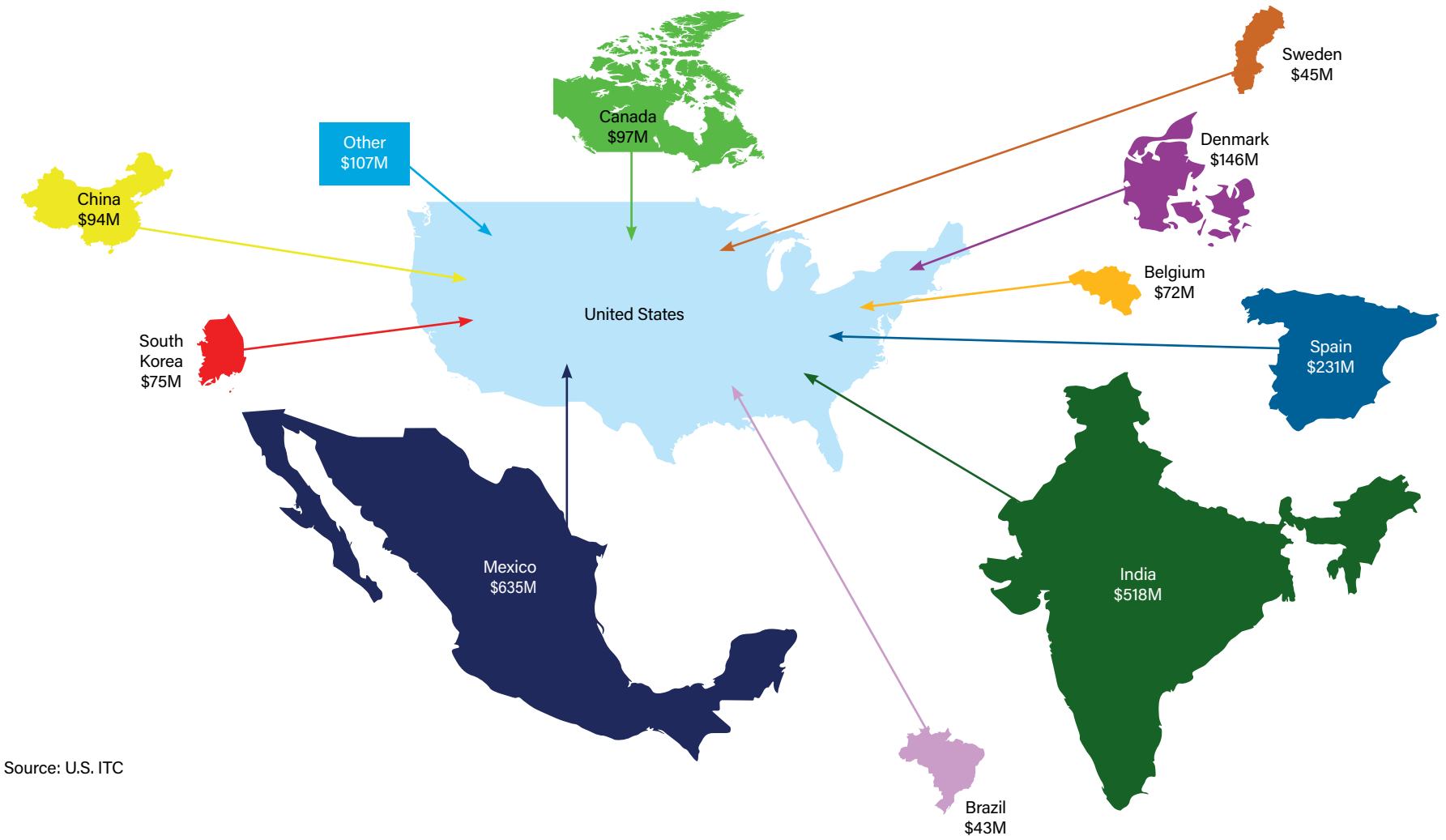


Source: U.S. ITC

Wind imports from around the globe

Mexico, India, and Spain account for two-thirds of wind imports

Wind Component Imports



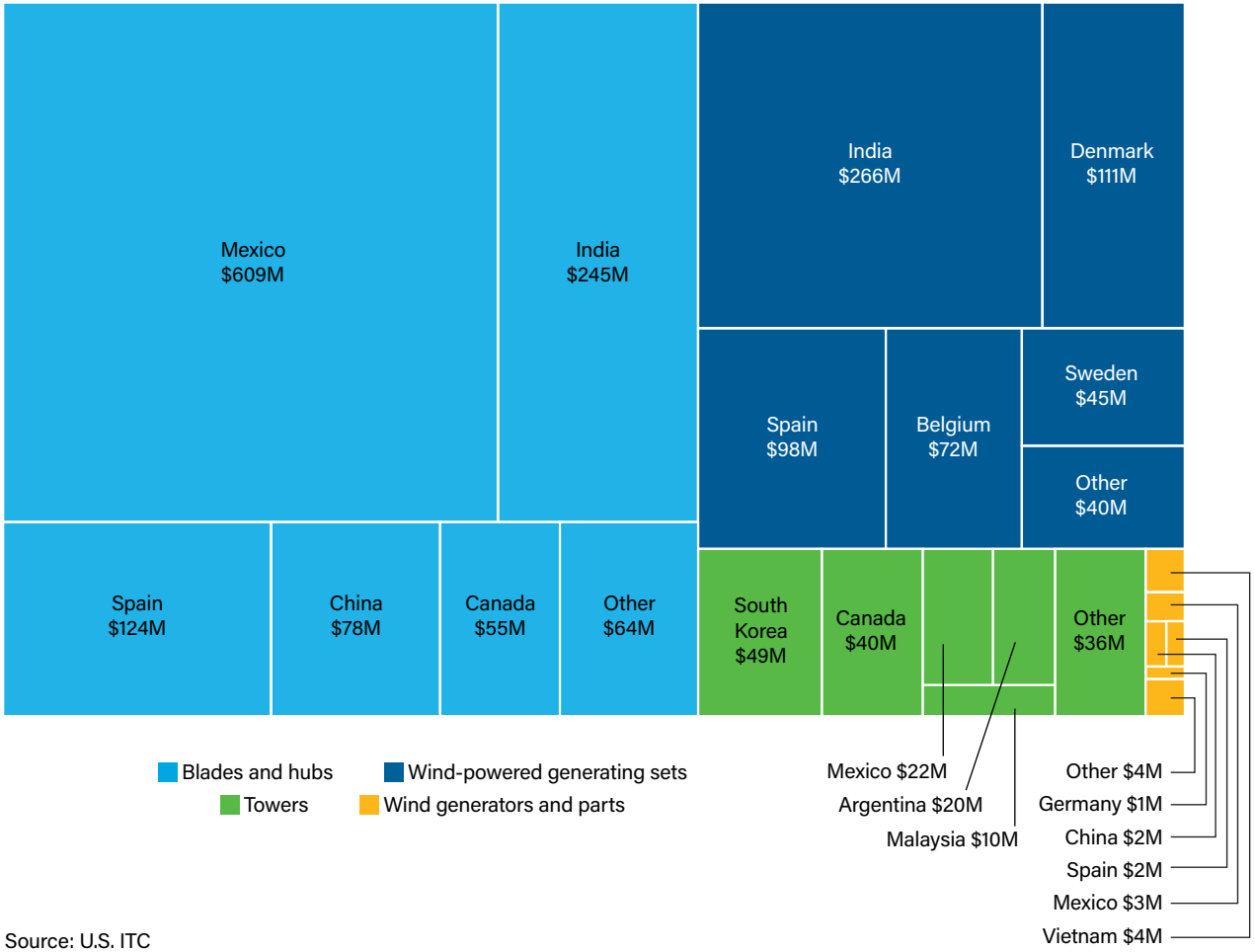
Source: U.S. ITC

Wind Component Import Origin

Mexico accounts for 30% of U.S. wind component imports

- America's top wind trading partners include Mexico, India, Spain, Denmark, and Canada. Combined, these five countries account for 80% of wind turbine component imports.
- Mexico is the largest source of wind turbine blades and hubs. The southern neighbor provided $609 million worth of the component in 2022, equal to just over half of all blade and hub imports. India is a distant second at 21% of imports, while Spain provided 11%. Blades and hubs represent 59% of all imported wind components.
- India is the single largest source of wind-powered generating sets—providing 42%. Comprised of a complete nacelle and rotor, generating sets represent 32% of imported wind components in 2022.
- Towers represent just 9% of imported wind components, with South Korea being the largest provider at 28%. Canada was the source of 23% of tower imports for the year, followed by Mexico which provided 13%.
- Wind generators and parts made up just 1% of imports. Vietnam, Mexico, and Spain were the largest contributors.

Origin of U.S. Wind Component Imports



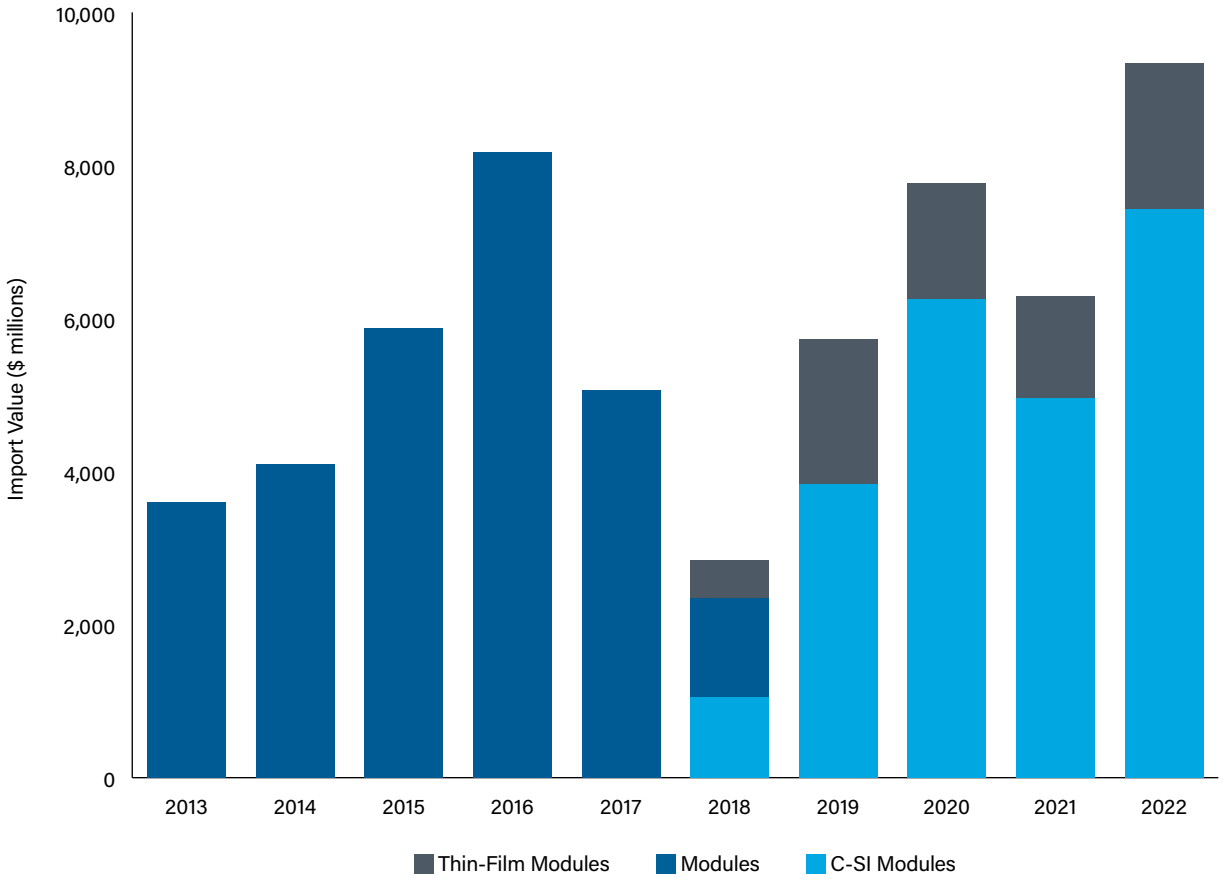
Source: U.S. ITC

Solar Module Imports

Silicon-based modules dominate imports; 80% of solar modules are C-Si

- There is insufficient domestic production of solar modules to serve the entire residential, commercial, and utility-scale solar power industry. Domestic facilities can produce an estimated 7.5 GWdc, far short of the 17 GWdc of utility solar built in 2022. As a result, the industry must source modules and cells from other countries, primarily those in Southeast Asia.
- In 2022, the solar industry imported $9.3 billion of solar modules, including $7.4 billion of C-Si modules and $1.9 billion of thin-film modules. This represents a 48% increase in module imports compared to 2021. Rising demand and increasing module prices are the primary factors for the increase.
- Strong import activity in 2022 represents a turnaround from a 19% decline in solar module imports in 2021. This turnaround is the result of a few factors: 1) recovery from COVID-related supply chain issues, including factory closures and falling freight costs; 2) policy clarity from the Presidential tariff waiver; and 3) strong deployment volumes as previously delayed projects got underway. As a result, both C-Si and thin-film module imports set new records for the value imported in 2022.
- Thin-film modules primarily originate in either Malaysia or Vietnam where First Solar has manufacturing facilities. As discussed later, the top providers of C-Si modules are Vietnam, Thailand, South Korea, Cambodia, and Malaysia.

Solar Modules Imports by Type



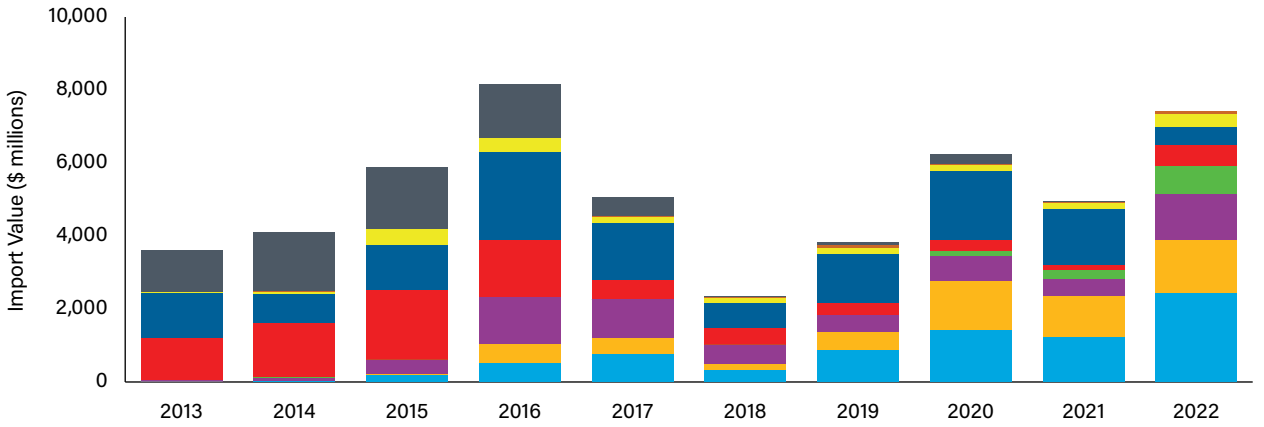
Source: U.S. ITC; Prior to July 2018, all imported modules were classified under a single code.

Solar Silicon Module and Cell Imports

Solar imports fell 18% in 2021 due to regulatory barriers

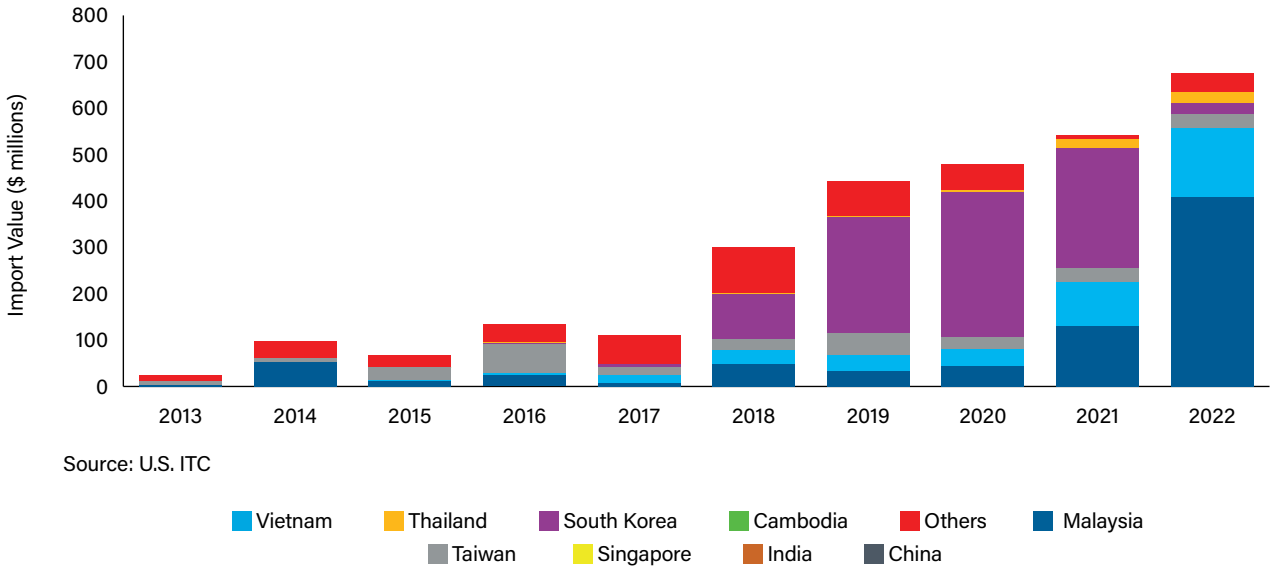
- Following a significant drop in solar module imports in the last four months of the year, imports were slow to rebound in 2022 as the Customs and Border Protection's Withhold Release Order (WRO) and and the pending ruling in the Auxin Petition weighed on markets. Ultimately, the President's Waiver program reinvigorated trade flows.
- Monthly C-Si import volumes eventually reached record levels as the industry brought in over $1 billion of product in December 2022. Again, rising demand following the passage of the IRA combined with relatively high prices are major factors in this spike.
- Vietnam, Thailand, South Korea, and Cambodia account for 80% of silicon solar module imports. Malaysia and Singapore account for a further 12% of the market. Prior to 2022, Malaysia was the top source of silicon solar panels. The Southeast Asian country was replaced by Vietnam last year.
- 86% of solar module imports originate in Malaysia, Vietnam, Thailand, and Cambodia. This includes thin-film modules. South Korea is also a major source, accounting for 8% of module imports. China used to be a primary source of modules, but trade barriers have rendered Chinese modules uneconomic.
- Malaysia supplanted South Korea as the largest provider of silicon solar cells in 2022. Capturing 60% of the market, Malaysia tripled the value of its solar cell imports to the U.S. from 2021. Conversely, South Korean solar cell imports fell 90% in 2022. Vietnam originated 22% of solar cell imports to the U.S.

Solar Silicon Module Imports by Country



Source: U.S. ITC

Solar Cell Imports



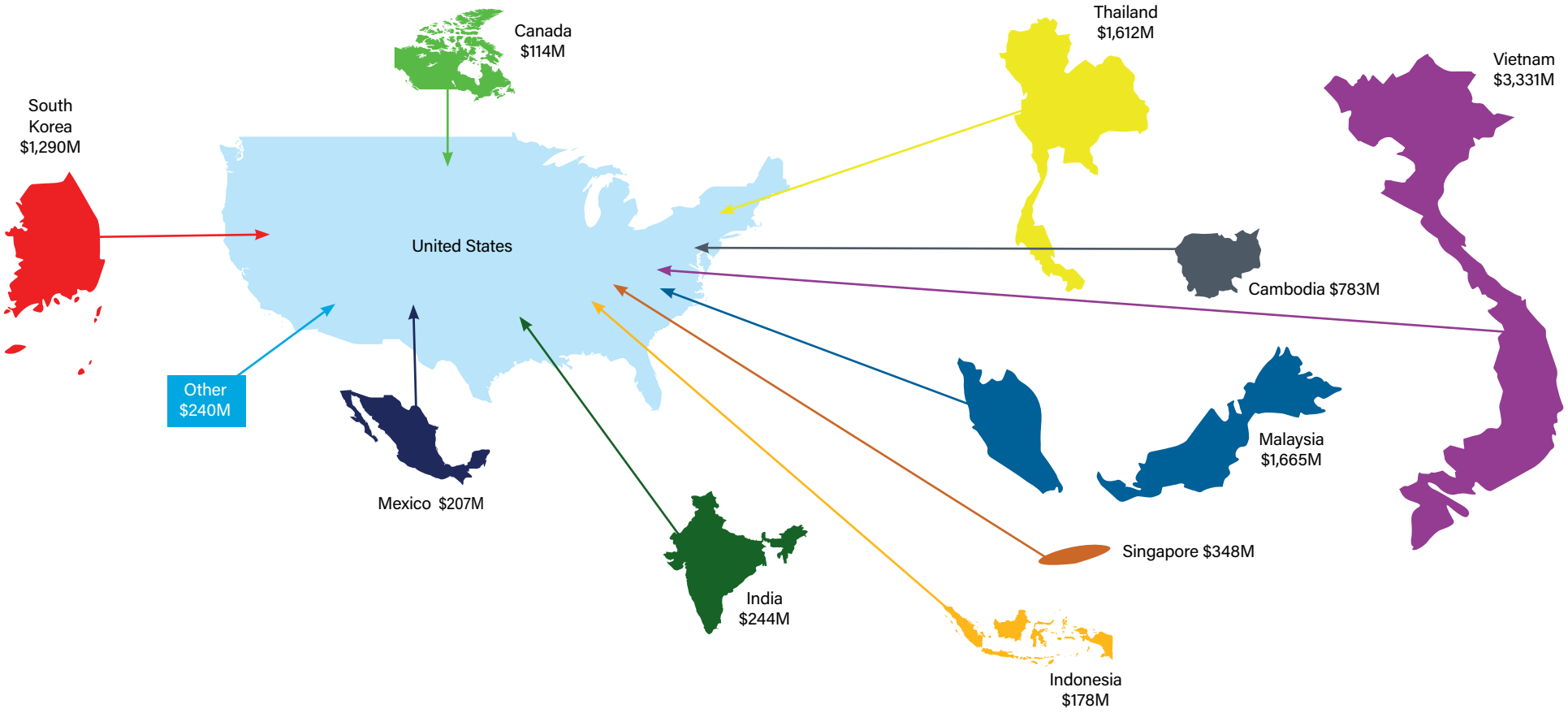
Source: U.S. ITC

Clean Power Manufacturing and Trade

Solar Imports From Around the Globe

Vietnam, Malaysia, and Thailand account for 66% of solar imports

Solar Component Imports



Source: U.S. ITC; includes solar modules and cells

Clean Power Manufacturing Announcements

59 New, expanded, or reopened manufacturing facilities announced

- The clean energy industry is investing heavily in domestic manufacturing capabilities. Since the beginning of 2022, clean energy manufacturers have been rapidly announcing new manufacturing capacity to support the clean energy supply chain across wind, solar, and battery storage.
- From the beginning of 2022 through the end of the first quarter of 2023, the industry has announced 59 new, expanded, or reopened manufacturing facilities. This includes 29 new solar manufacturing plants, 19 new grid-scale battery storage manufacturing facilities or facility expansions, 8 wind power manufacturing plants, and three offshore wind manufacturing facilities.
- These facilities are anticipated to create at least 18,000 new manufacturing jobs.

Location to Be Determined

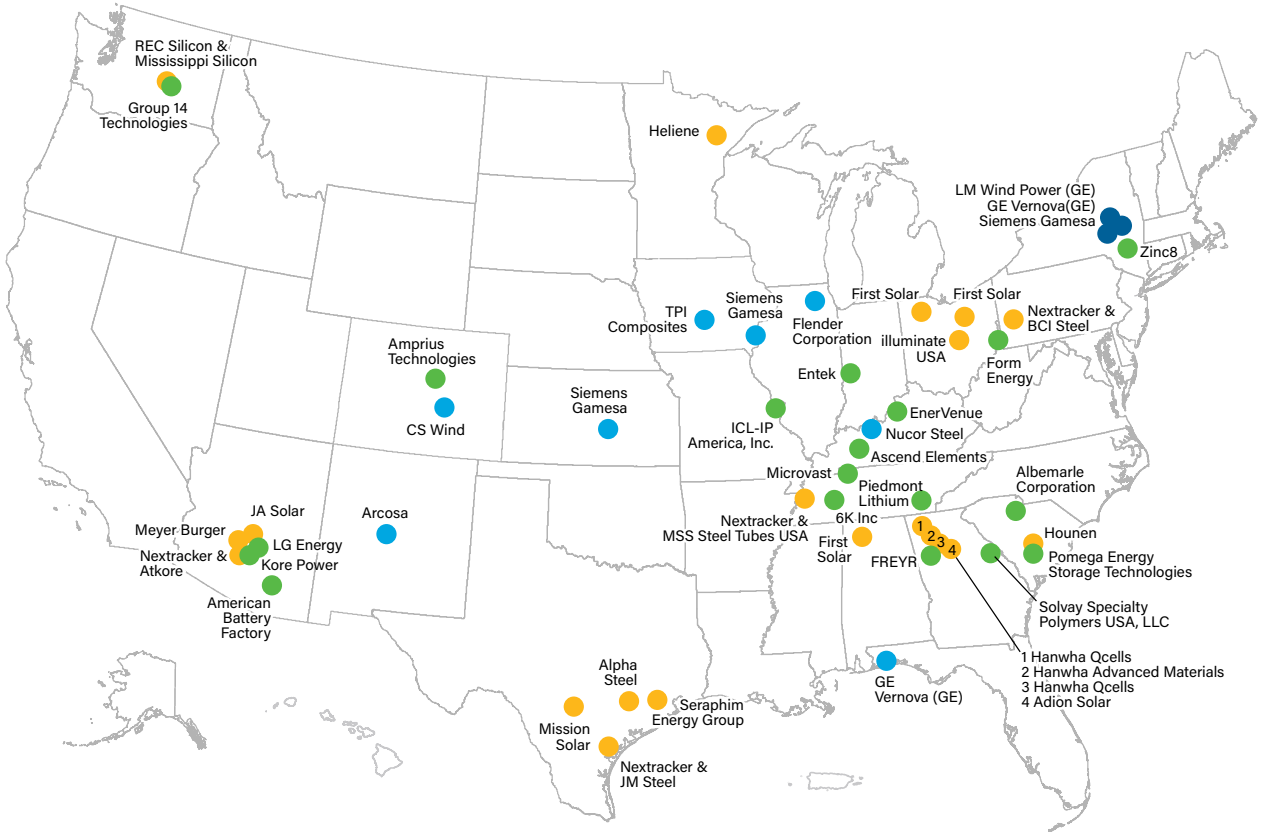
Solar

GameChange Solar	CubicPV
Enphase Energy	Mitrex
SolarEdge	Trading Philadelphia
Enel	Linton Crystal Technologies
Canadian Solar	PV Hardware

Battery

Hanwha & LG Energy Solutions

Utility-scale Clean Power Manufacturing Announcements since January 2022



Pricing and Cost

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Pricing and Cost Highlights

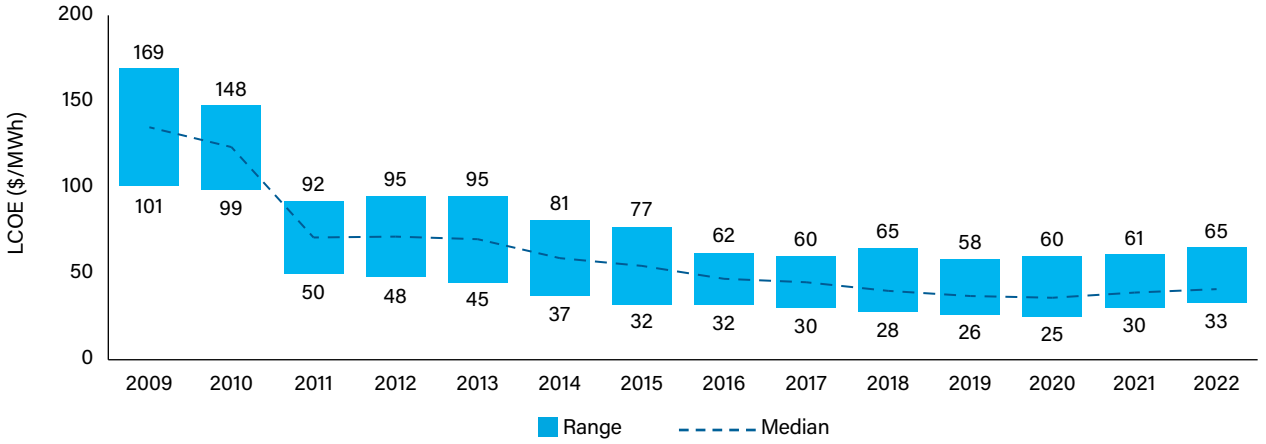
- Thanks to larger and more efficient turbines, the levelized cost of energy (LCOE) of wind power plants has dropped 42% in the last decade to $41/MWh. The LCOE of solar has decreased 57% over the last 10 years thanks to advances in module efficiency, increasing project size and scale, advances in operations and maintenance strategies, and better output performance. Despite the overall decline, both technologies experienced price increases over the past two years due to supply chain challenges and higher supply chain costs.
- The levelized cost of a four-hour duration energy storage facility serving energy markets in the U.S. ranged from $160-$287/MWh in 2022, while the average levelized cost of a solar plus storage facility ranged from $58-$188/MWh. For the first time, the IRA adds energy storage as an eligible technology to claim the Investment Tax Credit on a stand-alone basis. This increases the cost-competitiveness of the technology and expands the potential use cases.
- On an unsubsidized basis, wind and solar are the lowest cost sources of new electricity generation. Fold in tax benefits and the cost position of these technologies further improves.
- Commodity and freight prices have cooled from the record highs set in 2021, but they remain elevated compared to pre-pandemic levels.
- Global wind turbine prices fell slightly in 2022 to $840,000 per MW after peaking at $890,000 per MW in 2021. This 6% reduction reflects easing supply chain, logistics, and commodity price pressures.
- At the end of 2022, solar modules bound for the U.S. were up 14% in price compared to 2021, and priced 54% higher than the global average of 24 cents per watt.
- Year-over-year, the average corporate wind PPA price increased 27%, while the average solar PPA price increased 33%, according to LevelTen Energy.

Wind and Solar Levelized Cost of Energy

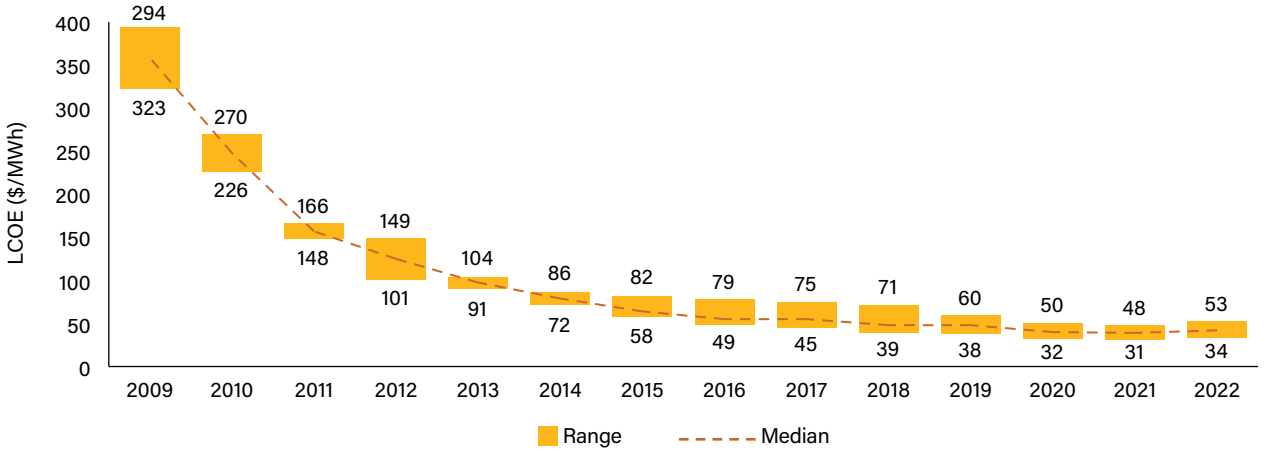
Despite recent cost increases, wind and solar costs remain competitive

- Levelized cost of energy (LCOE) is the lifetime price level that developers/owners of renewable energy projects need to secure to cover project and operational costs and receive a reasonable profit margin for their work bringing the project to market. As generation technologies that do not rely on fuel to produce electricity, technological advances that lead to falling turbine and solar module costs translate quickly to reductions in LCOE.
- The unsubsidized (not considering tax credits) LCOE of wind power plants has dropped 42% in the last decade to $41/MWh. Larger and more efficient turbines that capture the blowing winds have contributed to an increase in the overall output of wind projects, bringing down the incremental cost of energy production. Operational expertise and efficiency complement capital cost reduction and performance improvements.
- The cost of producing electricity from solar has declined 57% in the last 10 years thanks to advances in module efficiency, increasing project size and scale, advances in operations and maintenance strategies, and better output performance.
- Both technologies suffered cost increases over the last two years as supply chain challenges, logistics cost increases, higher commodity prices, and macroeconomic inflationary pressure impacted the industry. Despite the increase, wind and solar remained economically competitive.
- When including tax benefits, the realized cost of clean power is even lower, ranging from $19-$44/MWh for wind and $26-$40/MWh for solar.

Wind Levelized Cost of Energy



Solar Levelized Cost of Energy



Source: BNEF, Lazard
Does not include tax benefits

Levelized Cost of Storage and Hybrid Systems

Energy storage systems gain competitiveness

- The levelized cost of a four-hour duration energy storage facility serving energy markets in the U.S. ranged from $160-$287/MWh, down significantly from a range of $347-$739/MWh in 2015.
- These projects capture value from energy arbitrage—charging using low-cost electricity and discharging when prices are higher—frequency regulation, capacity provisioning, and/or serving as non-spinning reserves.
- The levelized cost of hybrid facilities pairing solar generation with battery storage have also declined over the past four years. In 2022, the average levelized cost of a solar plus storage facility ranged from $58-$188/MWh. The exact configuration of these hybrid plants plays a big role in the cost profile.
- For the first time, the Inflation Reduction Act adds energy storage as an eligible technology to claim the Investment Tax Credit on a stand-alone basis. This increases the cost-competitiveness of the technology and expands the potential use cases.

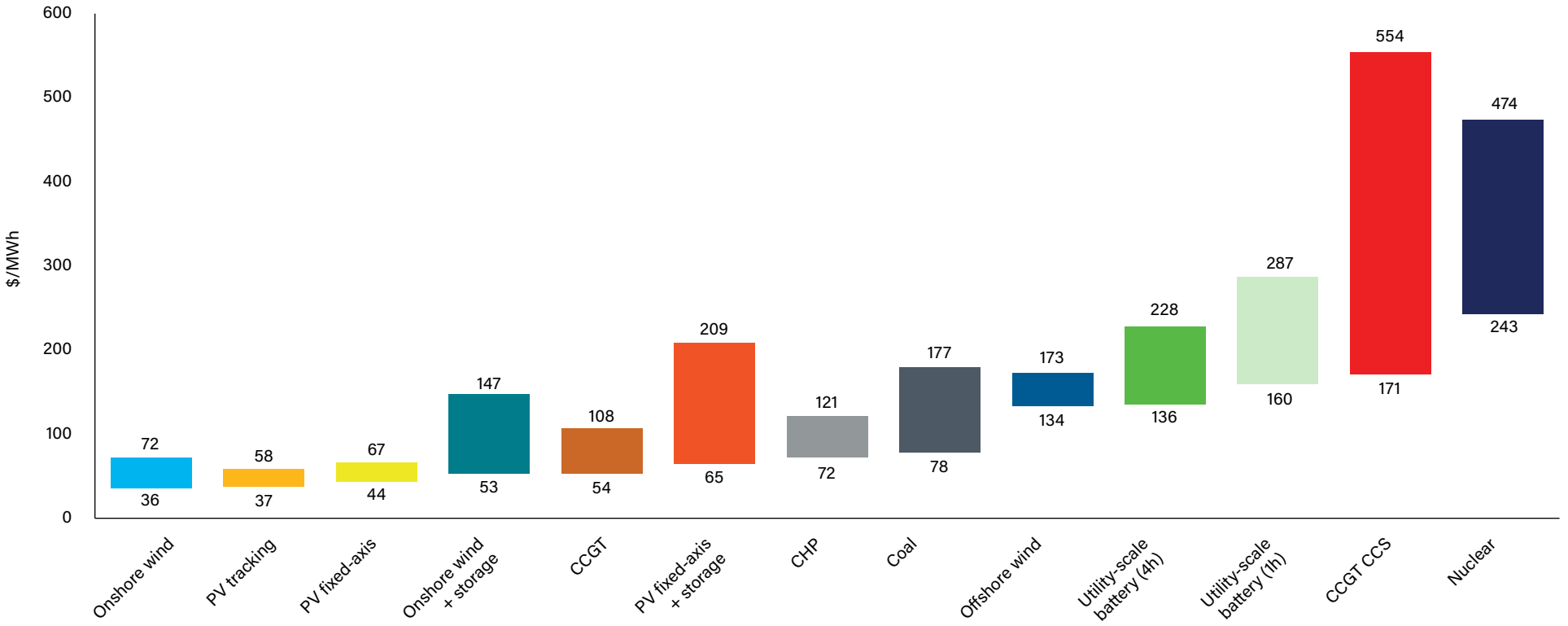
4-Hour Energy Storage and Solar + Storage Levelized Cost

Source: Lazard

Current Levelized Cost of Energy Comparison

Clean power technologies are the most cost-effective source of new power

Current Levelized Cost of Energy Comparison



Source: BNEF
Does not include tax benefits

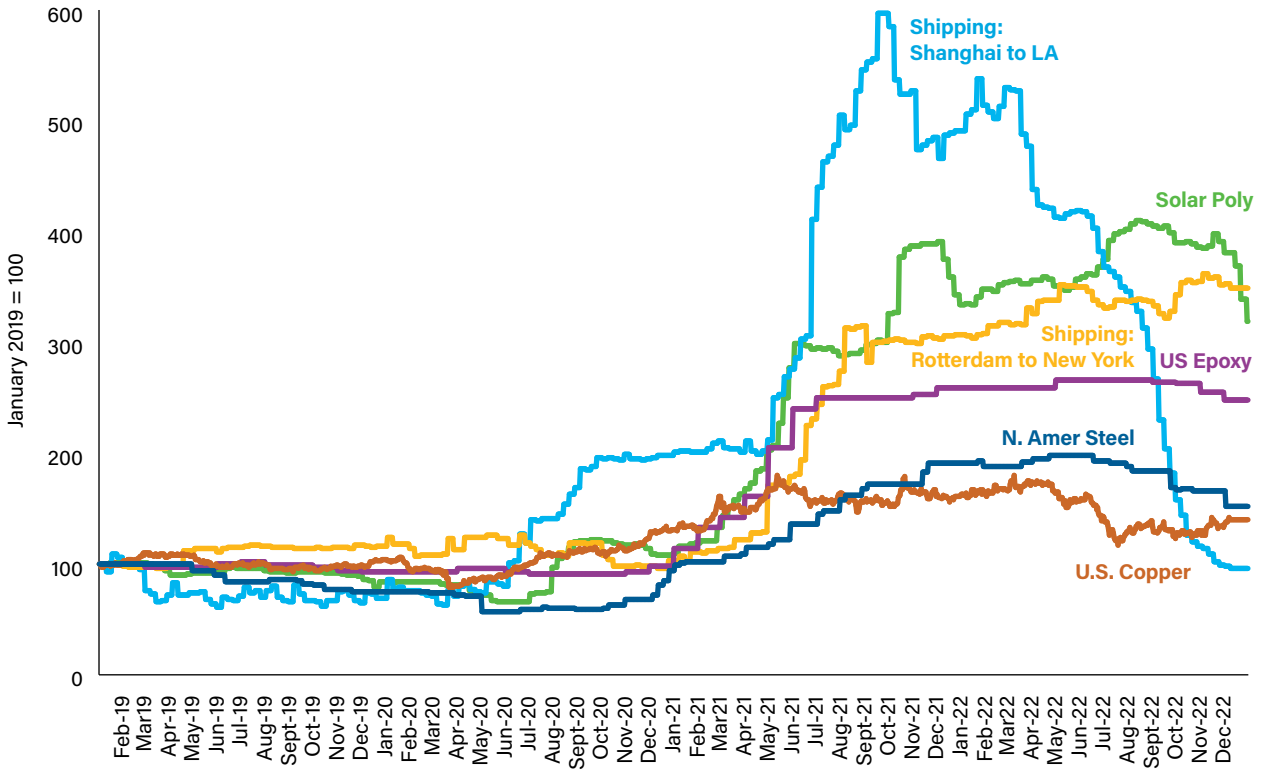
- On an unsubsidized basis, wind and solar are the lowest cost sources of new electricity generation. Fold in tax benefits and the cost position of these technologies improves further. In some cases and parts of the country, it is more cost-effective to replace existing fossil fuel plants with wind or solar than it is to continue to operate the existing power plant.

Commodity prices cool from 2021 peak

Volatile commodity prices are at the heart of recent clean power cost increases

- Commodity and freight prices have cooled from the record highs set in 2021, but they remain elevated compared to pre-pandemic levels. Freight from Europe to the U.S. remains 250% above 2019 prices, while North America steel is 1.6 times higher.
- Copper, critical in all electrical applications, fetched a 40% premium over pre-pandemic prices at the end of 2022. Epoxy prices have surged 2.5 times higher. Shipping from China to the West Coast is the sole commodity that has returned to pre-pandemic price levels.
- While the other commodities examined here have fallen from record price peaks in 2021, solar polysilicon prices remain elevated at near-peak levels. At the end of 2022, poly prices were 3.2 times higher than 2019 levels. High demand and production outages are chief factors.
- There does appear to be some softening in polysilicon prices in early 2023 as production outages cease and new production lines come online.

Commodity Price Index



Source: BNEF

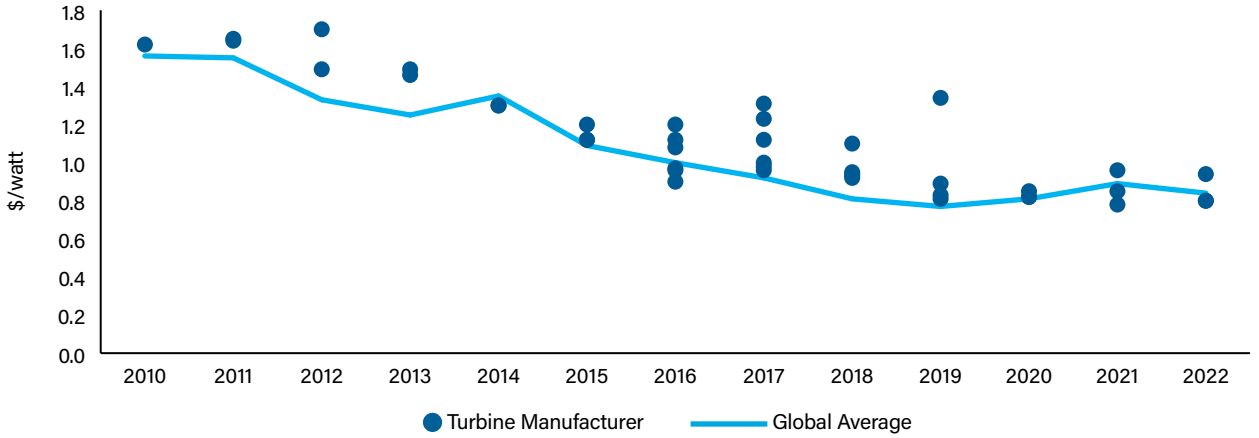
Turbine and Module Prices

Prices climb after years of decline

- Global wind turbine prices fell slightly in 2022 to $840,000 per MW after peaking at $890,000 per MW in 2021. This 6% reduction reflects easing supply chain, logistics, and commodity price pressures. These prices exclude Chinese turbine prices.
- Technology advancement has enabled wind power to absorb a portion of these higher costs and keep levelized energy costs flat or down. Longer blades, taller towers, better siting strategies, and digital technology advances all help the turbine perform better—ultimately delivering more electricity at a lower cost.
- Global and U.S. bound solar module prices are on divergent trends. Throughout 2022, global solar module prices fell 11%, while modules bound for the U.S. market rose 14% to roughly 35 cents per watt. At the end of 2022, modules bound for the U.S. were priced 54% higher than the global average of 24 cents per watt.
- In the U.S., module prices are challenged by trade barriers, congested ports, the Withhold Release Order (WRO), and continued uncertainty related to the Auxin petition.

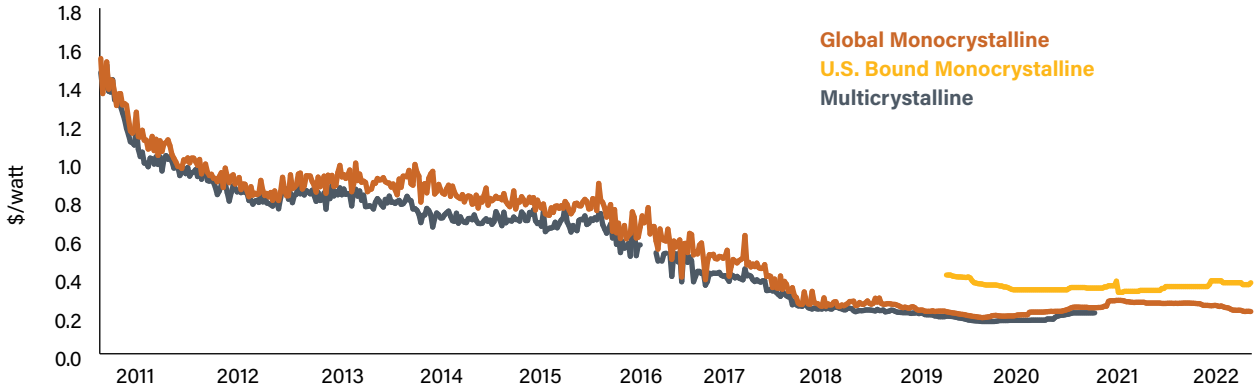
Global Wind Turbine Price Index

Wind Turbine Price Index



Source: BNEF; Excludes Chinese turbine prices

Solar Module Price Index



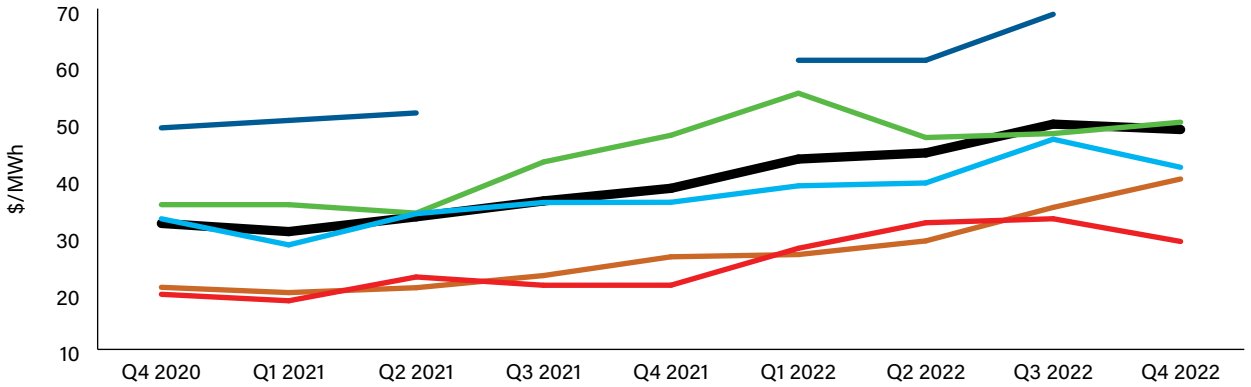
Source: BNEF

Corporate PPA Price Index

Parallel increase of PPA prices and wholesale electricity prices

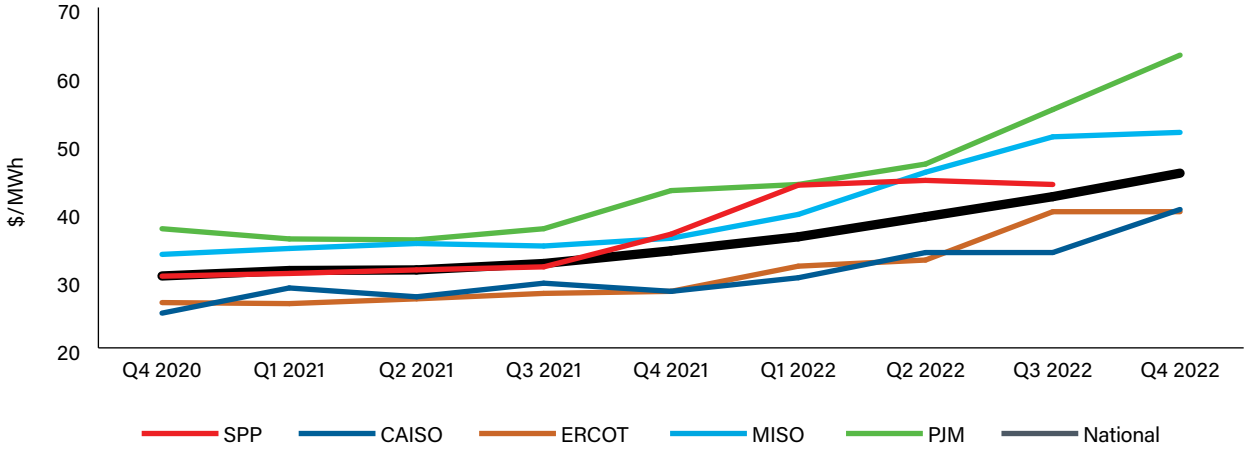
- LevelTen Energy reported that the market-averaged national price index for corporate PPAs in wind and solar reached a record high of $47.19/MWh in Q4. This represents a 3% increase from the previous quarter and a substantial 30% increase year-over-year.
- While the wind PPA price experienced a slight 2% decline in the fourth quarter, year-over-year the wind PPA price increased by 27% in 2022, compared to a 19% increase in 2021.
- The national corporate solar PPA index also grew, reaching $45.66/MWh, a significant 33% increase from the previous year. The solar PPA index exhibited an average 7% quarterly increase in 2022.

Wind PPA Prices, Q4 2020 – Q4 2022



Source: LevelTen Energy

Solar PPA Prices, Q4 2020 – Q4 2022

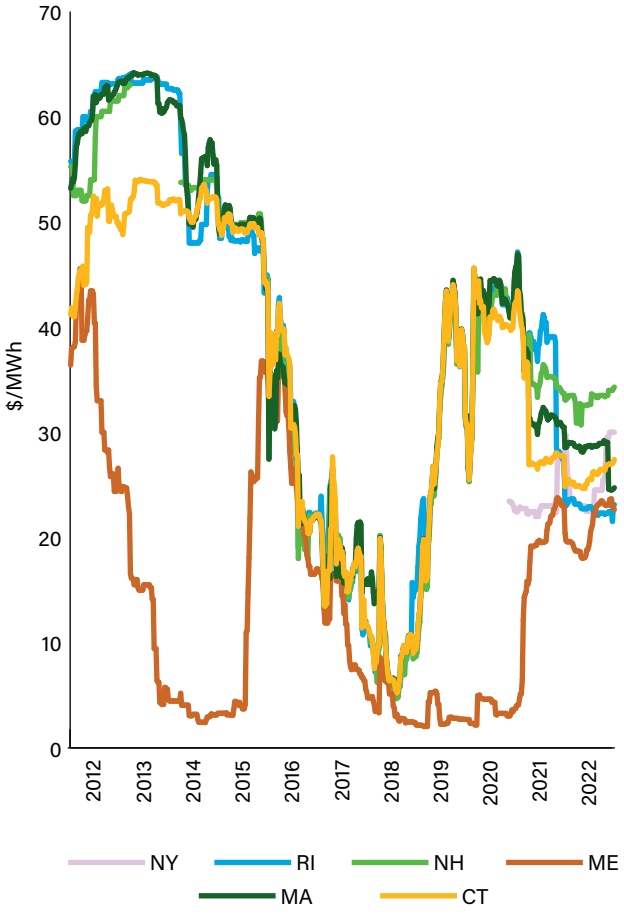


Source: LevelTen Energy

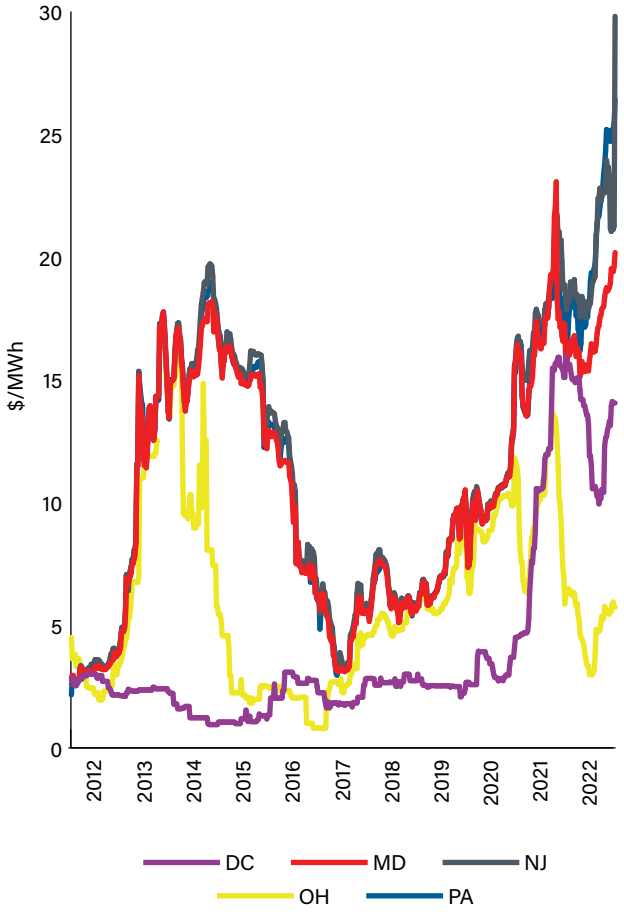
Renewable Energy Credit (REC) Prices

REC prices mixed in 2022

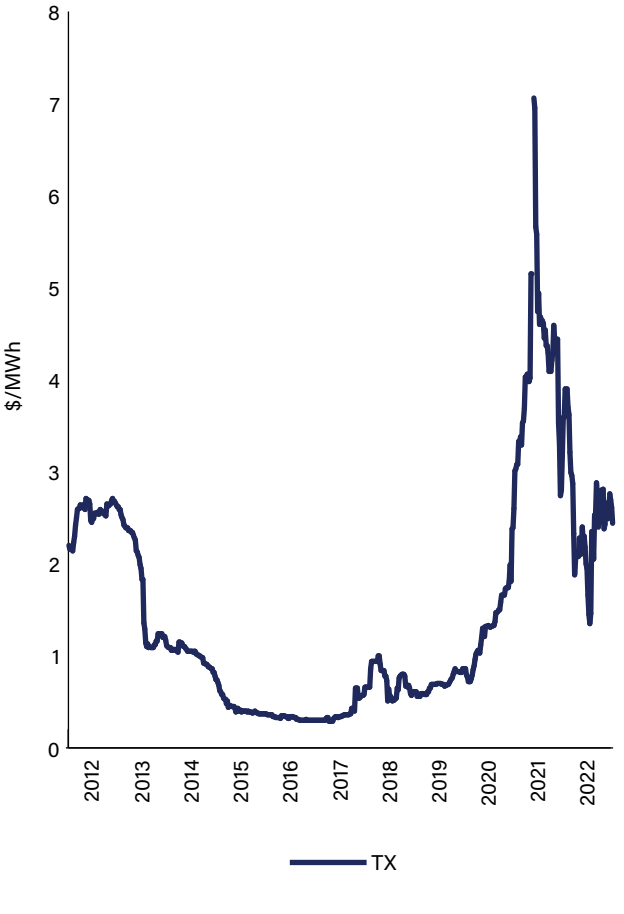
NEW ENGLAND AND NEW YORK



PJM



TEXAS



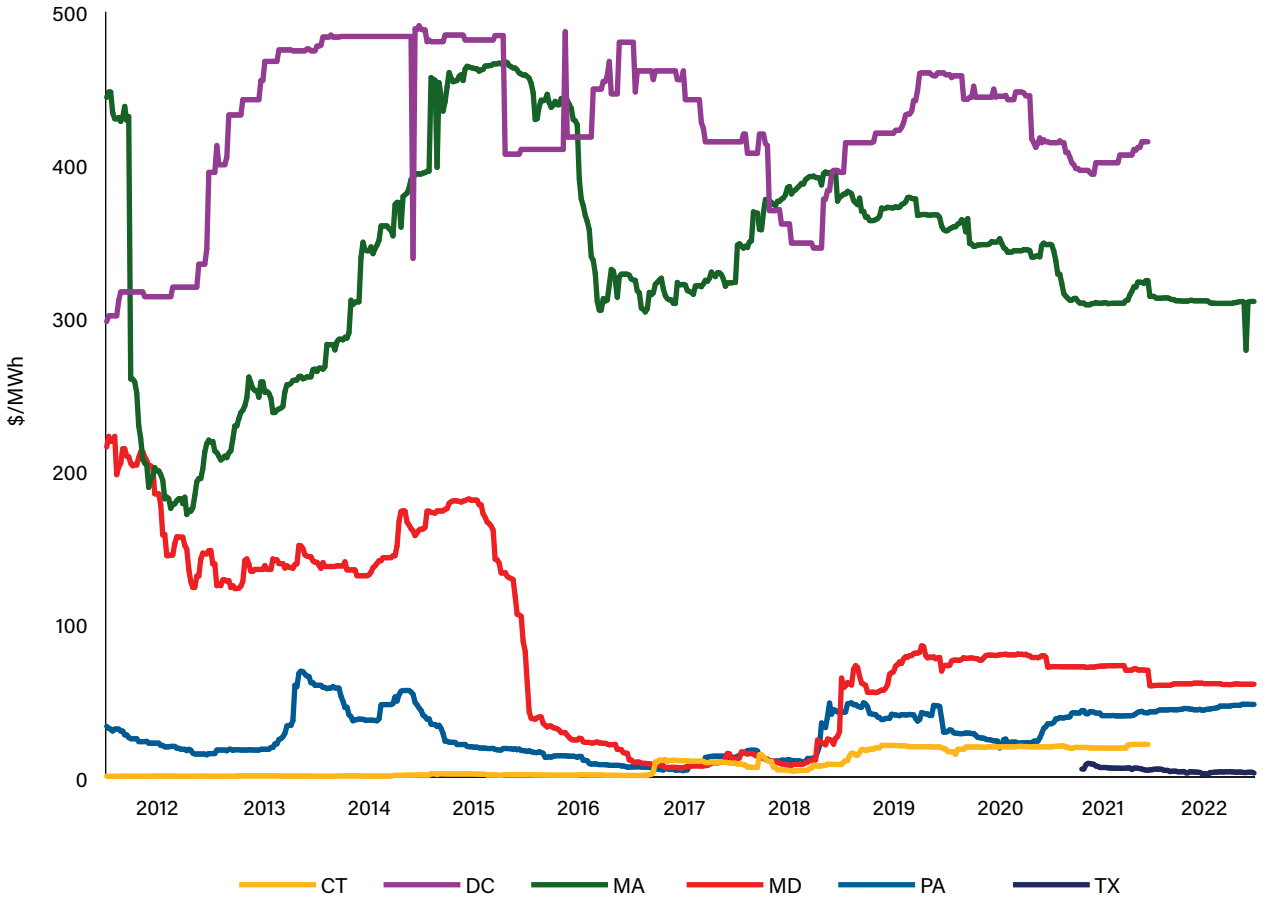
Source: S&P Global

Solar Renewable Energy Credit (REC) Prices

Solar RECs Remain Over $300 in DC and MA

- REC prices stayed at higher levels than those seen prior to 2021, however, their performance was variable during 2022.
- New England RECs continued to trade between $20-$35 in 2022, with New Hampshire and Massachusetts pricing highest. Maine and Rhode Island RECs priced at the lower end of the range. New York RECs traded in a similar band.
- RECs in the PJM region hovered around $20 with the exception of Ohio. Buckeye State RECs cratered to $5 after closing 2021 at $13. New Jersey RECs rose 16% to $22.50 while Maryland RECs fell 8% to $18.
- Texas voluntary RECs came back down to earth after trading above $8 at times in 2021. At the end of the year, Texas wind RECs traded for $3.
- Solar RECs gained in all states except Maryland and Texas. In Maryland, prices fell 17% to $60 while Texas solar RECs dropped 40% to $3.40. Prices in the District of Columbia and Massachusetts remain over $300 due to limited siting options and stringent targets.
- In markets with renewable portfolio standards, RECs make up an important revenue stream for renewable projects. In those states, renewable energy projects earn revenue from selling energy, RECs, capacity (if applicable), and ancillary services (again, if applicable).

Solar Renewable Energy Credit Prices



Source: S&P Global

Land-Based Wind Power

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Land-Based Wind Power Highlights

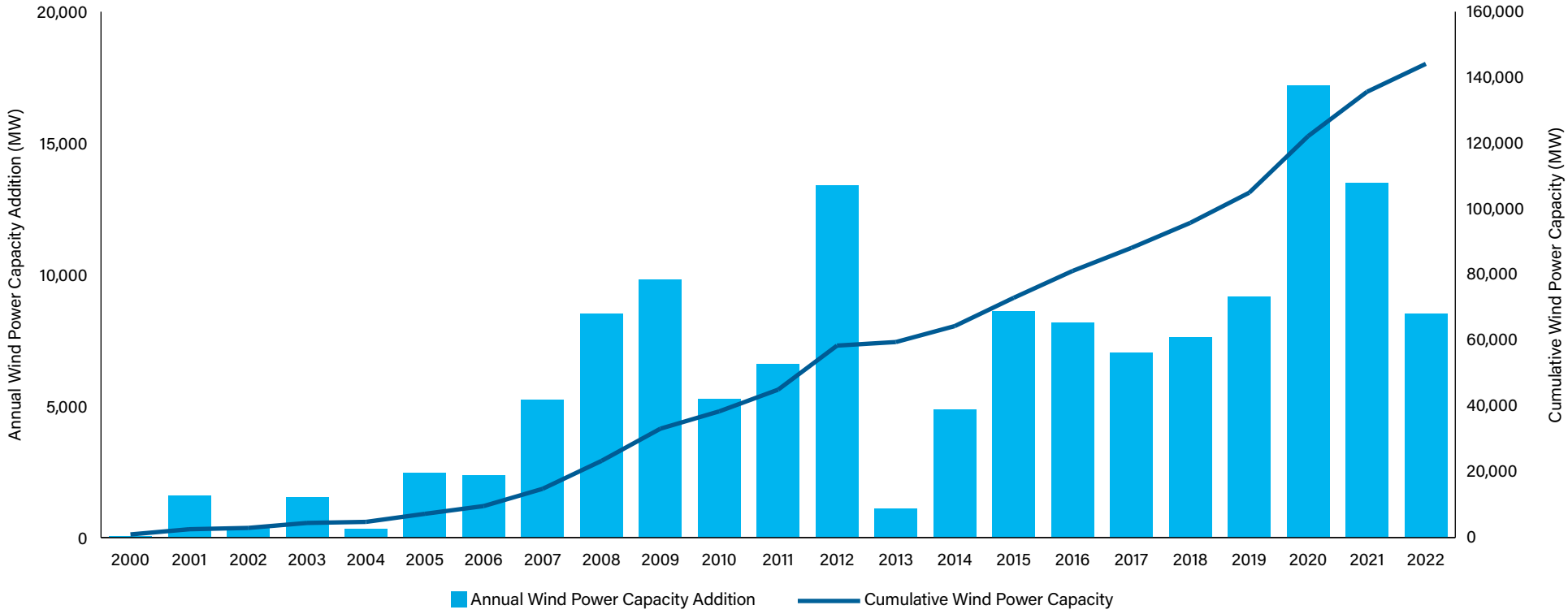
- In 2022, land-based wind industry installs reached a low point since 2018 with 8.5 GW commissioned due to factors such as changes in incentives, costs, and regulatory approvals.
- Texas has the most operating wind capacity at 40.2 GW, followed by Iowa (12.8 GW) and Oklahoma (12.2 GW). Texas and Oklahoma also lead new installs in 2022.
- Larger turbine models and increased number of turbines in each project have led to a record 363 MW capacity-weighted average wind project size in 2022.
- Over the past decade, the average hub height of land-based wind turbines has increased by 16% since 2012, reaching 94m in 2022, while the average rotor diameter reached 127m, a 40% increase from 2012. Consequently, the average turbine nameplate capacity has increased 60% since 2012 to 3.1 MW.
- GE Renewable Energy turbines accounted for 58% of capacity installed in 2022, followed by Vestas at 24%, Nordex at 10%, and Siemens Gamesa captured the remaining 8%. GE's 2.8-127 model was the most popular turbine of the year.
- Land-based wind turbines achieved a 37.6% average capacity factor in 2022, an almost 9% increase from the previous year.
- A total of 13.8 GW of land-based wind projects have been partially repowered. In 2022, 1.8 GW of wind projects were partially repowered, with GE dominating the majority of repowered turbines.
- Market consultant forecasts expect 102 GW of land-based wind power capacity to be built from 2023 to 2030, with forecasts ranging from 87 GW to 120 GW.

Land-Based Wind Power

Annual and Cumulative Wind Power Capacity

8.5 GW installed in 2022 brings the cumulative year-end capacity to 144 GW

U.S. Annual and Cumulative Wind Power Capacity Growth



- 2022 saw a significant decrease in wind capacity installations compared to 2021, marking the lowest year since 2018. The U.S. wind market installed 2,696 wind turbines with a total capacity of 8,511 MW, down from 13,400 MW installed in 2021.
- The cumulative operating wind power capacity rose to 144,132 MW at the end of 2022.
- Although the land-based wind market finished 2022 with its strongest quarter, the annual decline in wind capacity installations was primarily due to the sluggish growth seen in Q2 and Q3 of 2022.
- Wind installations were down due to market saturation, policy changes, economic challenges, permitting delays, and development timelines. Factors such as changes in incentives, fluctuations in costs, and delays in permitting and regulatory approvals may have influenced the reduced number of commissioned wind projects.

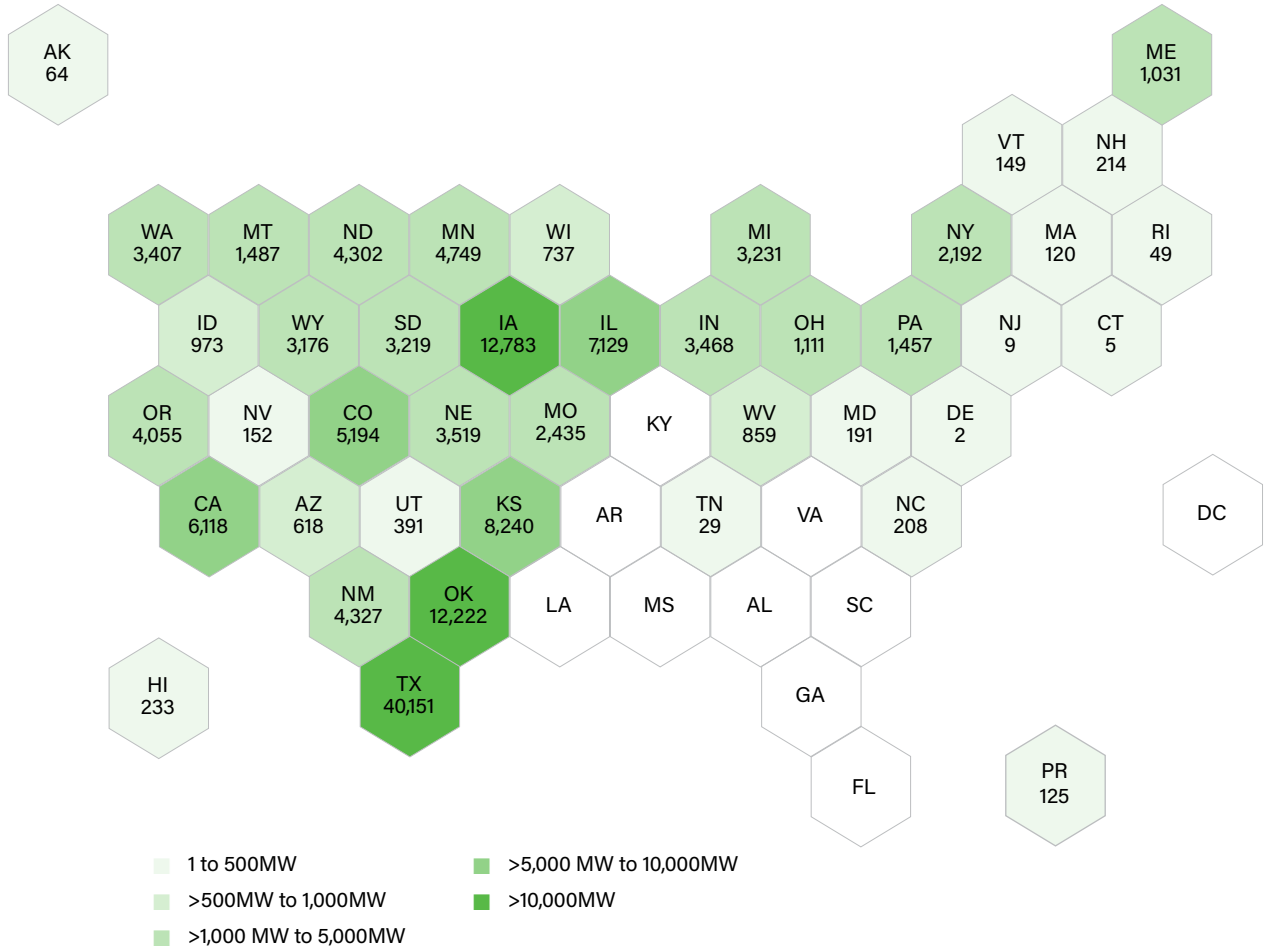
Land-Based Wind Power

Operating Wind Power Capacity

Wind continues to be the largest source of clean power on the grid

- 8,511 MW of land-based wind power was installed in 2022, bringing the U.S. to 144,132 MW of cumulative operating capacity. The operating wind power capacity of the U.S. is concentrated in the central plains, where world-class wind resources are located.
- With 40,151 MW installed, Texas has the highest operating capacity for wind power out of all U.S. states. Texas is followed by Iowa and Oklahoma, which have operating capacities of 12,783 MW and 12,222 MW, respectively.
- Overall, 23 states have more than 1 GW of operating wind power while seven states have crossed the 5 GW threshold for operating wind capacity.
- There are commercial wind projects operating in 41 states, Puerto Rico, and Guam.

Operating Wind Capacity

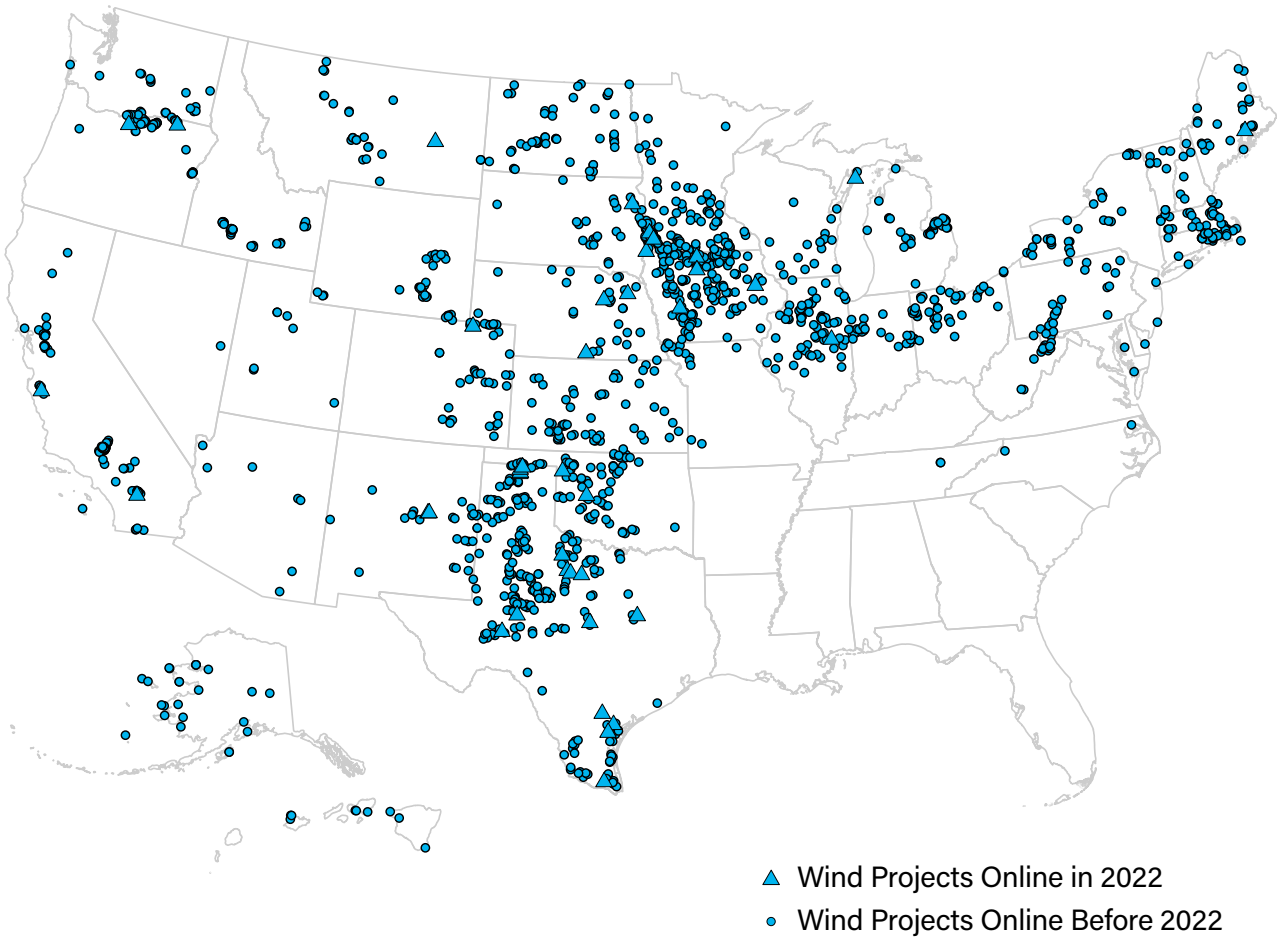


Land-Based Wind Projects

Over 8.5 GW of land-based wind power projects added to the grid in 2022

- Wind developers brought 40 project phases online, including repowers, totaling over 8.5 GW in 2022. These projects were spread across 14 states, including three states that added 500 MW or more.
- Texas led all states in new wind power, installing nearly 4.2 GW. Oklahoma followed with over 1.4 GW and Nebraska placed third with over 600 MW.
- The Great Prairie Wind (Firewheel Wind) took the top spot for the largest wind project project built in 2022 at over 1 GW across four phases. This was followed by the 996 MW Traverse Wind project in Oklahoma, and the 499 MW Young Wind project in Texas.
- Developers commissioned nearly 4.9 GW less wind power in 2022 compared to 2021, which itself was a down year compared to a record 2020. Year-over-year, wind installations declined by nearly 37% in 2022.
- Despite a down year, U.S. wind power capacity has increased more than two-fold in the last ten years and is 49 times larger than it was in 2002.

Land-based Wind Power Projects

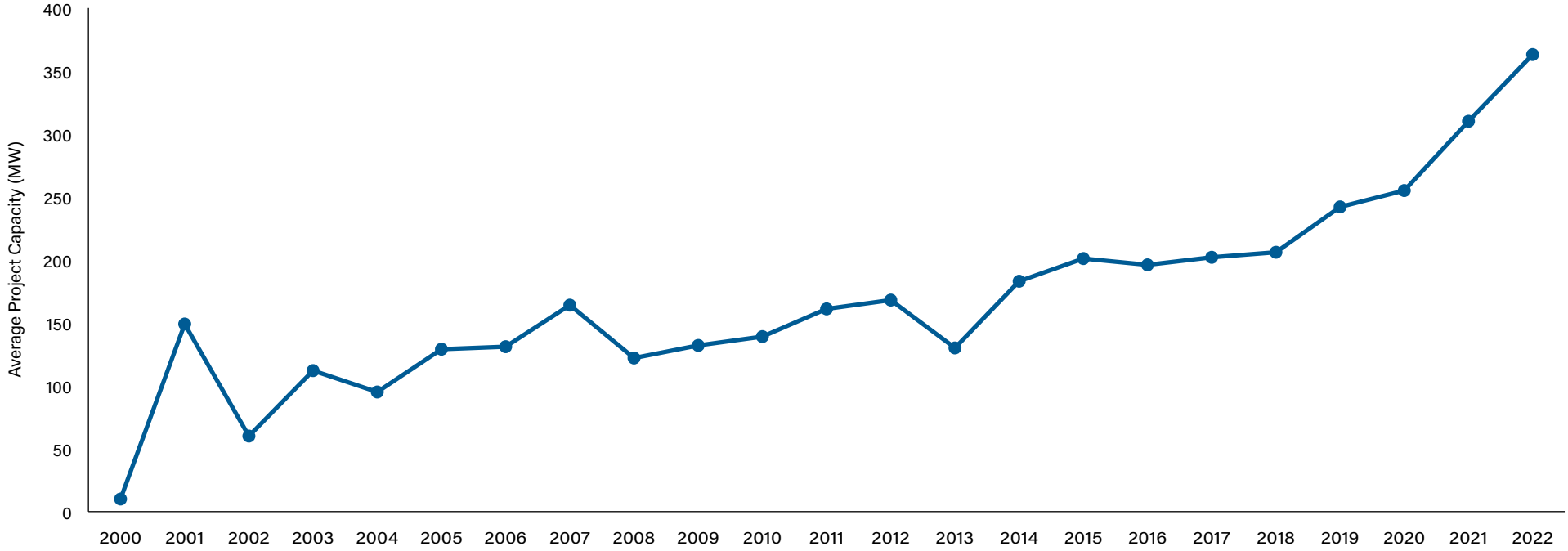


Land-Based Wind Power

Capacity-Weighted Average Wind Power Project Size

17% increase in average land-based wind project size in 2022

Capacity-Weighted Average Wind Power Project Size



- In 2022, the capacity-weighted average wind project size was a record 363 MW, representing a 17% increase from 2021.
- Over the past five years, the capacity-weighted average size of land-based wind projects has increased by an average of 13% each year, a significant escalation from the 8% average annual increase the industry saw between 2009 and 2012.
- Wind projects are increasing in size due to newer, larger turbine models becoming available, and a higher number of turbines being used in each project.

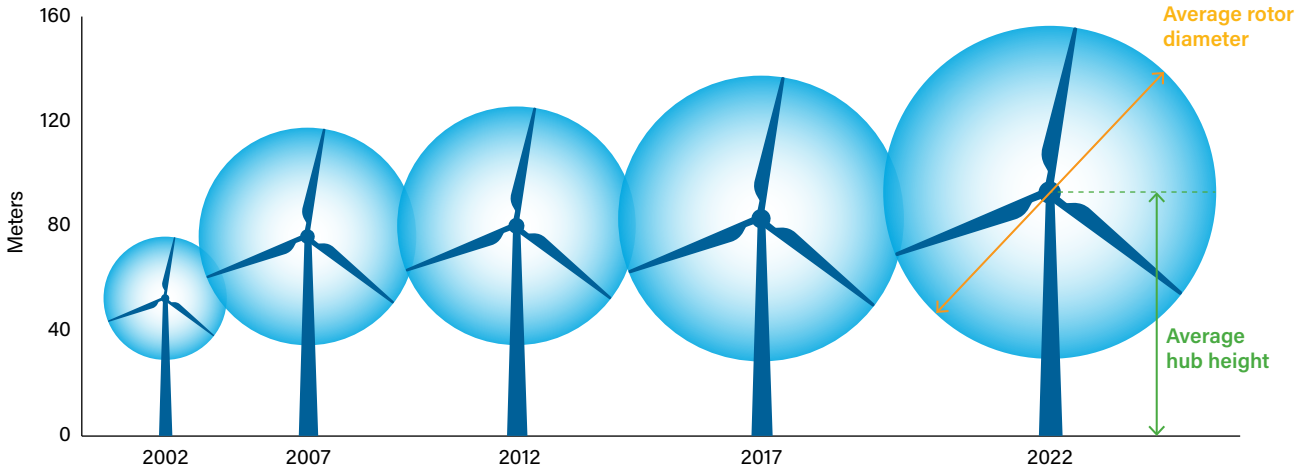
Land-Based Wind Power

Average Wind Turbine

In 2022 the average wind turbine had a 94m hub height, 127m rotor diameter, and 3.1 MW capacity

- Nearly 2,700 turbines were brought online in 2022, bringing the total operating turbine fleet to nearly 70,900 turbines.
- Over the past decade, the average hub height of land-based wind turbines has increased by 16%, reaching 94m in 2022.
- The average rotor diameter has experienced an even more significant increase, outpacing hub height growth. In 2022, turbines installed had an average rotor diameter of 127m, a 40% increase from 2010 and a 170% increase since 2002.

Evolution of the "Average" Utility-Scale Turbine



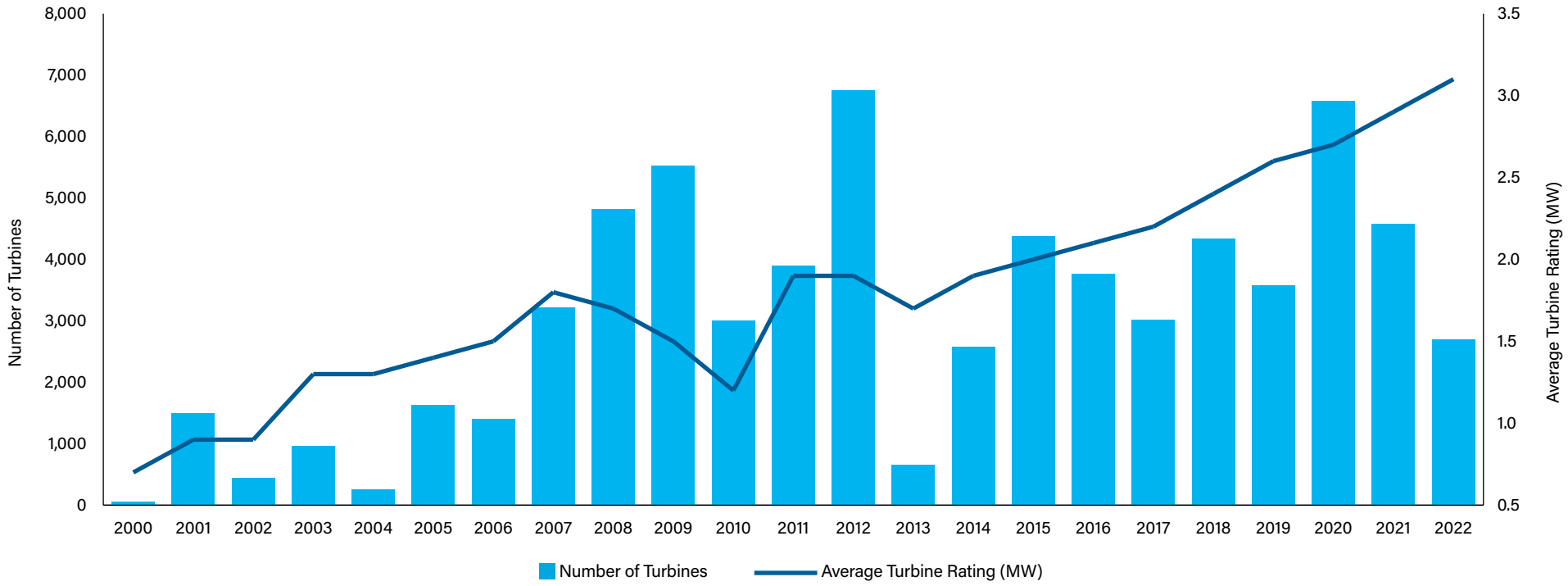
YEAR	2002	2007	2012	2017	2022
Average Hub Height	53m	77m	81m	84m	94m
Average Rotor Diameter	47m	83m	91m	109m	127m
Homes Powered	160	378	509	748	1,008

Land-Based Wind Power

Average Turbine Rating and Count over Time

Average turbine rating increased by 7% annually over the past five years

Average Turbine Rating and Count of Turbines Installed, 2000-2022



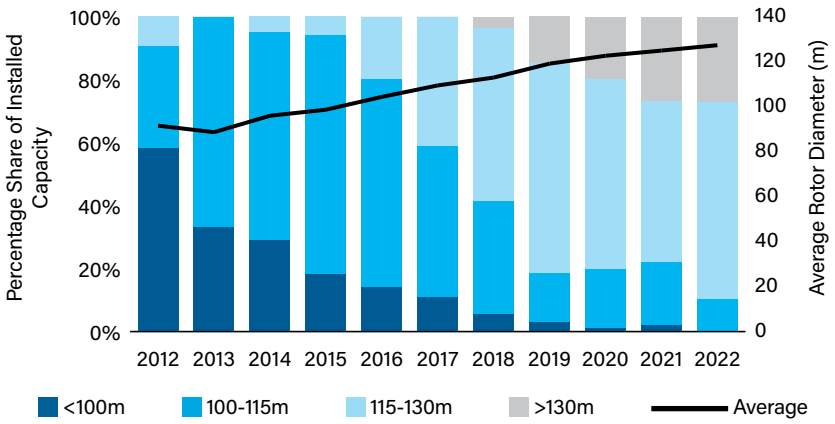
- Advanced wind turbine technology has led to significant increases in the average nameplate capacity of wind turbines. Along with larger rotor diameters and higher hub heights, advancements in aerodynamics, materials, and control system technology have contributed to the increase in the average nameplate capacity of wind turbines, allowing them to generate more electricity.
- The average turbine rating for the nearly 2,700 turbines commissioned in 2022 was 3.1 MW, a 5% increase from 2021.
- Although the installation of wind turbines in 2022 was the lowest since 2014, the individual generation capacity of each turbine has markedly increased.
- Since 2013, the average nameplate capacity of wind turbines has been steadily increasing at an average rate of 7% each year.
- The largest turbine installed in 2022 was Vestas' V162-5.6 MW model, followed by the SG 5.0-145 model made by Siemens Gamesa. In 2021, the largest turbine model installed had a nameplate capacity of 5 MW.

Land-Based Wind Power

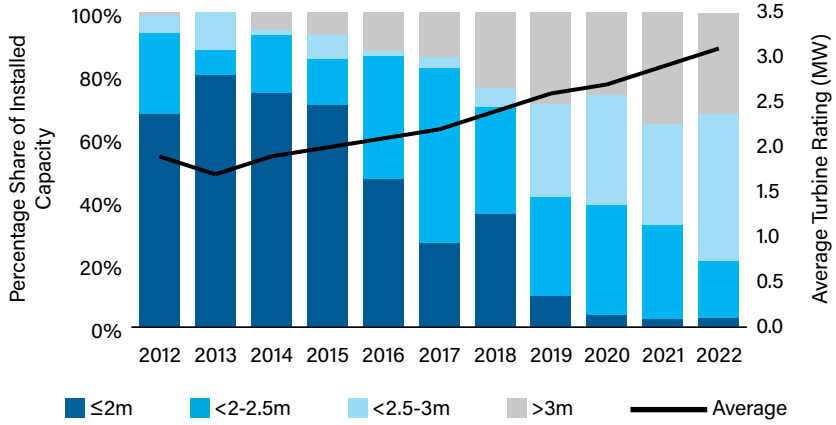
Wind Turbine Characteristics

Significant increases in hub heights, rotor diameter, and nameplate capacity

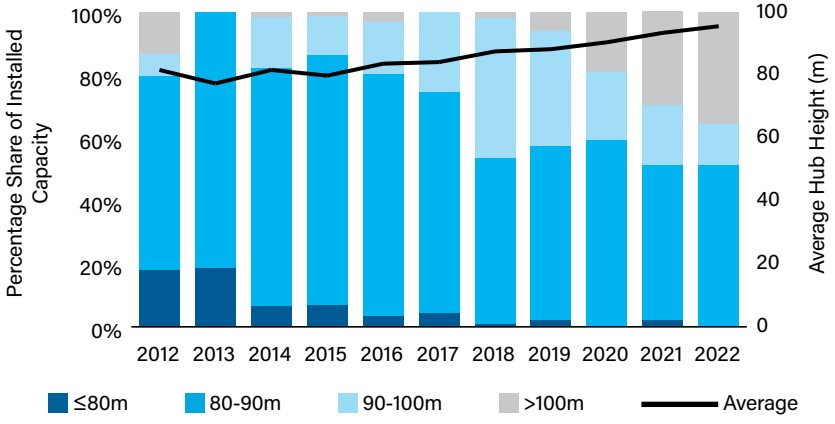
Rotor Diameter



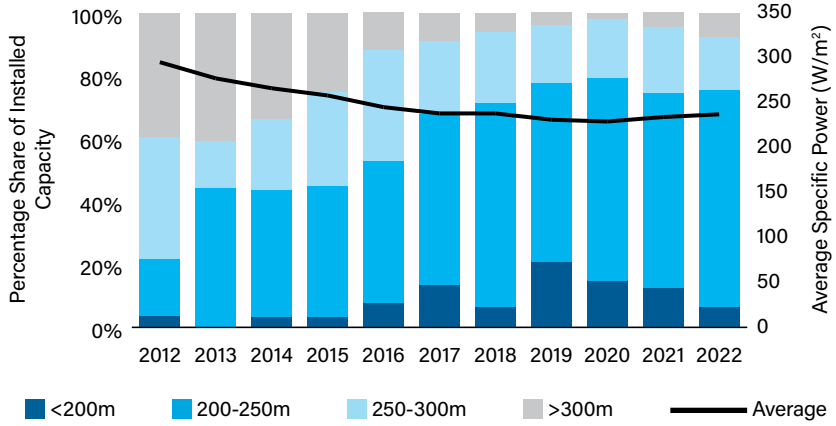
Turbine Rating



Hub Height



Specific Power



Wind Turbine Characteristics *(continued)*

Advancements in turbine technology allow individual turbines to capture more energy and be installed in new areas

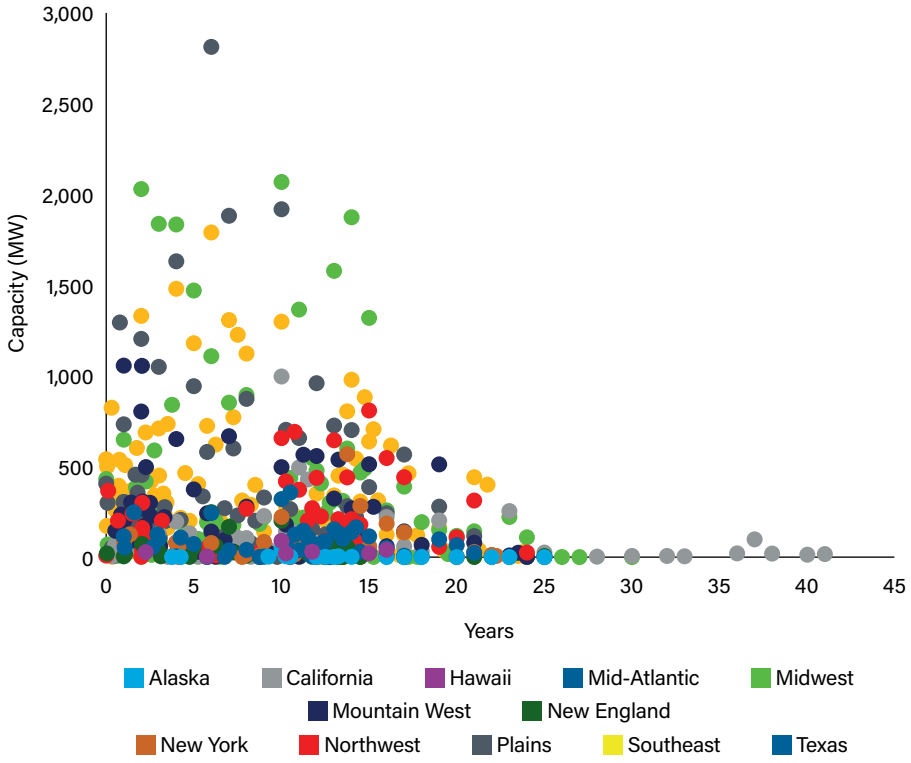
- In the past decade, wind turbines have undergone significant advancements in rotor diameter and hub height, resulting in increased nameplate capacities.
- Wind turbine hub heights have grown by 17% over the past decade, increasing at an average rate of 2% each year. Higher hub heights allow turbines to access the stronger and more consistent wind resources available at higher altitudes while decreasing wind shear and turbulence. Escalade Wind, located in Texas, had the highest hub heights of all the wind projects commissioned in 2022 at 119m.
- Rotor diameters have experienced a significant and remarkable increase, surpassing the growth in hub heights. The average rotor diameter in 2022 reached 127 meters, which is a substantial 39% increase compared to 2012. Turbines equipped with larger rotor diameters can capture more wind energy, especially at low wind speeds. Larger rotor diameters also help reduce the LCOE for wind because the increased energy production from larger rotors can offset the higher costs associated with manufacturing and installing larger turbine components. Turbines with larger rotor diameters are feasible thanks to economies of scale. As demand for larger turbines increases, manufacturers can achieve cost savings through mass production, streamlined manufacturing processes, and supply chain optimization.
- Thanks in part to advancement in hub heights and rotor diameters, the average turbine rating has also increased, meaning an individual turbine is able to generate significantly more electricity than a decade ago. In 2022, the average turbine rating was 3.1 MW, a 60% increase from 2012.
- Specific power, on the other hand, has decreased by 20% since 2012. In 2022, the average specific power was 237 W/m^2, up from 234 W/m^2 in 2021 but down from 295 W/m^2 in 2012. Specific power represents the ratio of the maximum nameplate capacity and the swept rotor area of the blades. Therefore, the increasing rotor diameters over the past decade have driven down specific power. Decreased specific power is also due in part to the siting of wind projects in lower wind-speed areas. In such areas, larger rotor diameters are needed to capture energy from low wind speeds. Turbines designed for low-wind speed sites tend to have lower specific powers as they require larger rotor swept areas to generate higher power outputs in lower wind conditions.

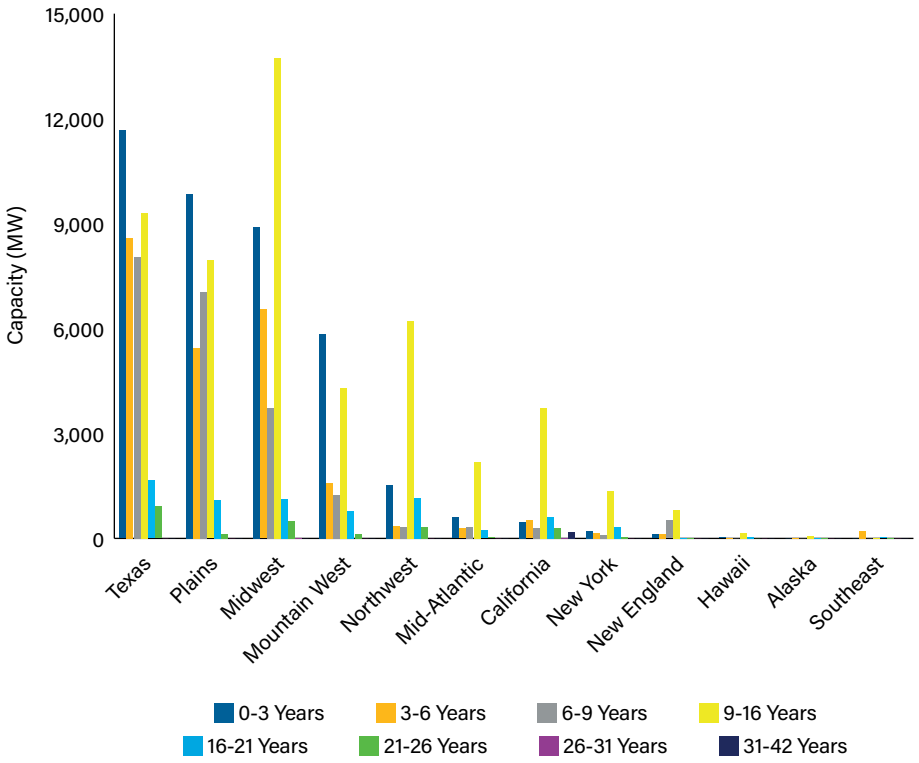
Land-Based Wind Power

Wind Project Age by Region

Average wind project age stands at 9 years and 11 months

Regional Age Profile of Wind Projects





- The age distribution of wind projects in the U.S. has become more diverse as the wind industry has continued to expand. While the oldest projects have been in operation for over thirty years, they only account for less than 1% of U.S. operating wind capacity. Overall, the average age for operating U.S. wind projects is nine years and 11 months, indicating that the U.S. wind industry is relatively new. Over 43% of projects were built in the last six years, and more than 89% have come online in the last 15 years.

- Only about 11% of the U.S. wind fleet has been operational for more than 15 years. Some of the oldest operating wind projects are located in California and the Midwest. As wind projects have aged, older projects have become targets for partial or full repowerings.

- Overall, the Plains, Texas, and the Mountain West have the youngest operating wind fleets in the U.S.

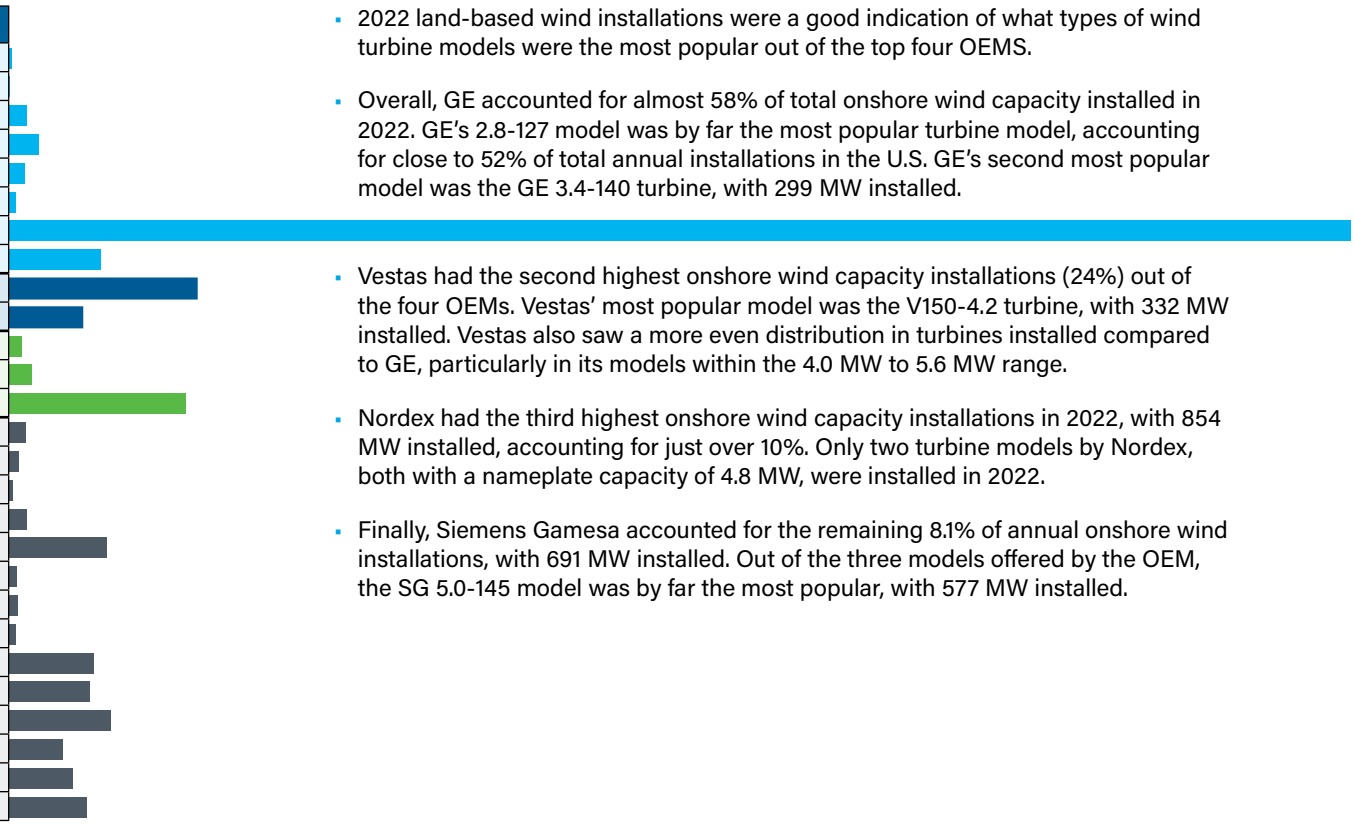
Land-Based Wind Power

Wind Turbines Installed in 2022, by Rating

GE's 2.8-127 model was the most popular turbine of the year

Wind Turbines Installed in 2022, by Rating

Manufacturer	Model	Capacity (MW)
GE Renewable Energy	GE 1.7-103	7
	GE 1.79-100	2
	GE 2.3-116	58
	GE 2.5-116	96
	GE 2.5-127	50
	GE 2.7-116	22
	GE 2.8-127	4,385
	GE 3.4-140	299
Nordex USA Inc.	N149/4800	614
	N155/4800	240
Siemens Gamesa Renewable Energy	SG 2.335 - 108	42
	SG 3.4-132	72
	SG 5.0-145	577
Vestas North America	V110-2.0	54
	V110-2.2	31
	V117-3.6	11
	V117-4.3	56
	V120-2.2	319
	V136-3.45	24
	V136-3.8	27
	V136-4.0	20
	V136-4.3	275
	V150-4.0	264
	V150-4.2	332
	V150-4.3	176
	V150-4.5	207
	V162-5.6	252



- 2022 land-based wind installations were a good indication of what types of wind turbine models were the most popular out of the top four OEMS.
- Overall, GE accounted for almost 58% of total onshore wind capacity installed in 2022. GE's 2.8-127 model was by far the most popular turbine model, accounting for close to 52% of total annual installations in the U.S. GE's second most popular model was the GE 3.4-140 turbine, with 299 MW installed.
- Vestas had the second highest onshore wind capacity installations (24%) out of the four OEMs. Vestas' most popular model was the V150-4.2 turbine, with 332 MW installed. Vestas also saw a more even distribution in turbines installed compared to GE, particularly in its models within the 4.0 MW to 5.6 MW range.
- Nordex had the third highest onshore wind capacity installations in 2022, with 854 MW installed, accounting for just over 10%. Only two turbine models by Nordex, both with a nameplate capacity of 4.8 MW, were installed in 2022.
- Finally, Siemens Gamesa accounted for the remaining 8.1% of annual onshore wind installations, with 691 MW installed. Out of the three models offered by the OEM, the SG 5.0-145 model was by far the most popular, with 577 MW installed.

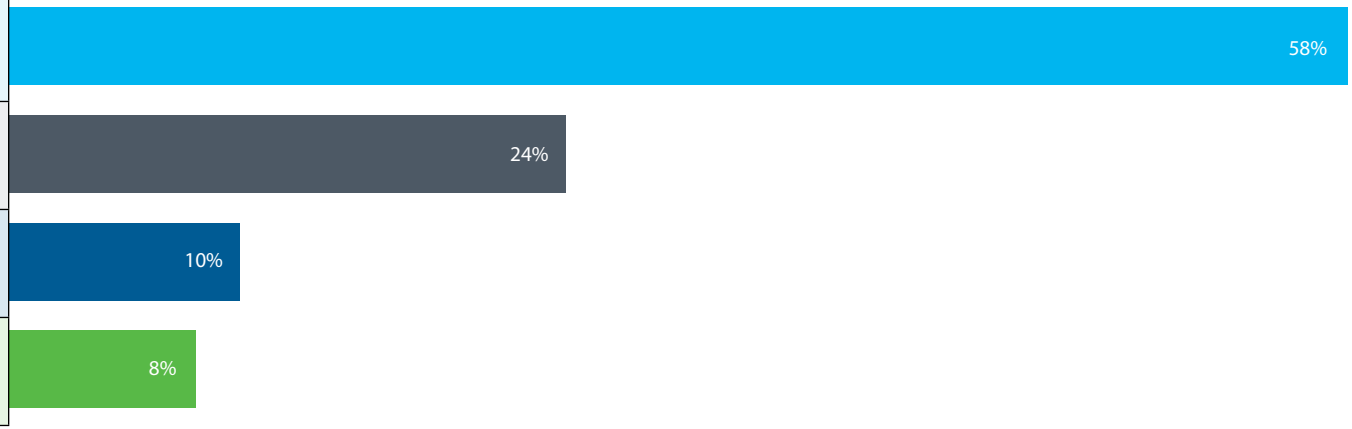
Land-Based Wind Power

Turbine OEM Market Share, 2022

GE captures well over half of the market

Wind Turbine Manufacturer Market Share of Wind Power Capacity Installed in 2022

Manufacturer	Number of Turbines	Capacity (MW)
GE Renewable Energy	1,752	4,918
Vestas North America	561	2,048
Nordex USA Inc.	178	854
Siemens Gamesa Renewable Energy	205	691



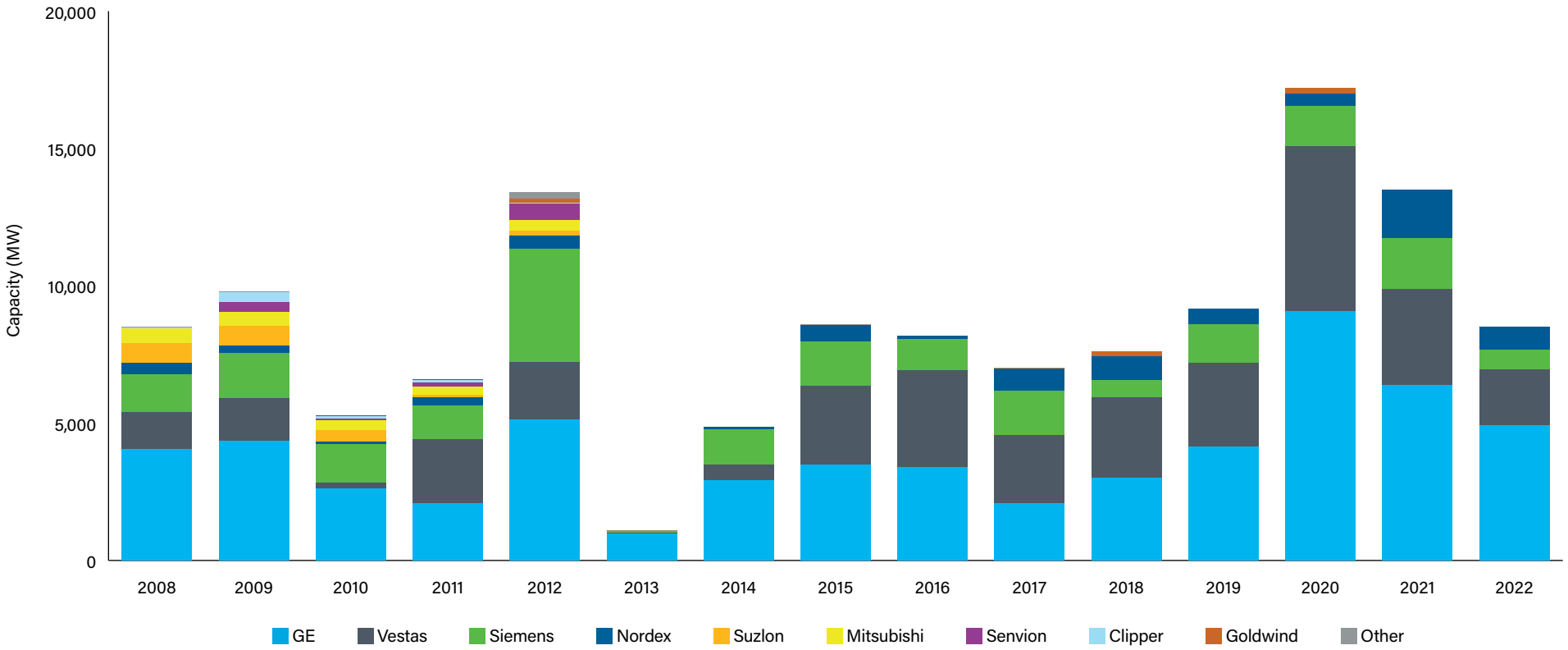
- The U.S. land-based wind market is dominated by four manufacturers: GE Renewable Energy, Nordex, Siemens Gamesa, and Vestas. Out of the four OEMs, GE has been the dominant manufacturer in the U.S. market for many years.
- GE wind turbines made up 58% of onshore wind capacity installations in 2022, making it the top-ranking manufacturer for the year. Vestas ranked second with 24% of total capacity installations, followed by Nordex at 10% and Siemens Gamesa at 8%.

Land-Based Wind Power

Annual Wind Turbine OEM Market Share

The U.S. market has been dominated by four OEMs for the past decade

Annual Turbine Manufacturer Market Ranking



- As noted in the ranking for OEM market share in 2022, the U.S. land-based wind market is dominated by four key manufacturers: GE, Vestas, Nordex, and Siemens Gamesa.
- For the past decade, these four OEMs have made up close to the entirety of the market, with Suzlon, Mitsubishi, and a few others installing a smaller share of the total land-based wind capacity.
- Between 2008 and 2012, there were more participants in the market. OEMs including Clipper, Senvion, and Goldwind were players in the industry until 2013.

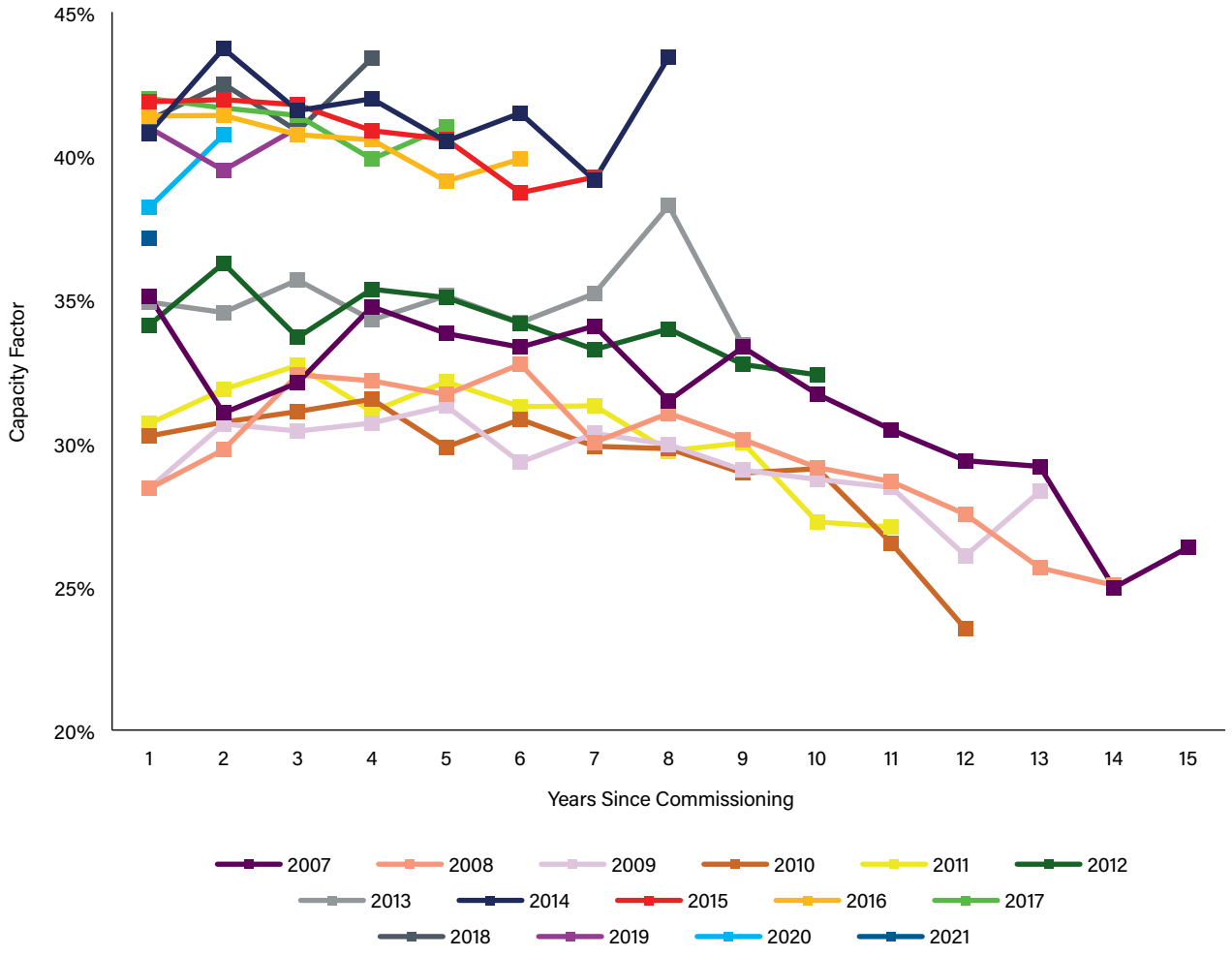
Land-Based Wind Power

Wind Capacity Factor Performance Over Time

Wind turbine performance generally stable over time

- New wind turbines in the U.S. are achieving impressive capacity factors of 40% to 50% or higher, indicating increased efficiency in harnessing the country's abundant wind resource and converting it into electricity. This success is attributed to improved performance of modern wind turbines.
- Fleet-wide average capacity factor broke the 40% barrier around 2014. These wind plants should continue to deliver consistently effective performance well into the 20-25 or more years of operational life.
- Older turbine vintages continue to deliver consistent performance with only slight degradation in capacity factor. The data here excludes repowered projects. Repowering older projects may increase capacity factor performance.
- In 2022, the average capacity factor for land-based wind turbines increased by almost 9% compared to the previous year, reaching 37.6% across the entire wind fleet. This improvement is notable as it surpasses the fleet average of 34.6% in 2021.

Wind Project Vintage Capacity Factor Performance Over Time



Source: EIA

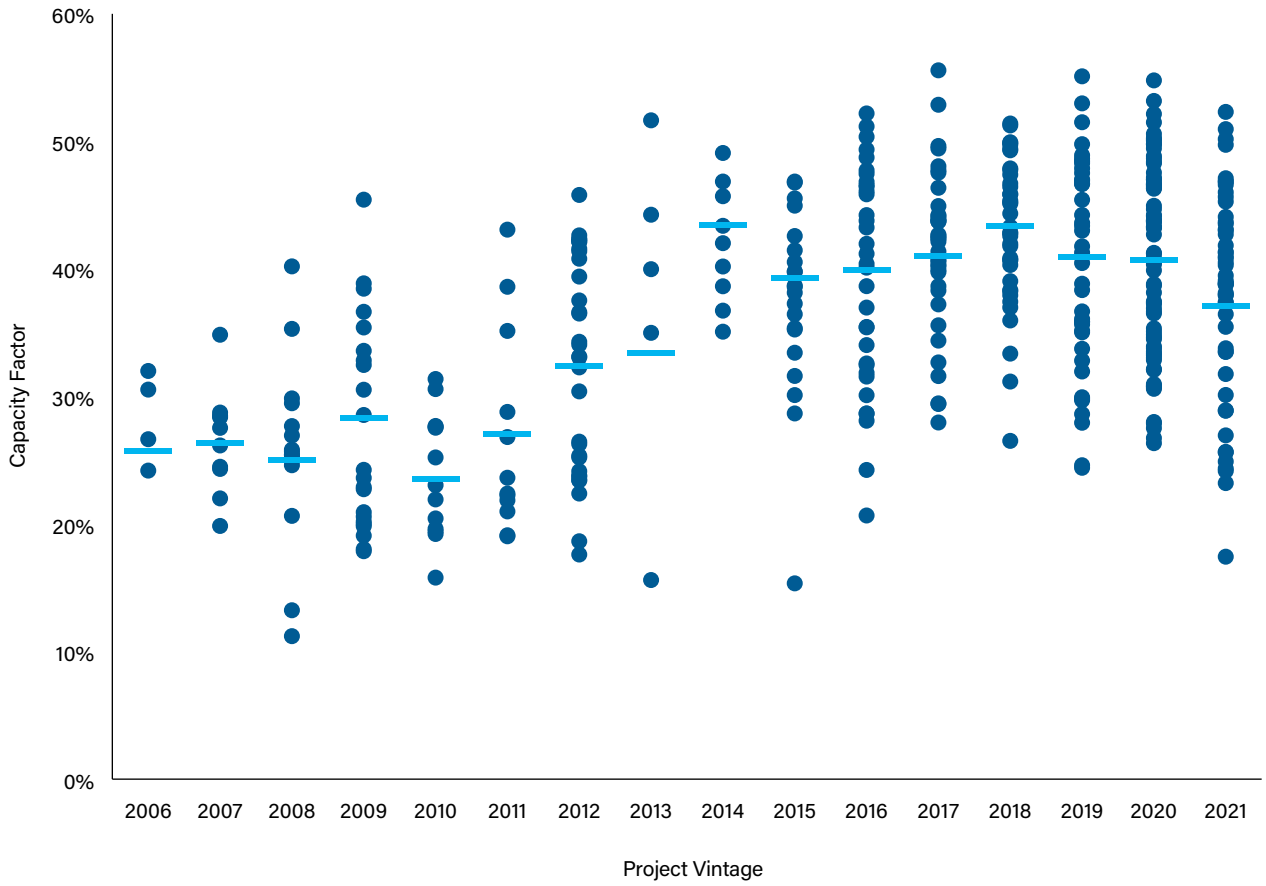
Land-Based Wind Power

Wind Capacity Factors in 2022, by Vintage

Flat to declining wind capacity factors by vintage year

- Over the last decade, the annual average capacity factor by vintage year has increased 4.7 percentage points from 32.4% for 2012 projects to 37.1% for 2021 projects, the latest year that data are available.
- Turbines installed in 2014, 2017, 2018, 2019, and 2020 broke the 40% barrier in 2022. Projects installed in 2015 and 2016 performed at capacity factors of 39.3% and 39.9%, respectively, nearly reaching the 40% mark.
- The decline in average capacity factors in 2019, 2020, and 2021 may be attributed to the saturation of prime wind project sites with high wind speeds near transmission access, leading to the development of newer projects in slightly less optimal locations.
- A similar trend has been seen with solar projects as well with a flat-to-declining fleet-wide solar average capacity factor trend since 2016 reflecting the expansion of the solar market into less-sunny regions of the United States.

Wind Project Capacity Factors in 2022, by Vintage Year



Source: EIA

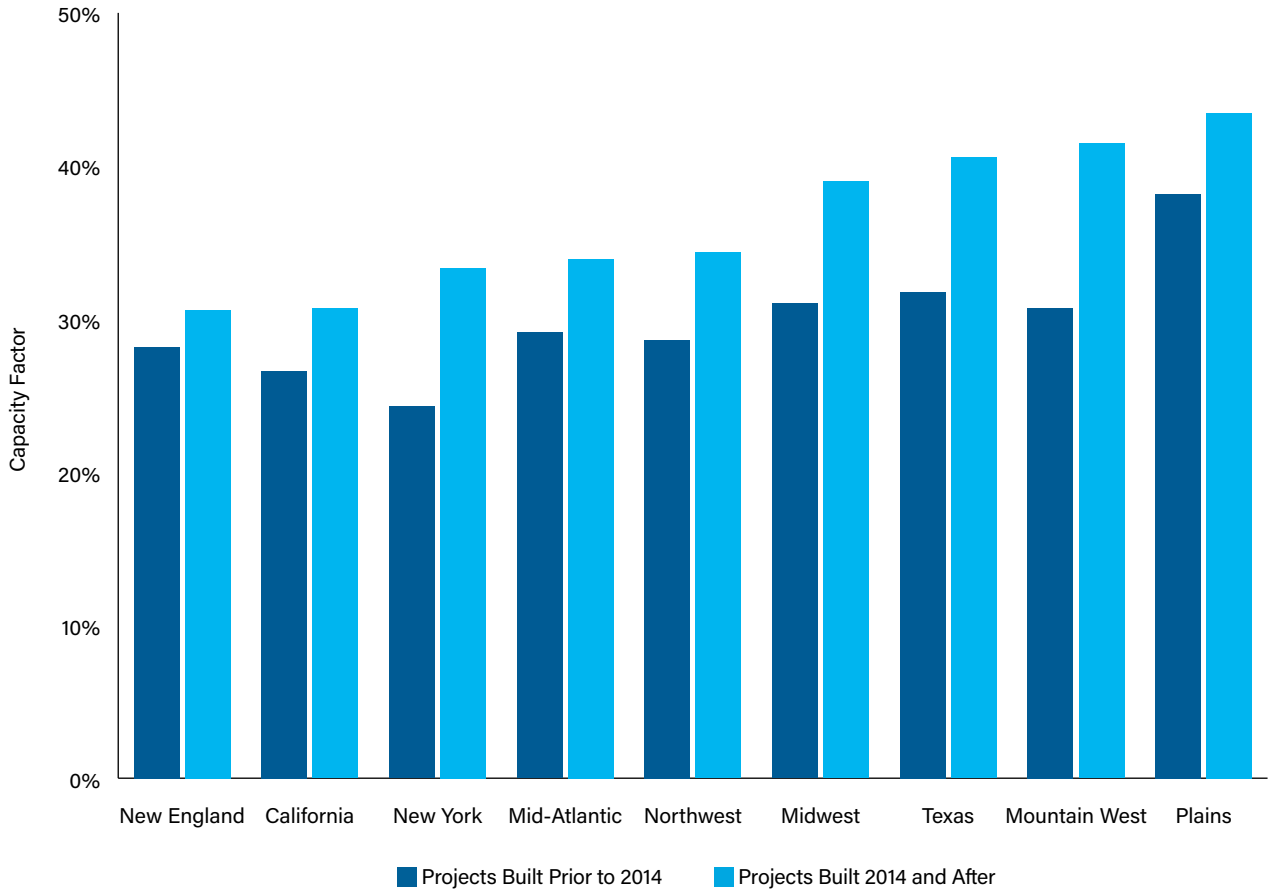
Land-Based Wind Power

Regional Capacity Factors

Strongest capacity factors found in Plains and Mountain West; Texas and Midwest not far behind

- Naturally, wind turbine capacity factors are heavily influenced by the relative strength or weakness of the wind resource in a project location. When assessing projects built after 2014 – which is generally when new, more efficient turbines entered the market – average capacity factors varied by region from a low of 30.1% in New England and 30.7% in California to highs between 39.0% and 43.5% the Midwest, Texas, the Mountain West, and the Plains states.
- The substantial boost in capacity factors found at newer projects demonstrates the technological advancements that wind turbine manufacturers have been able to deliver.

Regional Wind Capacity Factors



Source: EIA

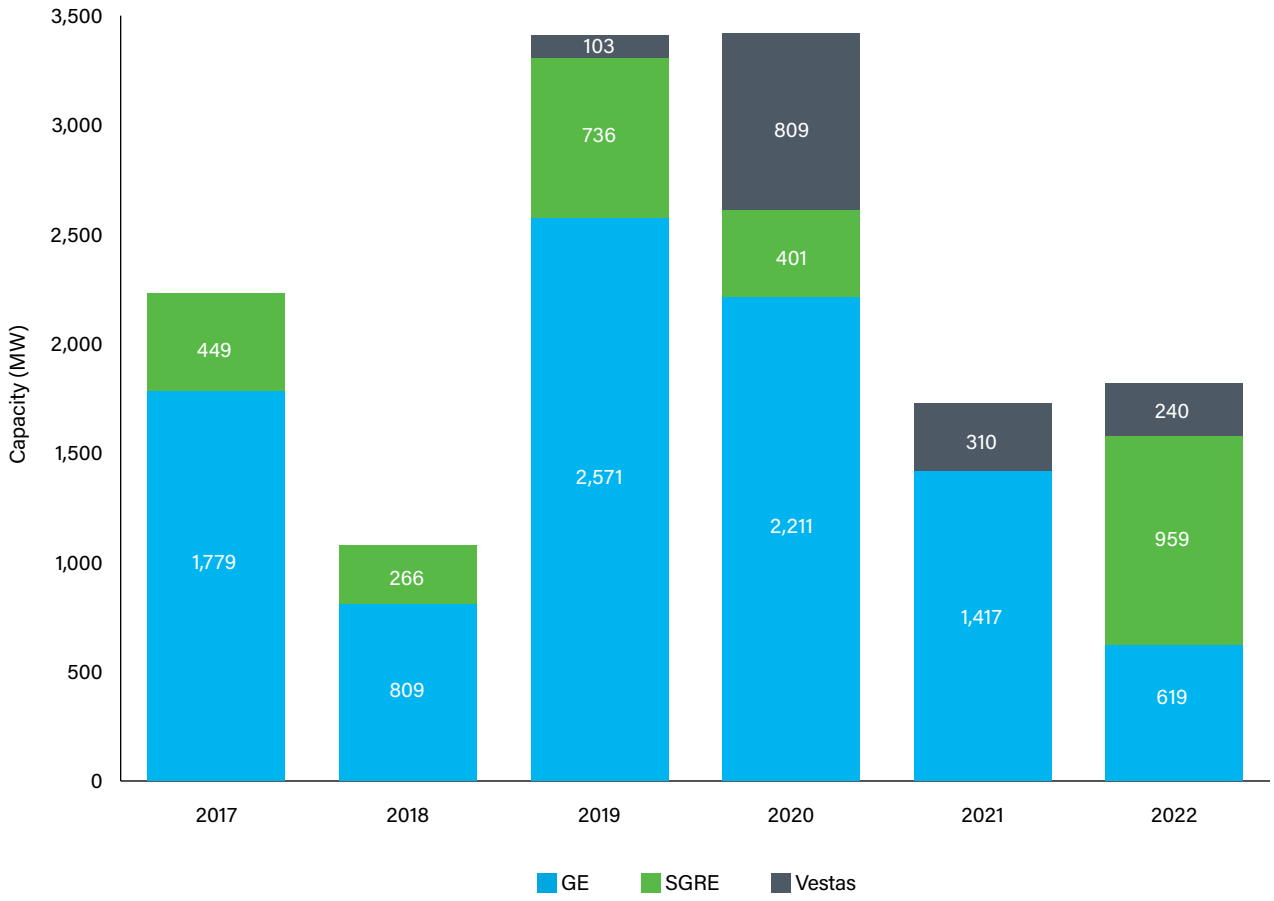
Land-Based Wind Power

Wind Partial Repowering

1.8 GW of wind projects partially repowered in 2022

- Partial repowering extends the life of existing wind projects while also often increasing the projects' maximum output.
- In partial repowerings, ACP includes major retrofits, defined as 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, and nacelle replacements, defined as complete replacement of a utility-scale wind turbine's nacelle, rotor, and blades, along with retention of the tower and foundation.
- A total of 13.8 GW of land-based wind projects have been partially repowered. In 2022, 1.8 GW of wind projects were partially repowered, a slight uptick from 2021 but far lower than the volumes of projects repowered in 2019 and 2020.
- GE accounted for 34% of the turbines used to partially repower projects in 2022, Siemens Gamesa 53%, and Vestas 13%.
- Overall, GE makes up 69% of partially repowered turbines, Siemens Gamesa 21%, and Vestas the remaining 11%.

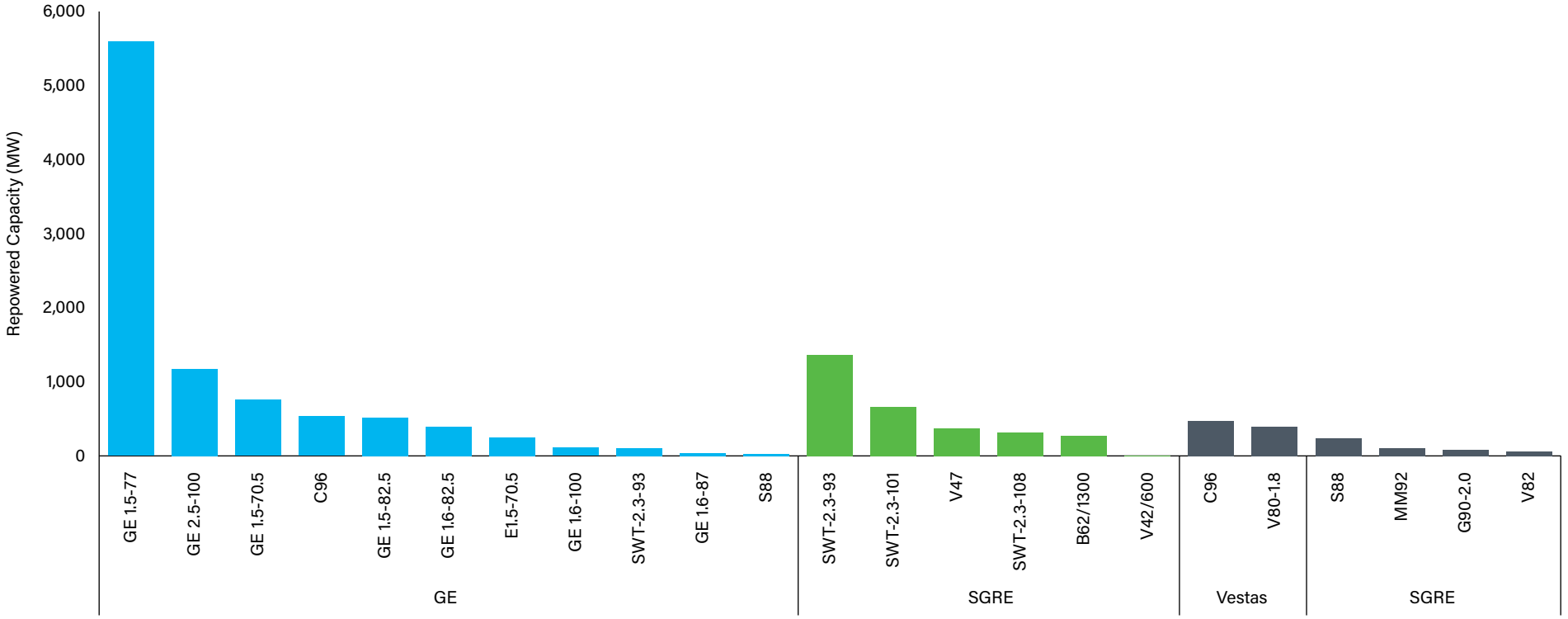
Wind Power Partial Repowerings



Wind Partial Repowerings by OEM and Model

GE's 1.5-77 turbine is the most repowered turbine

Repowered Turbine Models



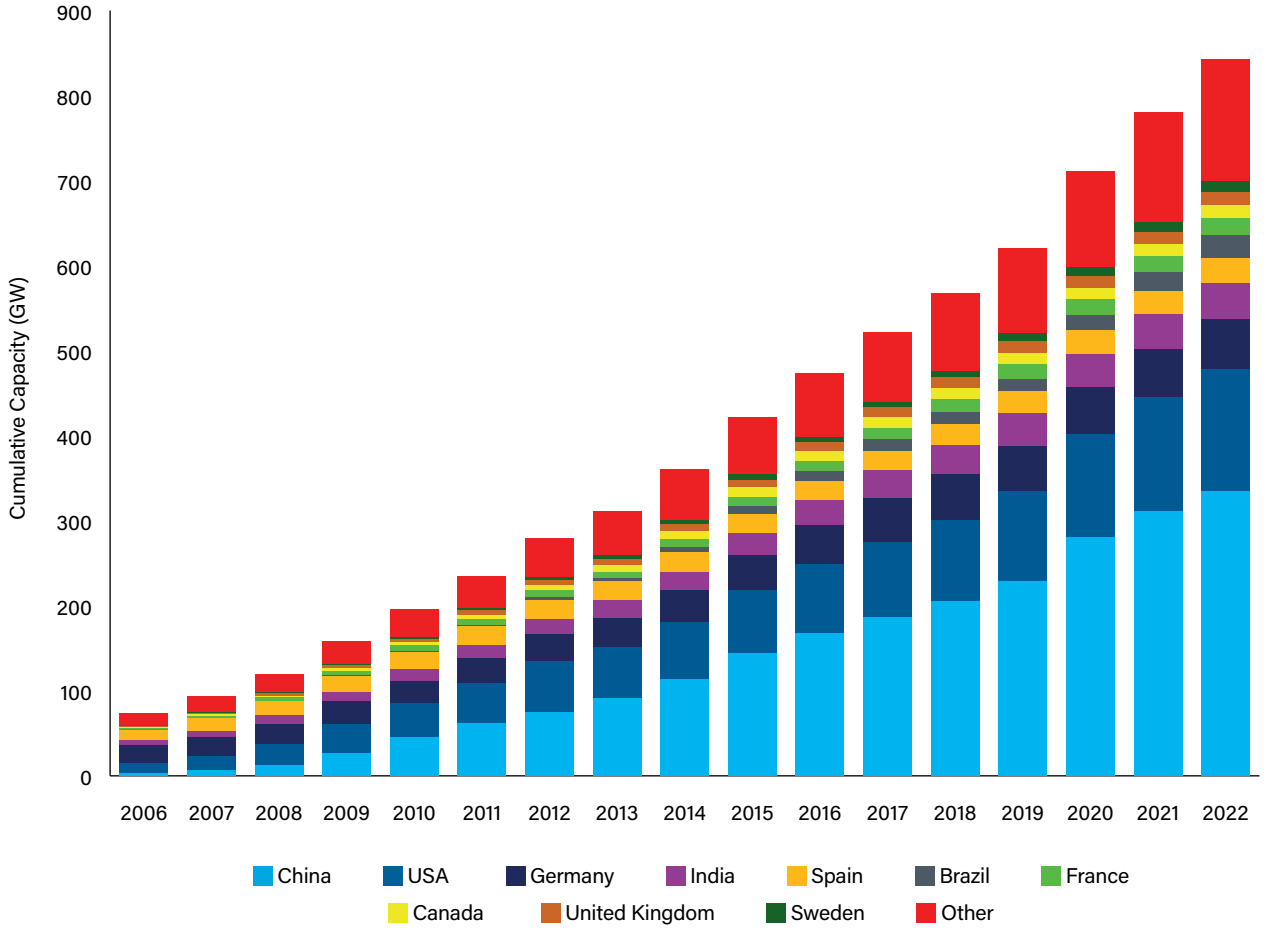
- Due to its dominant market share in the operating U.S. wind market, GE Renewable Energy typically has the highest amount of repowering activity in a given year, as it possesses a greater number of turbines that are eligible for partial repowering. In total GE has partially repowered nearly 9.5 GW of wind capacity.
- Siemens Gamesa has partially repowered nearly 3 GW of turbines, primarily with projects using its 2.3 models.
- Vestas has partially repowered approximately 1.4 GW of wind capacity, most commonly replacing Clipper C96 turbines.
- GE most often repowers projects that use GE turbines, although the OEM has also repowered more than 500 MW of projects that originally used Clipper Windpower C96 turbines.
- GE's 1.5-77 turbine is the most commonly repowered model, followed by Siemens Gamesa's SWT 2.3-93 turbines and Clipper's C96 turbine.

Global Wind Power

Global land-based wind capacity surpasses 840 GW

- Across the world, 62 GW of land-based wind was added in 2022, bringing the cumulative operating capacity to 842 GW.
- For the past two years, annual global wind installations have fallen from the record levels set in 2020, mirroring what the industry has experienced in the U.S. 2022 wind installations were down 14% compared to 2021 and 30% compared to 2020.
- China and the U.S. both reported decreases in annual wind installations in 2022 compared to 2021, both reporting the lowest level in new installed capacity in recent years.
- The other countries represented in this chart increased their annual wind installations in 2022 by anywhere between 6% and 98%. However, because annual wind installations in the U.S. and China are more than twice as large as any other nation, it was not enough to make up for the down year the wind industry experienced in 2022.
- In terms of total operating capacity, China ranks first at 334 GW, followed by the U.S. with 144 GW online, and Germany with 59 GW.

Cumulative Global Land-Based Wind Capacity



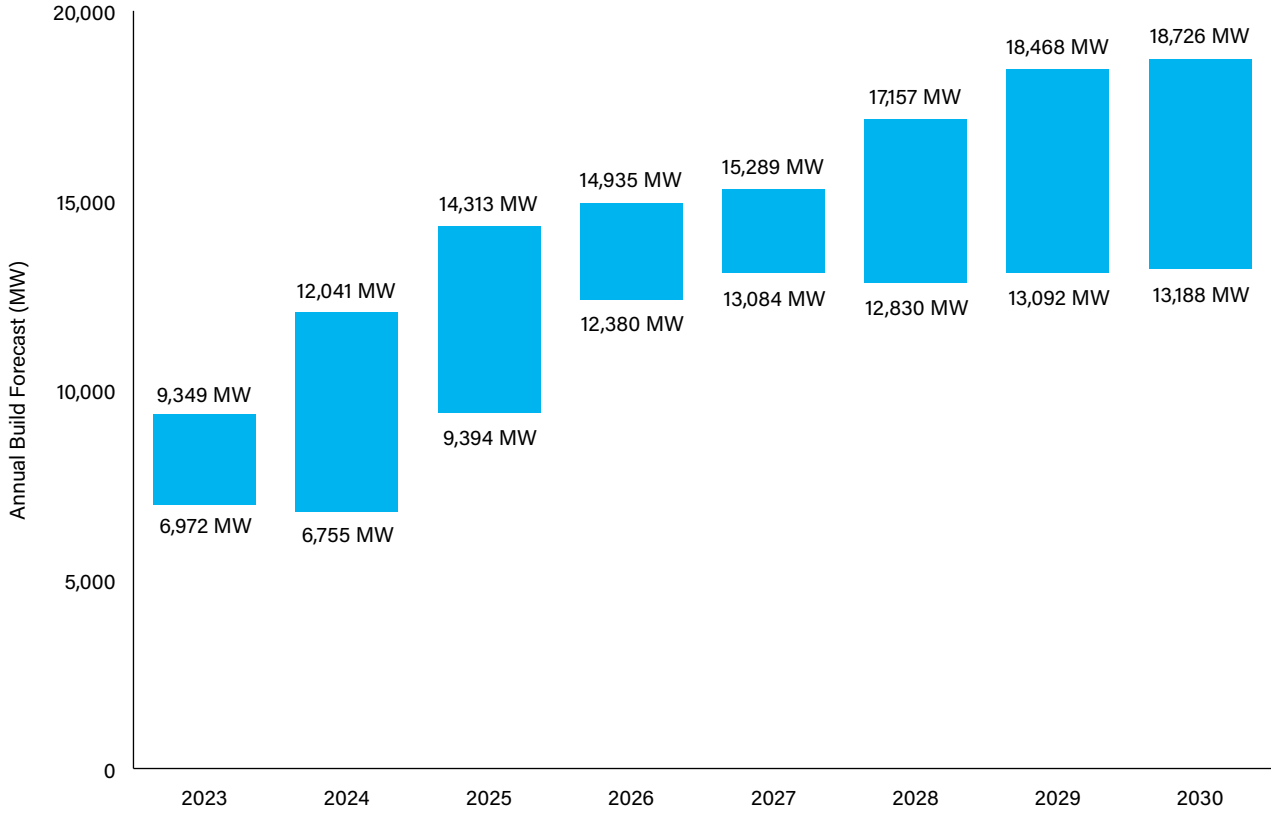
Source: GWEC

Land-based Wind Power Forecast

Market participants anticipate 102 GW of wind installations this decade

- The average market consultant forecast expects 102 GW of land-based wind power capacity to be built from 2023 to 2030. Forecasts range from a low of 87 GW to a high of 120 GW.
- These forecasts fully incorporate the newly passed clean energy tax provisions in the Investment Reduction Act. As a result, this year's average consultant forecast is 20 GW higher—a 25% increase—than 2021's average forecast for the same period.
- Years 2023 and 2024 are expected to be the most challenging with annual build expectations ranging from 7 to 12 GW. The previous phase-down of the PTC is largely to blame, though supply chain challenges continue to impact near term build.
- Build volumes grow each year through the end of the decade, eventually reaching nearly 16 GW on average in 2030. One consultant anticipates 19 GW in that year.

Industry consultant land-based wind power capacity forecast, 2023-2030



Source: BNEF, S&P, Wood Mackenzie

Offshore Wind

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Photo Credit: Ørsted

Offshore Wind Power Highlights

- The three lease auctions held in 2022 in the New York Bight, Carolina Long Bay, and California generated over $5.4 billion in federal revenue. The New York Bight lease prices were high, averaging $8,313/acre across six leases, while the Carolina Long Bay and California leases averaged $2,657/acre and $1,884/acre, respectively.
- No new offshore wind capacity was produced in 2022. However, New York issued its third large-scale solicitation in July 2022, seeking to procure at least 2 GW of offshore wind and Rhode Island Energy released the state's largest request for proposals (RFP) to date, seeking at least 600 MW and up to 1 GW of new offshore wind capacity.
- Ten states have set offshore wind procurement targets totaling over 81,000 MW. Louisiana, California, New Jersey, and Maryland all set or increased offshore wind goals.
- There have been a number of announced investments in the domestic offshore wind supply chain, resulting in a total public investment figure of $1.7 billion.
- Consultants anticipate, on average, 26 GW of offshore wind to be operational in 2030, a 2 GW improvement over last year's forecast.

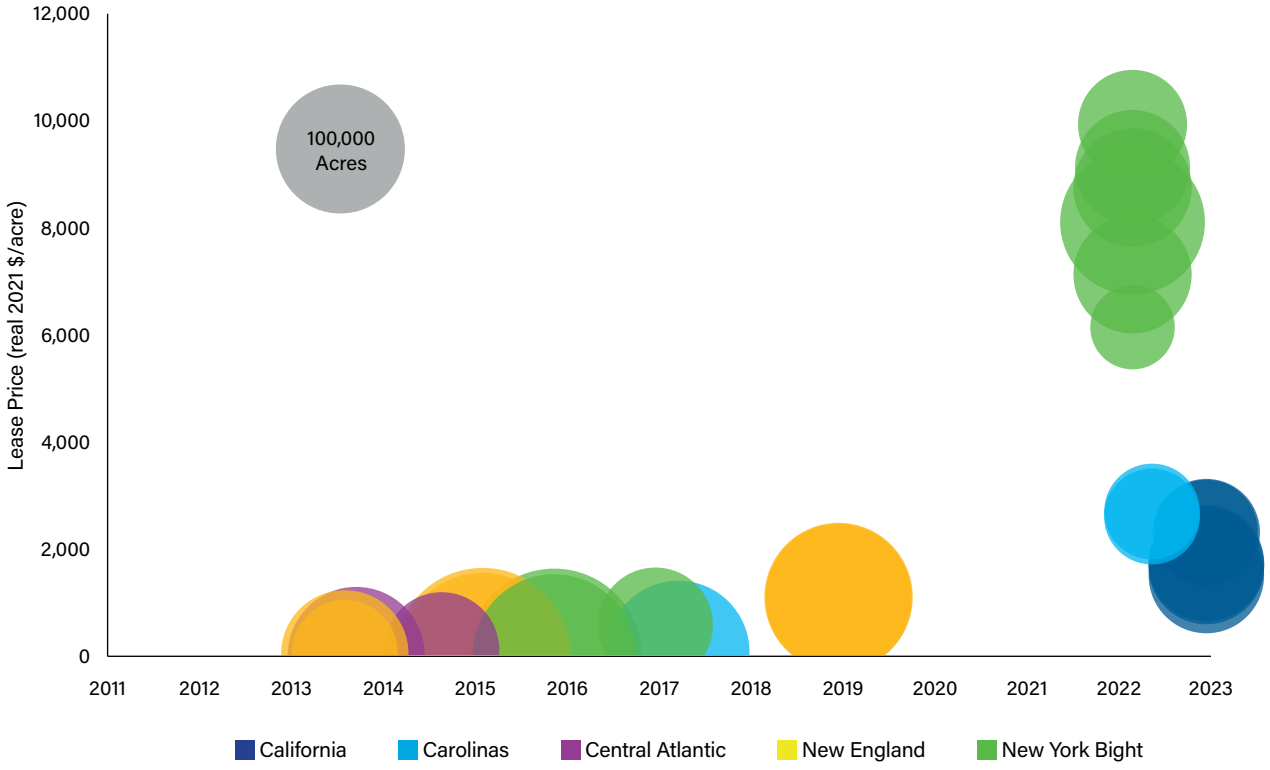
Offshore Wind

Lease Auction Prices

New York Bight, Carolina Long Bay, and California lease auctions generated over $5.4 billion in federal revenue

- The New York Bight lease auction resulted in very high lease prices, both in total terms and in terms of dollars per acre. In 2018, the auction of three leases off the coasts of Massachusetts and Rhode Island yielded lease prices ranging from $1,077/acre to $1,119/acre. In 2022, lease prices reached new heights in the New York Bight. Sale prices ranged from a low of $6,147/acre to as much as $9,933/acre, averaging $8,313/acre across six leases.
- The other 2022 lease auctions, in Carolina Long Bay and off the coast of Northern and Central California, had lower prices. In the former, lease prices averaged $2,657/acre while lease prices averaged just $1,884 off California. Part of this can be explained by the lack of established procurement processes in place in those regions. In California, lower lease prices can also be partially explained by the fact that deep waters off the state's coast necessitate the use of floating wind technology which may be more expensive than its fixed-bottom counterpart, at least initially.

Offshore Wind Lease Auction Prices

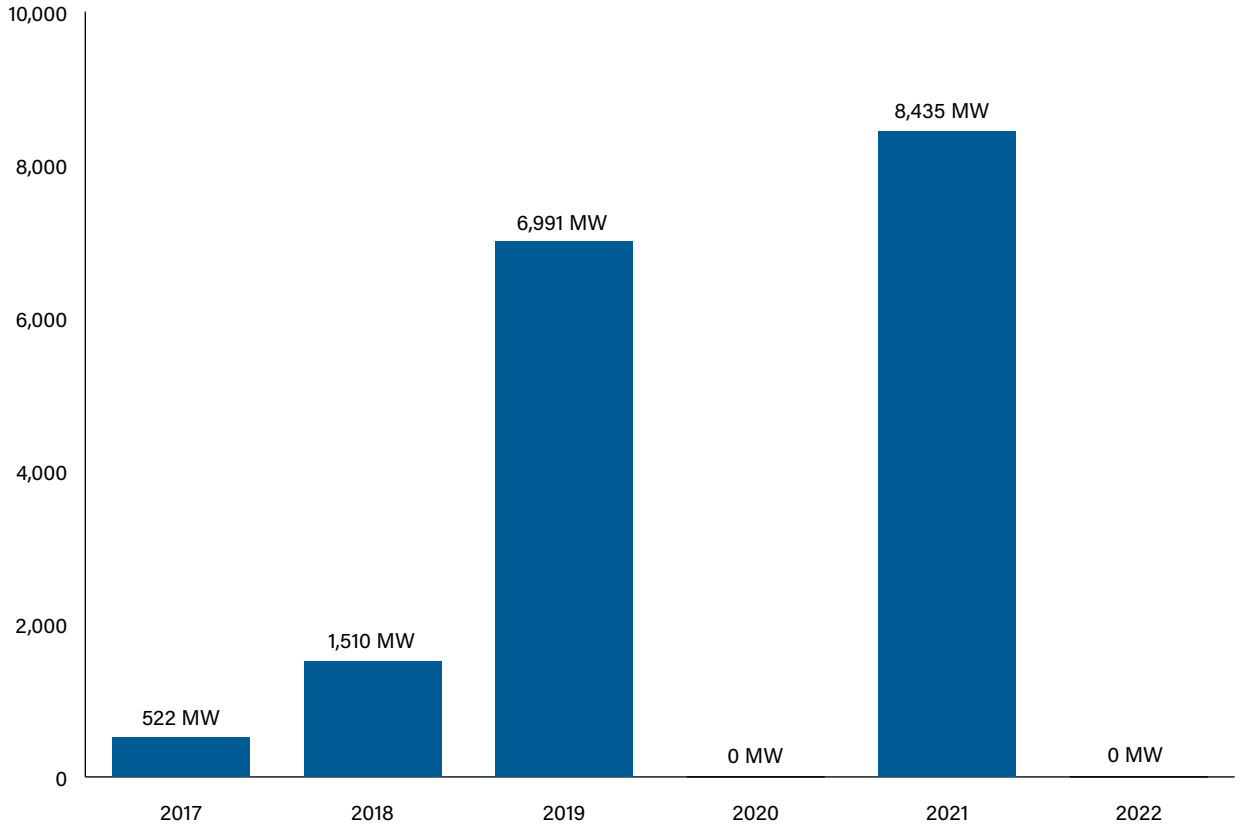


Offshore Wind Procurement

No new capacity was procured in 2022

- While 2021 was a record-setting year for offshore wind procurement, no new capacity was procured in 2022. There were, however, two new solicitations that are expected to procure new offshore wind capacity in 2023.
- The state of New York issued its third large-scale solicitation in July 2022, seeking to procure at least 2 GW of offshore wind. Proposals were due January 26, 2023. Winners are set to be announced in Q2 2023.
- In October 2022, Rhode Island's largest utility, Rhode Island Energy, released the state's largest RFP to date, seeking at least 600 MW and up to 1 GW of new offshore wind capacity. Proposals were due March 13, 2023, and the winner(s) are expected to be announced on June 21, 2023.

Offshore Wind Procurement by Year



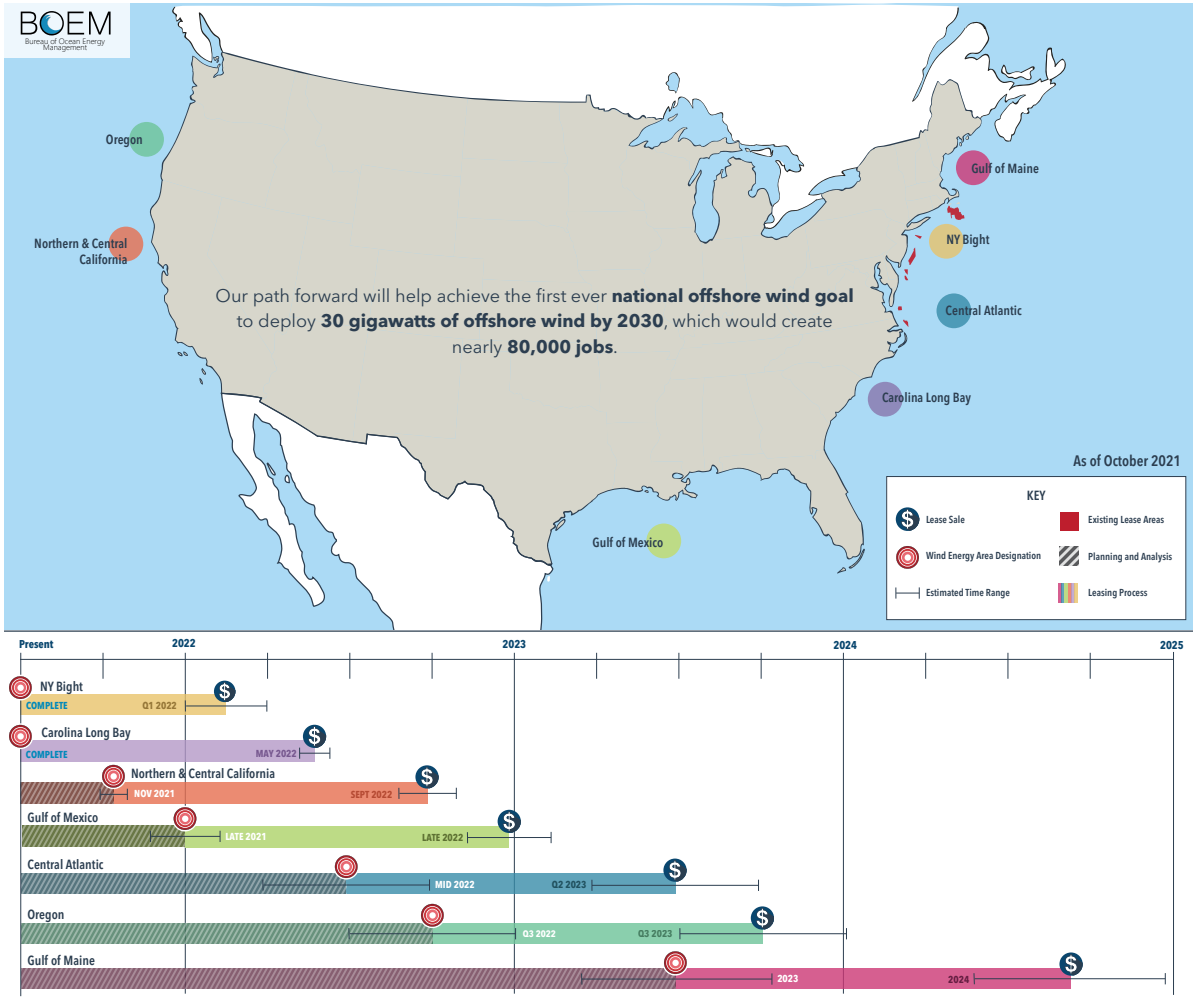
Offshore Wind

BOEM Path Forward

BOEM held three lease auctions in 2022, with federal revenue topping $5.4 billion

- At ACP's Offshore WINDPOWER conference in October 2021, Secretary of the Department of the Interior Deb Haaland announced BOEM's Offshore Wind Leasing Path Forward 2021-2025.
- As planned in the Path Forward, BOEM held an offshore wind lease auction in the New York Bight in February 2022. Following that, the agency held an auction in the Carolina Long Bay region in May 2022 and finished the year with a lease auction for two areas off California in December 2022.
- The New York Bight lease sale drew roughly $4.37 billion in federal revenue across six leases. Combined with Carolina Long Bay ($315 million across two leases) and California ($757 across five leases), 2022 lease auctions resulted in over $5.4 billion in federal revenue.
- BOEM plans to hold lease auctions in the Gulf of Mexico (2023), Central Atlantic (2023), Oregon (2023) and the Gulf of Maine (2024) to round out the Path Forward.

Offshore Wind Leasing Path Forward 2021-2025

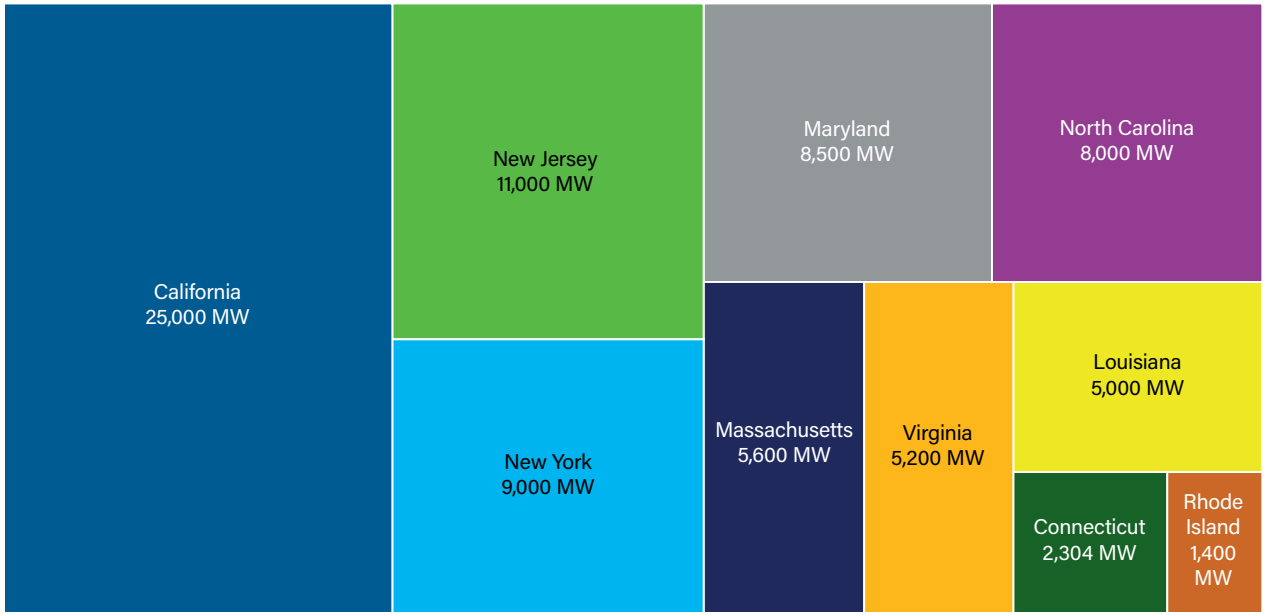


State Offshore Wind Targets

Ten states have set offshore wind procurement targets totaling over 81,000 MW

- Louisiana's Climate Initiatives Task Force approved the state's first ever Climate Action Plan on January 31, 2022. Among a number of strategies and actions to reduce greenhouse gas emissions, the Plan proposes an offshore wind goal of 5 GW by 2035.
- In August 2022, the California Energy Commission (CEC) adopted a report establishing offshore wind goals of 2 – 5 GW by 2030 and 25 GW by 2045.
- In September 2022, Governor Phil Murphy signed Executive Order #307, raising New Jersey's offshore wind target to an East Coast-leading 11,000 MW by 2040. Only California's 25,000 MW by 2045 goal is larger.
- In April 2023, Maryland lawmakers passed a bill setting the state's offshore wind target to 8.5 GW by 2031.
- To date, ten states have combined to set offshore wind procurement targets totaling 81,000 MW.

Offshore Wind Targets by State



Offshore Wind Investment Announcements

Announcements of major manufacturing facilities for major offshore wind components top $1.7 billion

- There have been a number of announced investments in the domestic offshore wind supply chain, the majority of which occurred before 2022. These announcements are typically tied to project awards in state solicitations. Where an investment amount is publicly available, announcements of manufacturing facilities for major offshore wind components top $1.7 billion. With three state solicitations closed or set to close in 2023, with awards pending, additional supply chain investment announcements should be expected.
- For example, in early 2023, 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 customers in the State's ongoing solicitation.
- Similarly, Siemens Gamesa announced its intention to build a major offshore nacelle manufacturing facility in New York State, subject to the company's wind turbines being selected by the New York authorities in their third offshore wind solicitation.

Major Offshore Wind Component Manufacturing Announcements

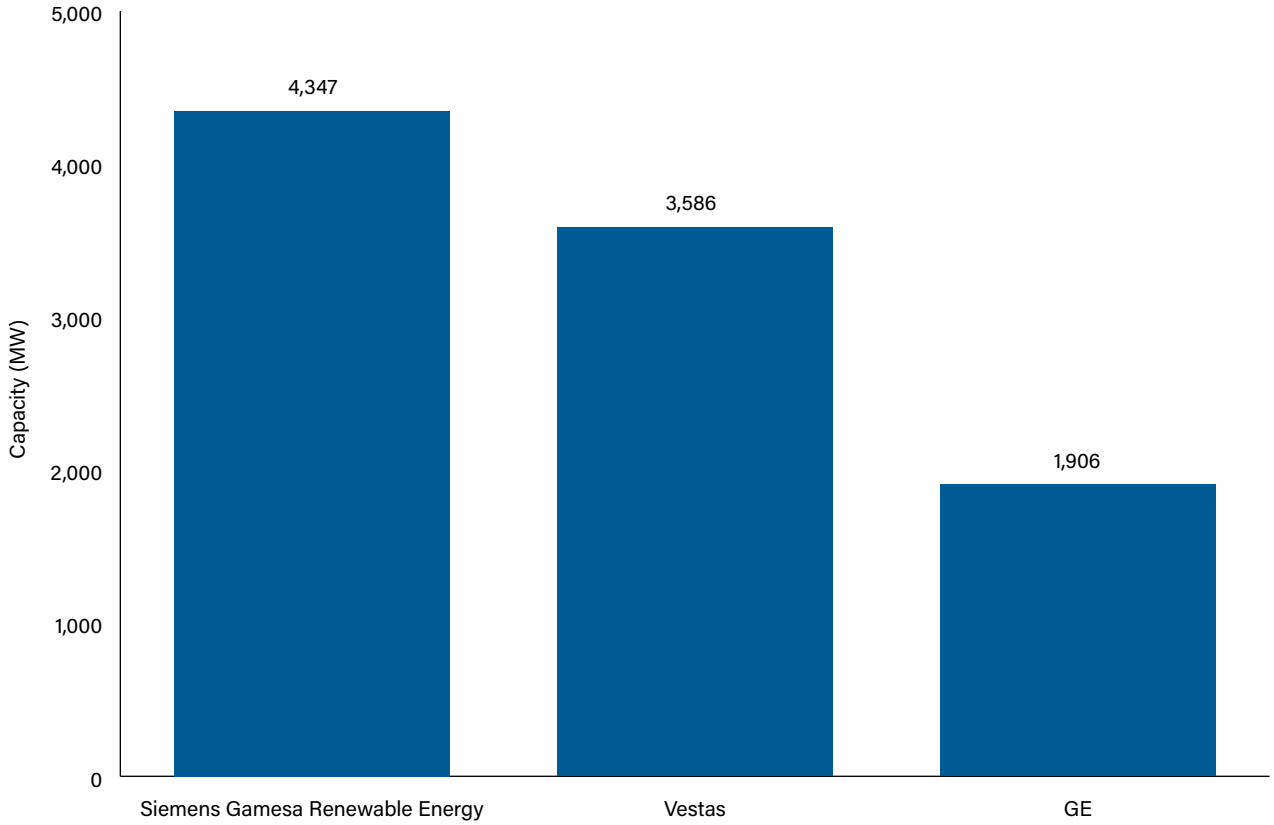
Component	State	Investors	Investment ($million)	Status
Blades	Virginia	Siemens Gamesa	200	Announced
Nacelle Assembly	New Jersey	Vestas, Atlantic Shores		Announced
	New Jersey	GE, Ørsted		Announced
Towers	New York	Marmen Welcon, Equinor	350	Announced
	Maryland	Ørsted		Announced
Monopiles	New Jersey	EEW, Ørsted	250	Under Construction
	Maryland	US Wind	150	Announced
Foundation Platforms	Rhode Island	Eversource, Ørsted	40	Announced
Secondary Steel	Maryland	Ørsted		Under Construction
Transition Pieces/ Advanced Foundation Components	New York	Marmen Welcon, Smulders		Announced
	New York	Ørsted, Eversource, Riggs Distler & Company	86	Announced
	Rhode Island	Ørsted, Eversource		Announced
	Connecticut	Avangrid		Announced
Array and Export Cables	South Carolina	Nexans	310	Operational
	Connecticut	Kerite, Marmon Group, Vineyard Wind	4	Operational
	Maryland	Ørsted, Hellenic Cables	140	Announced
	Massachusetts	Prysmian, Avangrid	200	Announced
Offshore Substations	Texas	Kiewit, Eversource, Ørsted		Operational

Offshore Wind Turbine OEMs

Siemens Gamesa Renewable Energy leads Vestas and GE where a preferred supplier is known

- Where a turbine supplier has been named through either a firm order or a preferred supplier announcement, Siemens Gamesa Renewable Energy (4,347 MW) leads Vestas (3,586 MW) and GE (1,906 MW) in projected wind capacity. However, nearly 7.7 GW of offshore wind capacity in advanced development has yet to publicly announce a preferred supplier.

Offshore Wind Turbine Commitments by OEM

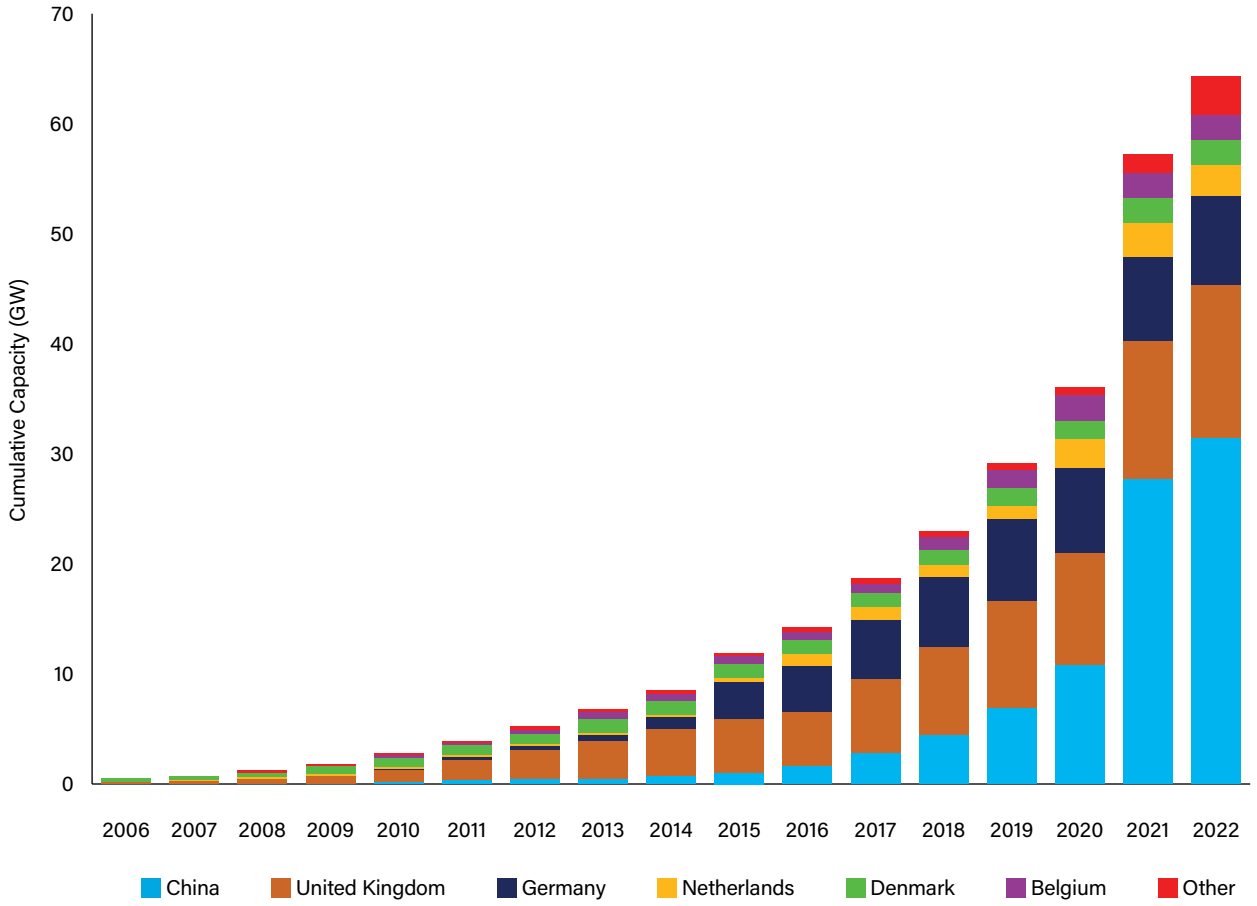


Cumulative Global Offshore Wind Capacity

China leads offshore wind with more than twice the operating capacity of any other nation

- According to Global Wind Energy Council (GWEC), global offshore wind capacity reached 64.3 GW after installing 7.1 GW in 2022.
- The United Kingdom (UK) was the global leader in offshore wind power until 2020. In 2020, China installed 3.8 GW of offshore wind power and took over the top spot.
- In 2021, China commissioned an astronomical 16.9 GW of offshore wind. In 2022, installations cooled, dropping back to 2020 levels. Cumulatively, the nation has 31.4 GW online.
- The UK still ranks second with 13.9 GW online, followed by Germany with 8.1 GW and the Netherlands with 2.8 GW.
- Over the past five years, global offshore wind capacity has grown at an average of nearly 30% each year.

Cumulative Offshore Wind Capacity by Country



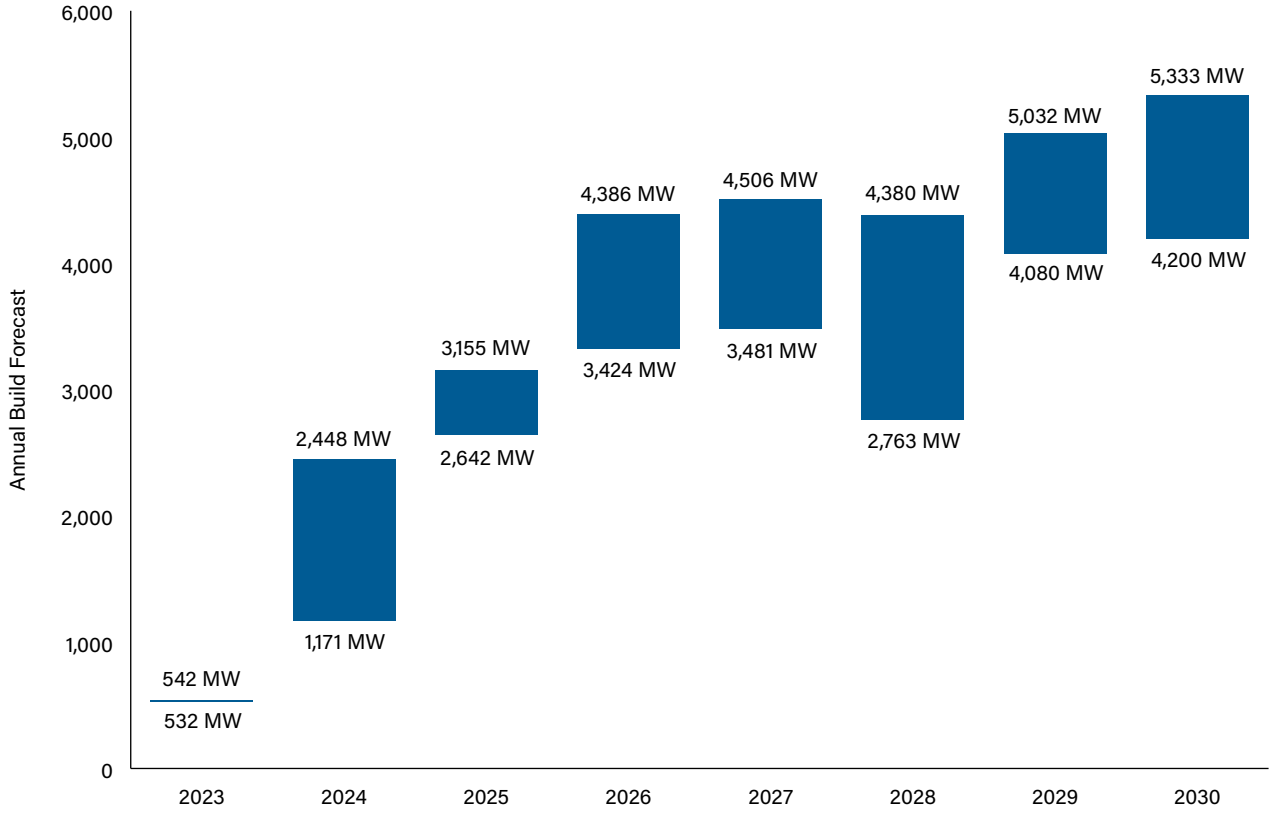
Source: GWEC

Offshore Wind Forecast

Consultants grow more optimistic in offshore wind—outlook now at 26 GW by 2030

- It's still not to the level of the industry's nor the Biden Administration's expectations, but consultant forecasts are heading in the right direction. Bloomberg, S&P Global, and Wood Mackenzie anticipate, on average, 26 GW of offshore wind to be operational in 2030, a 2 GW improvement over last year's forecast.
- The most optimistic forecast projects offshore installations to hit 28 GW by the end of the decade, within reach of the 30 GW goal.
- The offshore wind market is largely driven by state policy support, solicitation schedules, and seabed leasing availability.
- Chief among forecaster's concerns are long development timelines, anticipated delays, supply chain bottlenecks, and other factors.
- Multi-gigawatt annual installations are expected starting in 2025, while 2030 is anticipated to be the peak year for new offshore wind additions at nearly 5 GW.

Industry consultant offshore wind power capacity forecast, 2023-2030



Source: BNEF, S&P, Wood Mackenzie

Utility-Scale Solar

AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Utility-Scale Solar Highlights

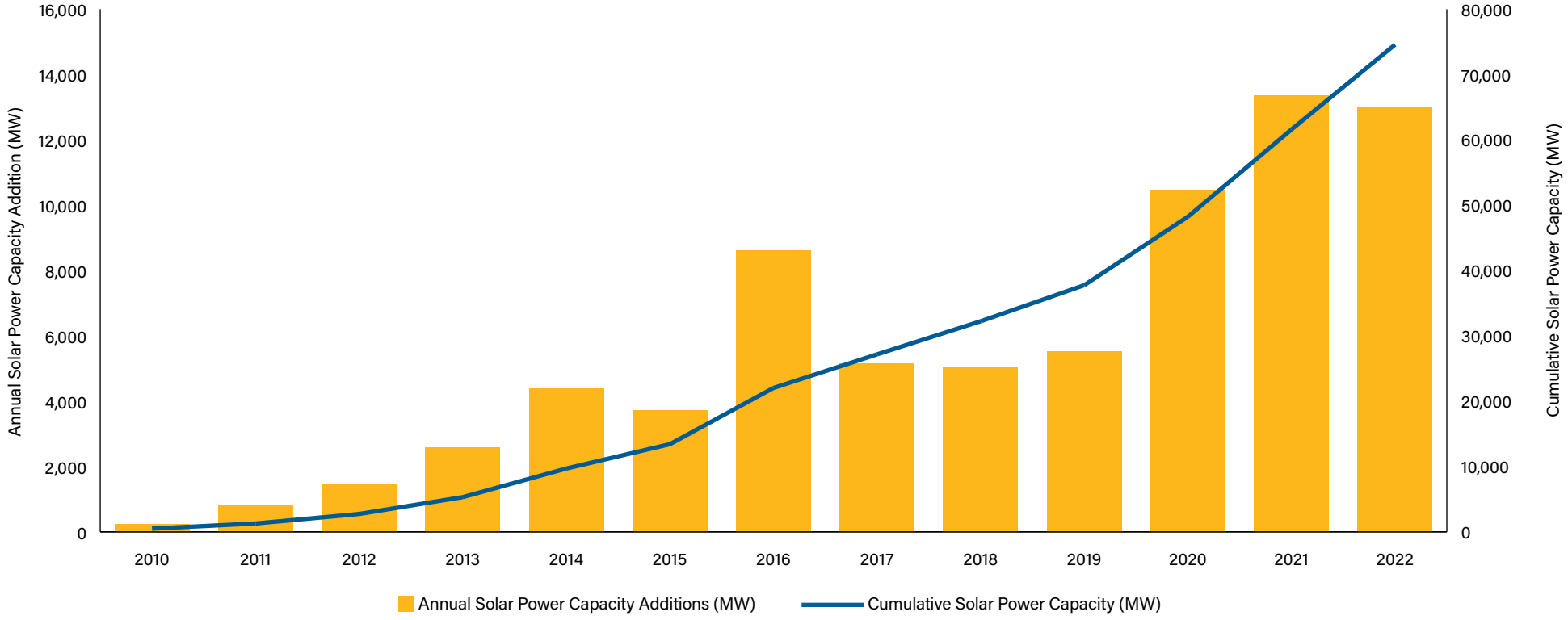
- The 13 GW of utility-scale solar installed in 2022 falls 3% short of the record year in 2021. In total, nearly 75.6 GW of utility-scale solar is operating.
- With plentiful solar resources, supportive solar policies, and a large population, California continued to lead the U.S. in terms of solar capacity. However, Texas installed more new solar capacity in 2022, while California ranked second.
- Single-axis trackers are the most common among operating solar capacity, accounting for more than half of all operating capacity. Fixed tilt systems make up about a quarter of operating capacity, and dual-axis trackers remain uncommon.
- The U.S. solar market has seen gradual improvements in average solar-plant capacity factors. Projects built in 2013 had an average capacity factor of 23.8% in 2022, compared to 25% for projects built in 2021.
- The passage of the IRA has had the largest impact on the utility solar forecast, boosting installation expectations between 2023 and 2030 by 37%. On average, forecasters project 206 GW to be built over the next eight years.

Utility-Scale Solar

Annual and Cumulative Solar Power Capacity

Just under 13,000 MW of utility-scale solar added to the grid

U.S. Annual and Cumulative Solar Power Capacity Growth



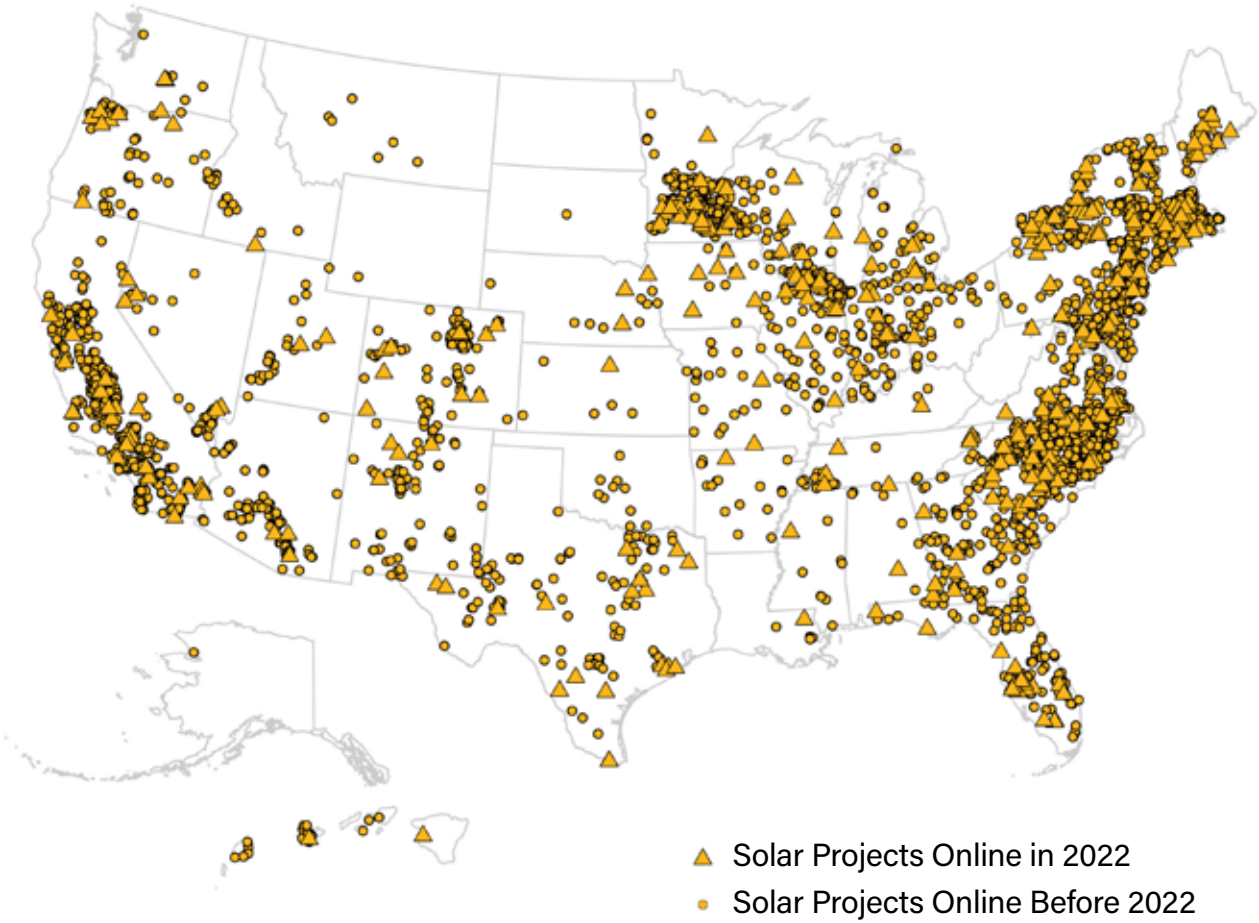
- The U.S. solar industry installed 12,993 MW of utility-scale solar power capacity in 2022. This brings the cumulative operating capacity to 74,576 MW.
- The capacity installed in 2022 marked a slight decrease from 2021. Year-over-year, solar capacity installations fell by 3%, as the industry added 354 MW less compared to 2021.
- After two years of rapid growth, utility-scale solar capacity additions decelerated in 2022. This was likely due to supply chain issues, interconnection queues, uncertainty over IRA implementation, and trade restrictions resulting in developers struggling to procure solar panels.

Utility-Scale Solar Projects

Nearly 360 utility-scale solar projects added to the grid in 2022

- Solar developers brought 354 utility-scale solar projects online in 2022, totaling nearly 13 GW in 2022. These projects were spread across 43 states and the District of Columbia, including six states that added 500 MW or more.
- Texas led all states in new utility-scale solar power, installing over 3.9 GW. California followed with over 2.1 GW. Florida placed third, adding nearly 1.1 GW.
- The largest solar project phase to come online in 2022 was the 430 MW Old 300 Solar project located in Texas. The 350 MW Fighting Jays Solar Project also located in Texas and the 300 MW Slate Solar project in California round out the top three spots.

Utility-Scale Solar Power Projects



ACP reports solar capacity in MWac

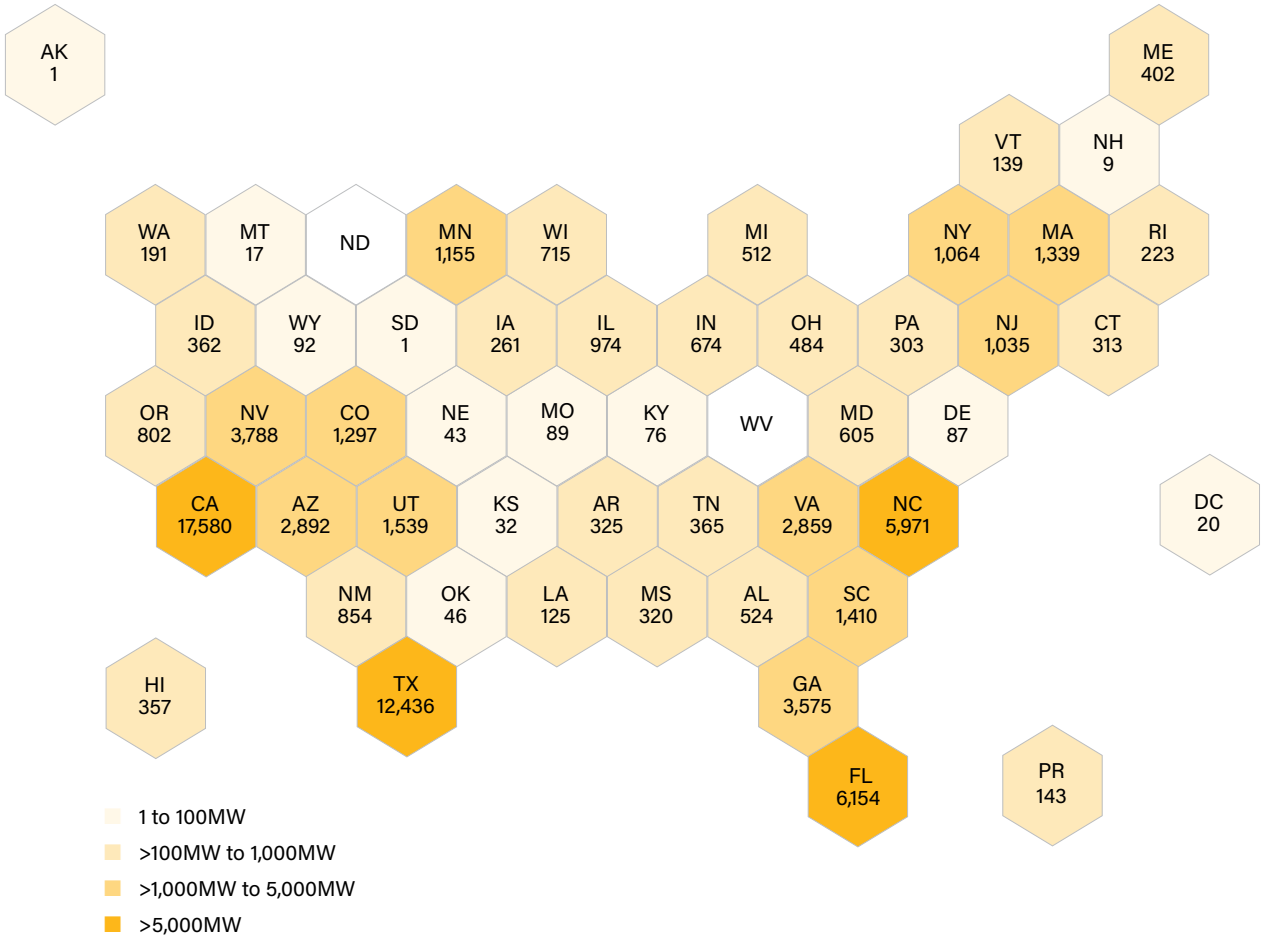
Utility-Scale Solar

Operating Utility Solar Power

Over 74.5 GW of solar is operating in the U.S.

- By the end of 2022, the cumulative operating capacity for utility-scale solar had reached 74,567 MW. Utility-scale solar projects were present in 48 states, the District of Columbia, and Puerto Rico.
- North Dakota and West Virginia were the only states to lack utility-scale solar power capacity.
- With plentiful solar resources, supportive solar policies, and a large population, California continued to lead the U.S. in terms of solar capacity. In 2022, California had 17,580 MW of utility-scale solar online, followed by Texas (12,436 MW), Florida (6,154 MW), North Carolina (5,971 MW), and Nevada (3,788 MW).

Operating Utility-Scale Solar Power by State

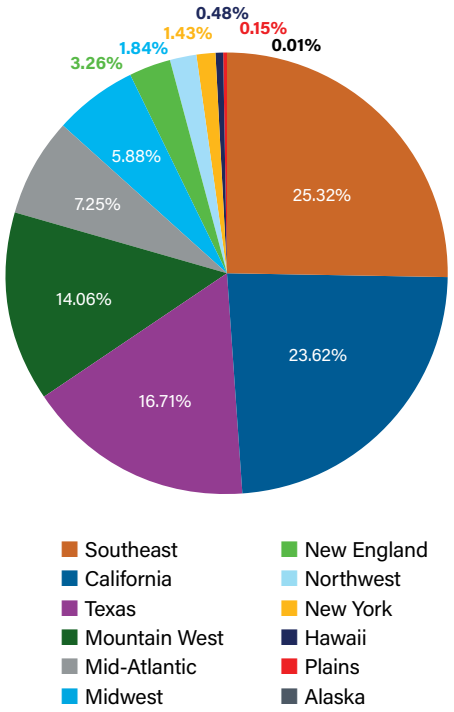


Utility-Scale Solar

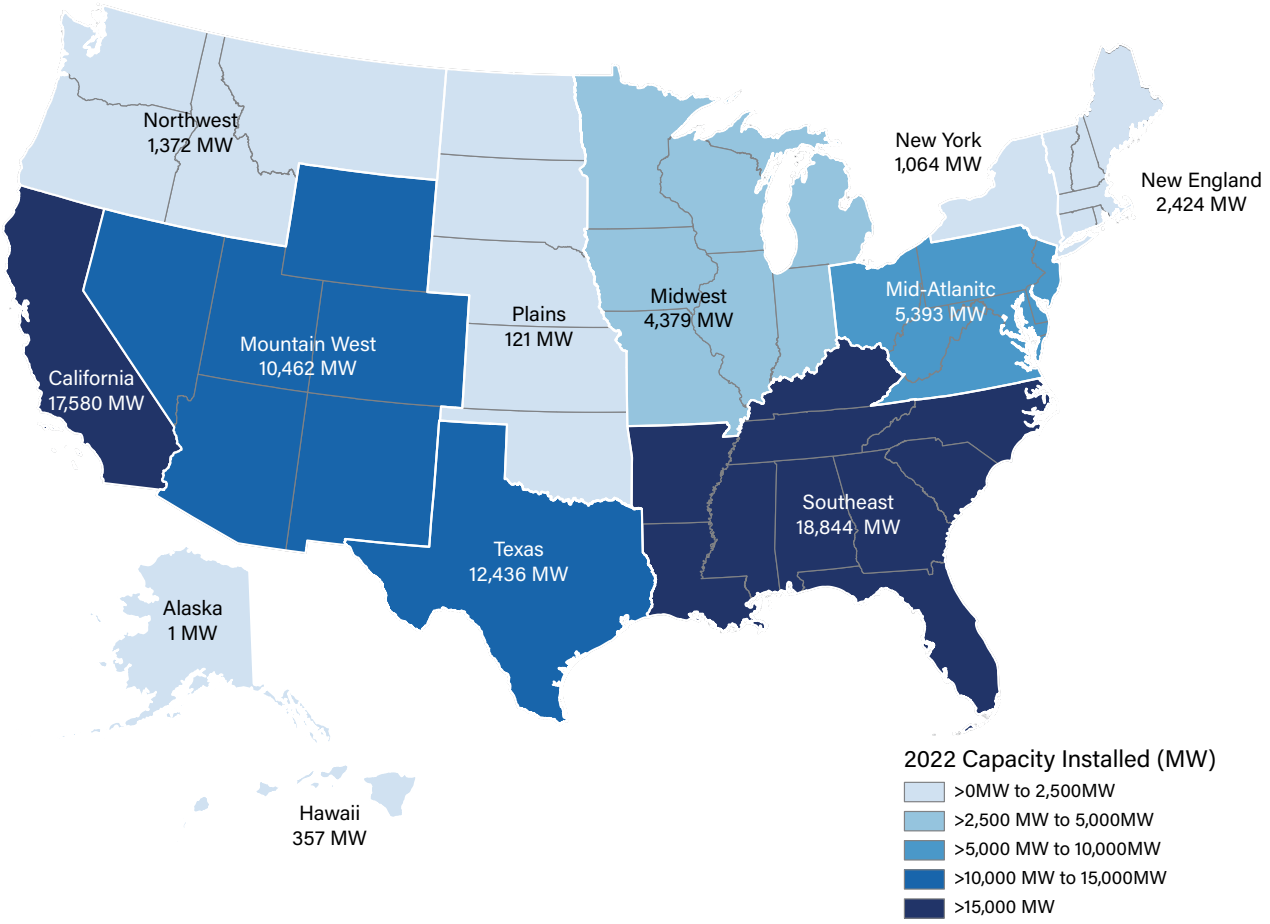
Operating Utility Solar Power by Region

The Southeast leads regional rankings

- At 18,844 MW, the Southeast leads all regions in terms of operating utility-scale solar capacity as of the end of 2022.
- California is in second place with 17,580 MW of operating utility-scale solar installed. Texas took third place this year, with 12,436 MW installed. Notably, Texas surpassed the Mountain West, which was ranked third in 2021 and had a total capacity of 10,462 MW in 2022.



Operating Utility Solar Power by Region

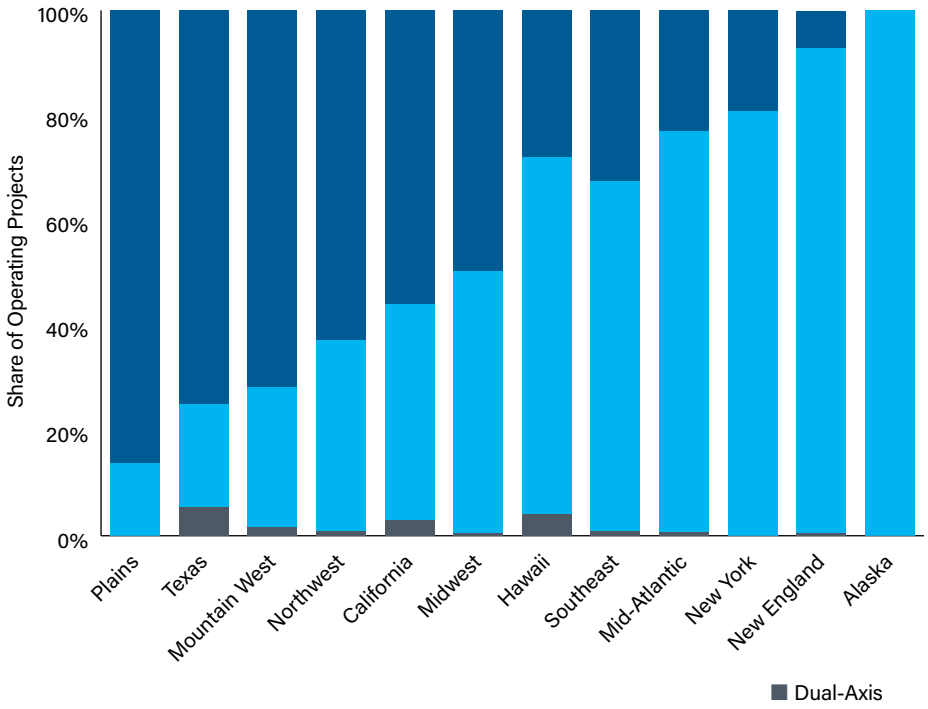


Utility-Scale Solar

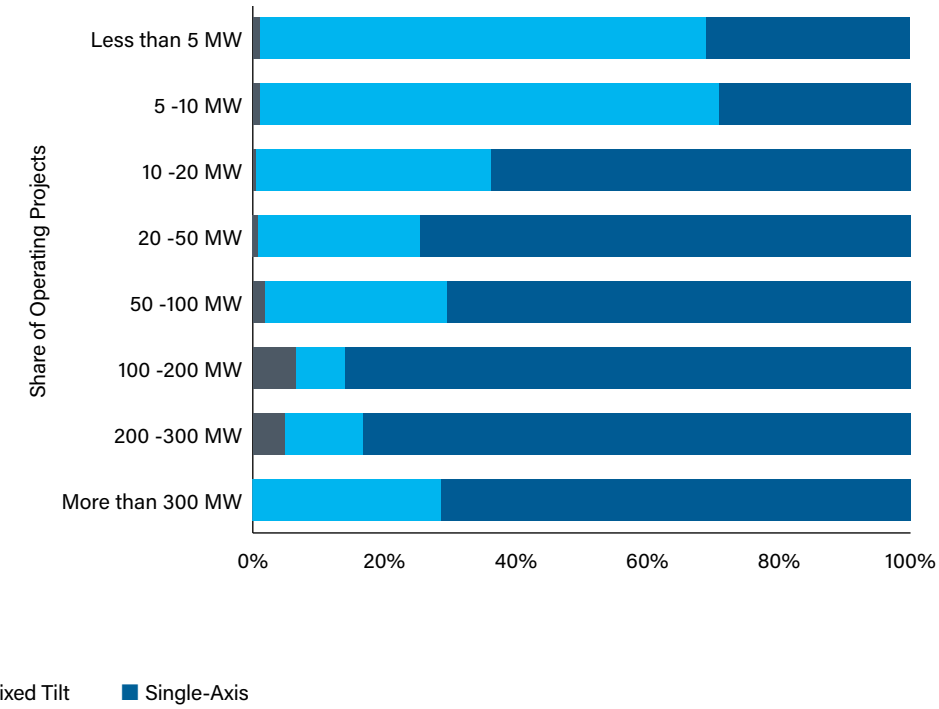
Tracking Type by Region & Capacity

Single-axis trackers dominant in the utility-scale space

Tracking Type Share by Operating Projects by Project Size



Tracking Type Share of Operating Projects, Where Tracker is Known



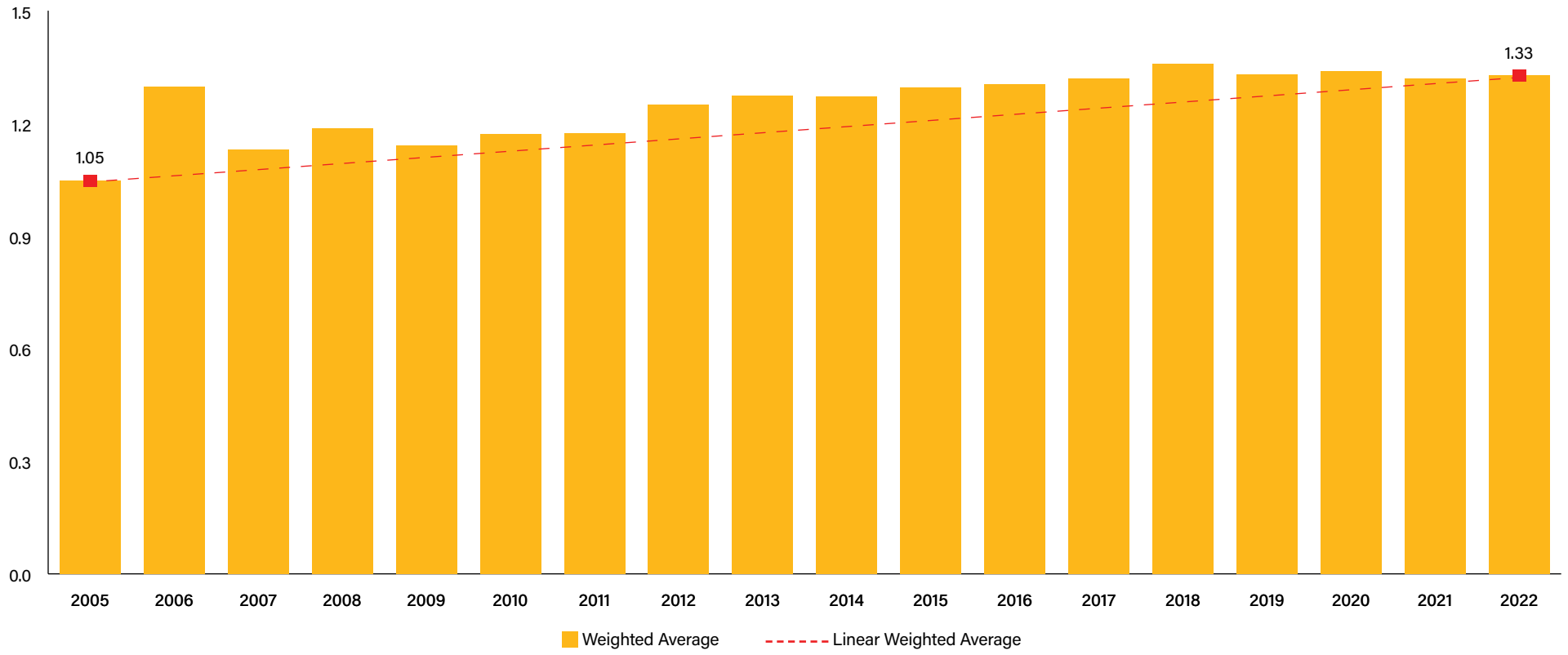
- Single-axis trackers are the most common among operating solar capacity, accounting for 57% of all operating capacity. Fixed tilt systems make up 24% of operating capacity, and dual-axis just 2%. ACP was unable to determine the tracker type for 17% of operating capacity.
- Larger projects use single-axis trackers more often than smaller projects. More than 75% of projects larger than 100 MW in size use single-axis trackers. Fixed tilt systems, on the other hand, are much more common for smaller projects. Nearly 70% of projects less than 10 MW in size used fixed tilt systems. Dual-axis trackers have high upfront capital costs and are uncommon across all projects regardless of size.
- The type of tracker used at solar projects varies significantly by region. In the Plains, 86% of operating projects use single-axis trackers, while in New England 92% of operating projects use fixed tilt systems. Alaska only has one operating solar project where the tracker type is known, which uses a fixed tilt system.

Utility-Scale Solar

Solar Inverter Loading Ratio

Project inverter loading ratio gradually increasing over time

Average Inverter Loading Ratio by Installed Year



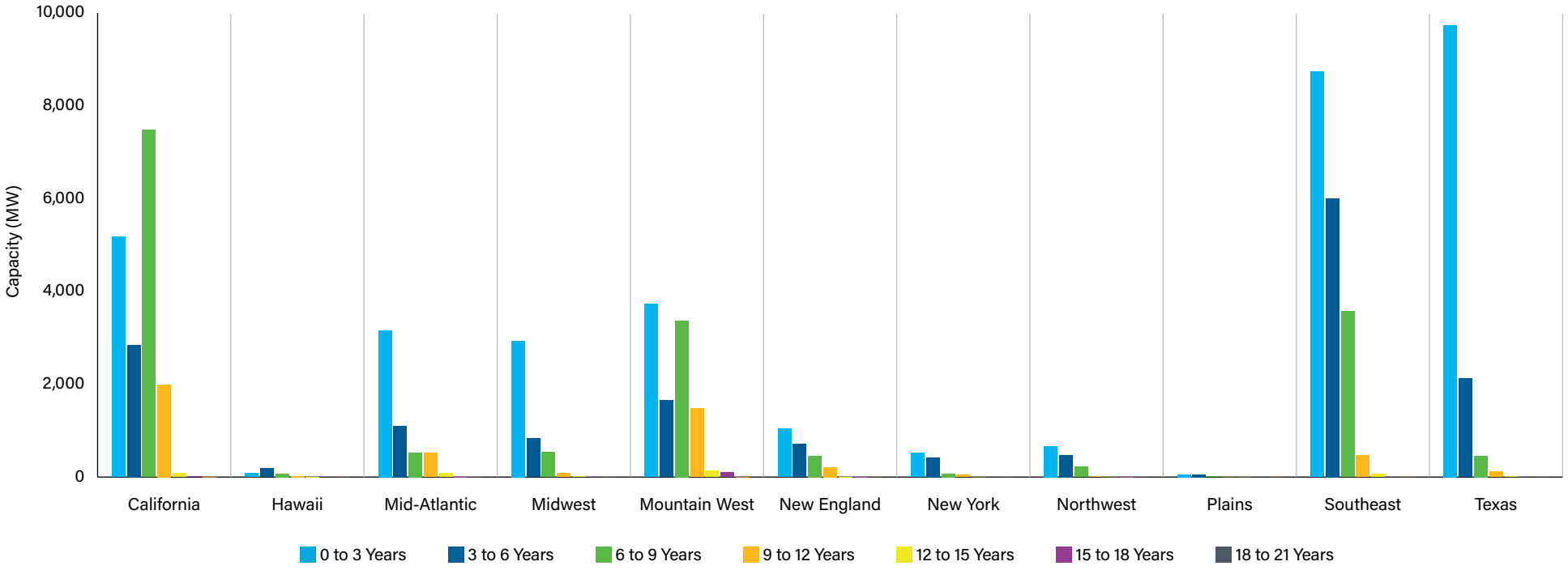
- Over the past decade, there has been an increase in the DC-to-AC ratio, also known as the inverter loading ratio (ILR), in solar projects. This means that solar projects are often designed with a DC capacity that is 10% to 30% higher than the AC capacity, driven by economic and engineering considerations.
- Since 2005, the ILR for operating utility-scale solar projects has increased from 1.05 to 1.33. The increase can be attributed to the increase in the average capacity of solar projects over time. Larger projects generally have a higher ILR compared to smaller projects.
- Based on ILRs, the 74,576 MWac of operating solar capacity translates into 98,137 MWdc.

Utility-Scale Solar

Solar Project Age

The average solar project in the U.S. is just over five years old

Regional Age Profile of Solar Projects



- Nearly half of all the operating solar capacity in the U.S. was installed within the last three years. 45% of operating solar capacity was installed between three and nine years ago, and only 8% of capacity has been operating for more than nine years.
- By region, the Mountain West was the earliest adopter of solar energy. The only project that has been operating for more than 18 years is located in the Mountain West, and the region has the most capacity that is more than 12 years old.
- Over 2 GW of solar capacity operating in California has been operating for more than nine years.
- Texas is a more recent adopter of solar energy. Only 5% of operating capacity is the State is more than 6 years old. The dramatic increase in installed capacity over the past three years propelled Texas to rank second for total operating solar capacity.
- The average solar project in the U.S. has been operating for just over five years.

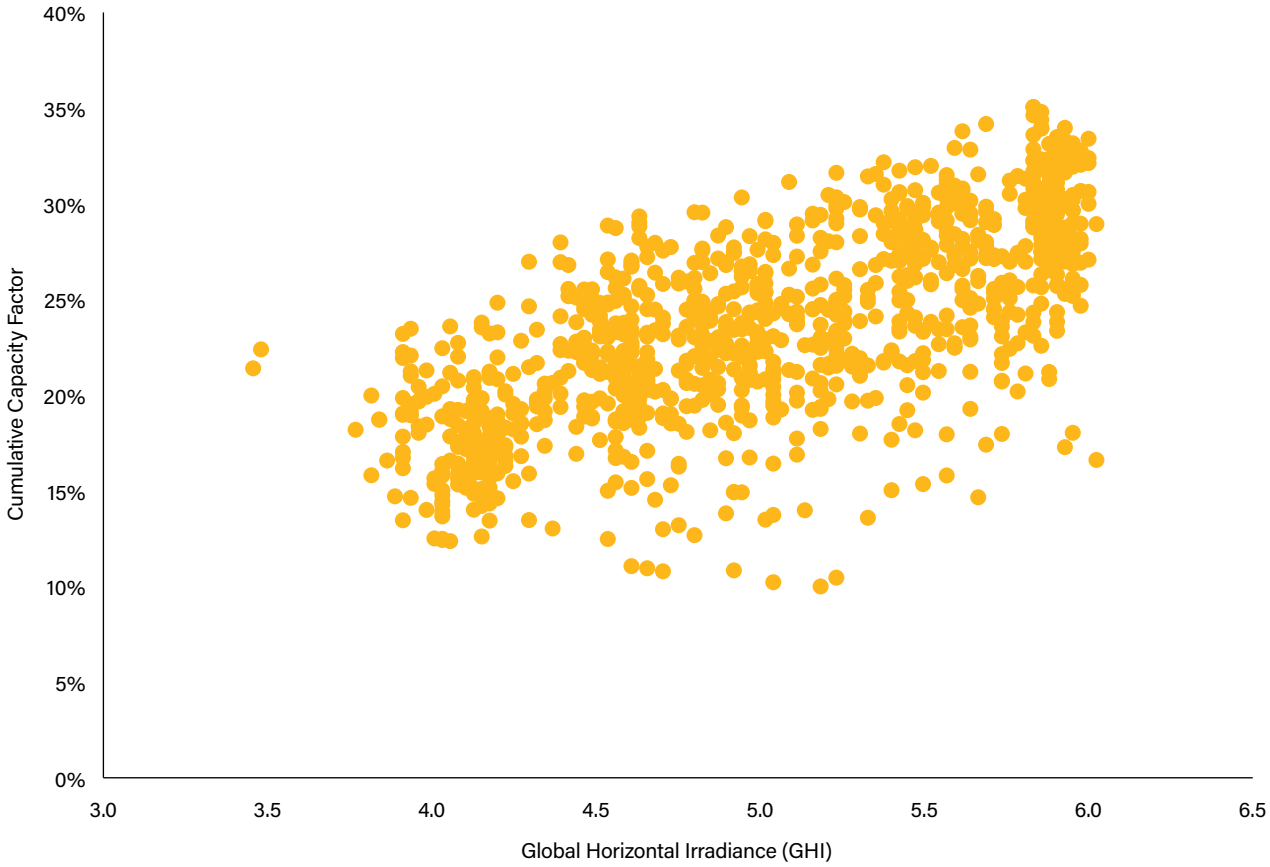
Utility-Scale Solar

Solar Capacity Factors by GHI

Project GHI and capacity factors are decreasing due to geographic dispersion of solar

- Global Horizontal Irradiance (GHI) is an important measure of total solar radiation – similar to average wind speeds in a given region for wind projects. The higher the GHI, the more electricity can be produced. Projects located in areas with higher GHI values have higher capacity factors.
- Historically, solar projects were built in high GHI areas because they were the most cost-effective locations for developers to build projects. As technology has improved and capital costs have decreased, more solar projects are being built in areas with lower solar resources. This makes it appear that solar capacity factors are decreasing, but it is a sign that the industry is expanding to areas that were previously not suitable for solar energy development.
- GHI sourced from: Sengupta, M., Y. Xie, A. Lopez, A. Habte, G. Maclaurin, and J. Shelby. 2018. "The National Solar Radiation Data Base (NSRDB)." Renewable and Sustainable Energy Reviews 89 (June): 51-60.

Solar Capacity Factors by Global Horizontal Irradiance (GHI)



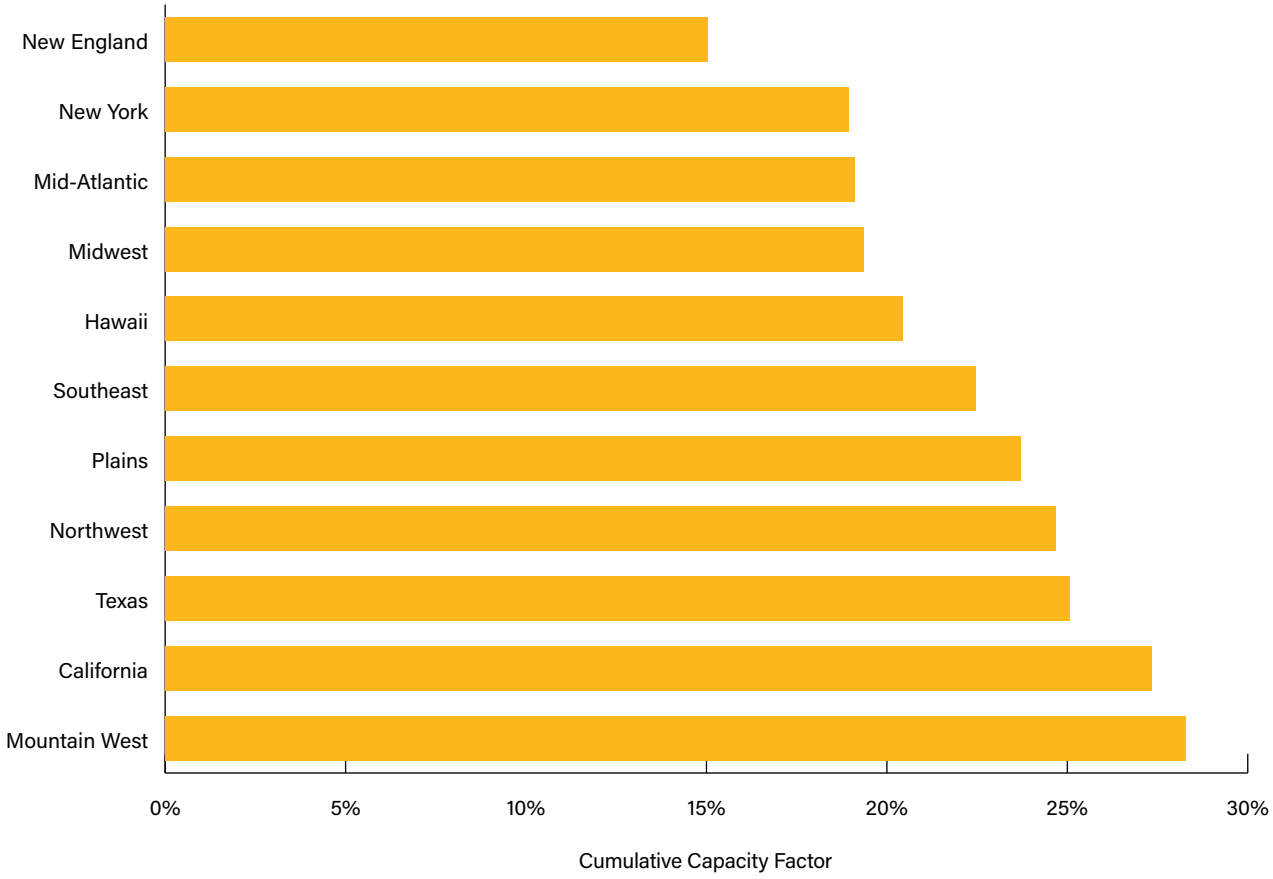
Utility-Scale Solar

Regional Capacity Factors

The Mountain West and California lead with cumulative capacity factors above 27%

- Capacity factors for solar energy are heavily impacted by site-specific resources. Solar technologies function most effectively in the southwestern U.S., which receives the greatest amount of solar irradiance.
- California and the Mountain West receive the most consistent sunlight. Cumulative capacity factors average 27.3% in California and 28.2% in the Mountain West.
- The lowest cumulative capacity factors are found in New England at just 15.0% due to it being in the Northernmost corner of the U.S. with longer winters and higher incidence of cloudiness.
- For similar reasons, cumulative capacity factors in New York, the Midwest, and the Mid-Atlantic all average under 20%.

Regional Solar Capacity Factors



Source: EIA

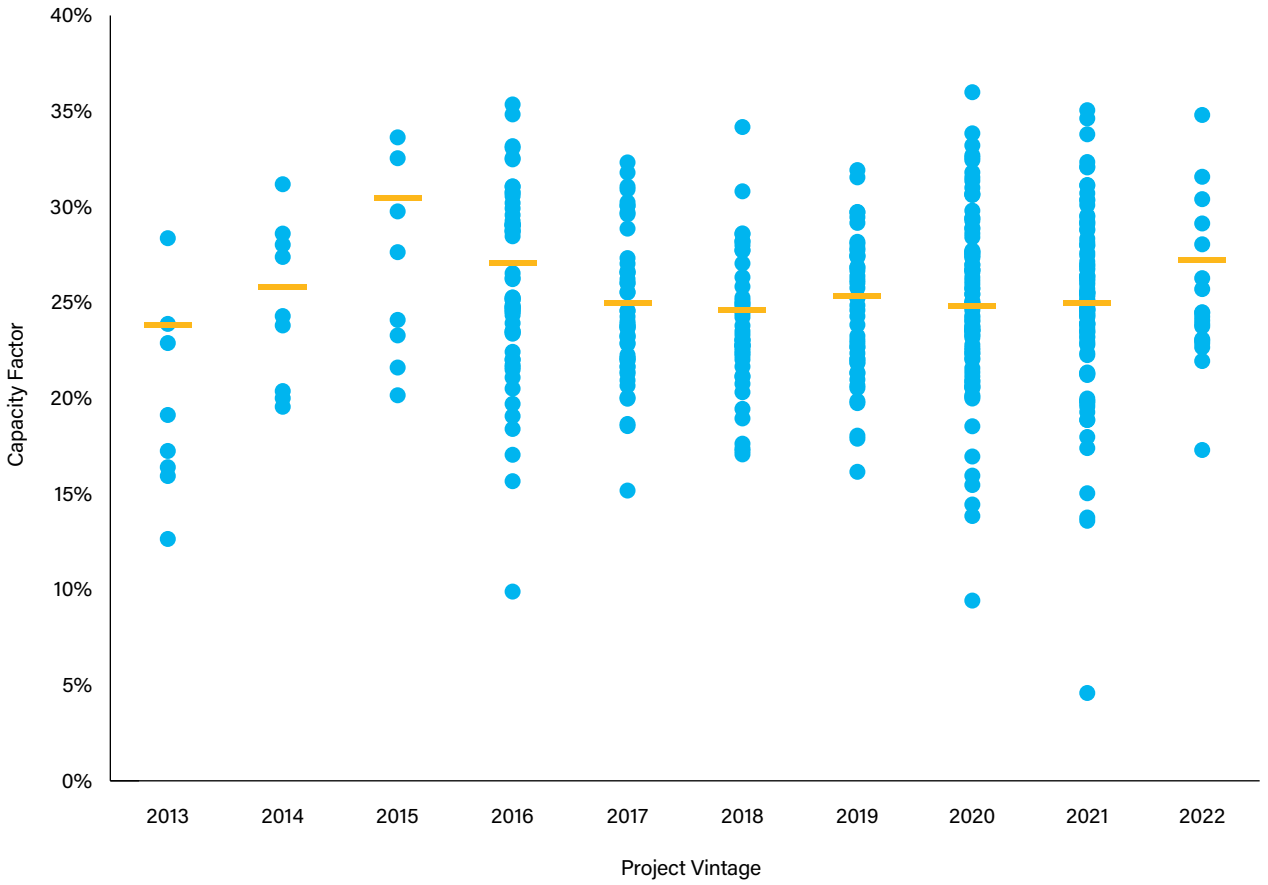
Utility-Scale Solar

Solar Capacity Factors in 2022, by Vintage

Flat-to-declining vintage capacity factors since 2016

- The U.S. solar market has seen gradual improvements in average solar-plant capacity factors. This is the result of increases in solar PV module level capacity factors and other efficiencies and improvements. Increased use of single- and dual-axis trackers and bi-facial panels have also helped increase efficiencies.
- Projects built in 2013 had an average capacity factor of 23.8% in 2022. The average 2022 capacity factor for projects built in 2015 grew to a maximum of 30.5%. Starting with the 2016 vintage of projects, average capacity factor in 2022 is lower, in the 24%-27% range. Projects built in 2021 had an average capacity factor of 25.0% in 2022.
- The decrease in average capacity factor across project vintage is likely explained by the expansion of the solar market into less sunny regions of the United States. As equipment costs have decreased, projects in areas such as the Northeast have become cost effective despite a lower GHI and in turn, lower energy production.

Solar Capacity Factors in 2022, by Vintage



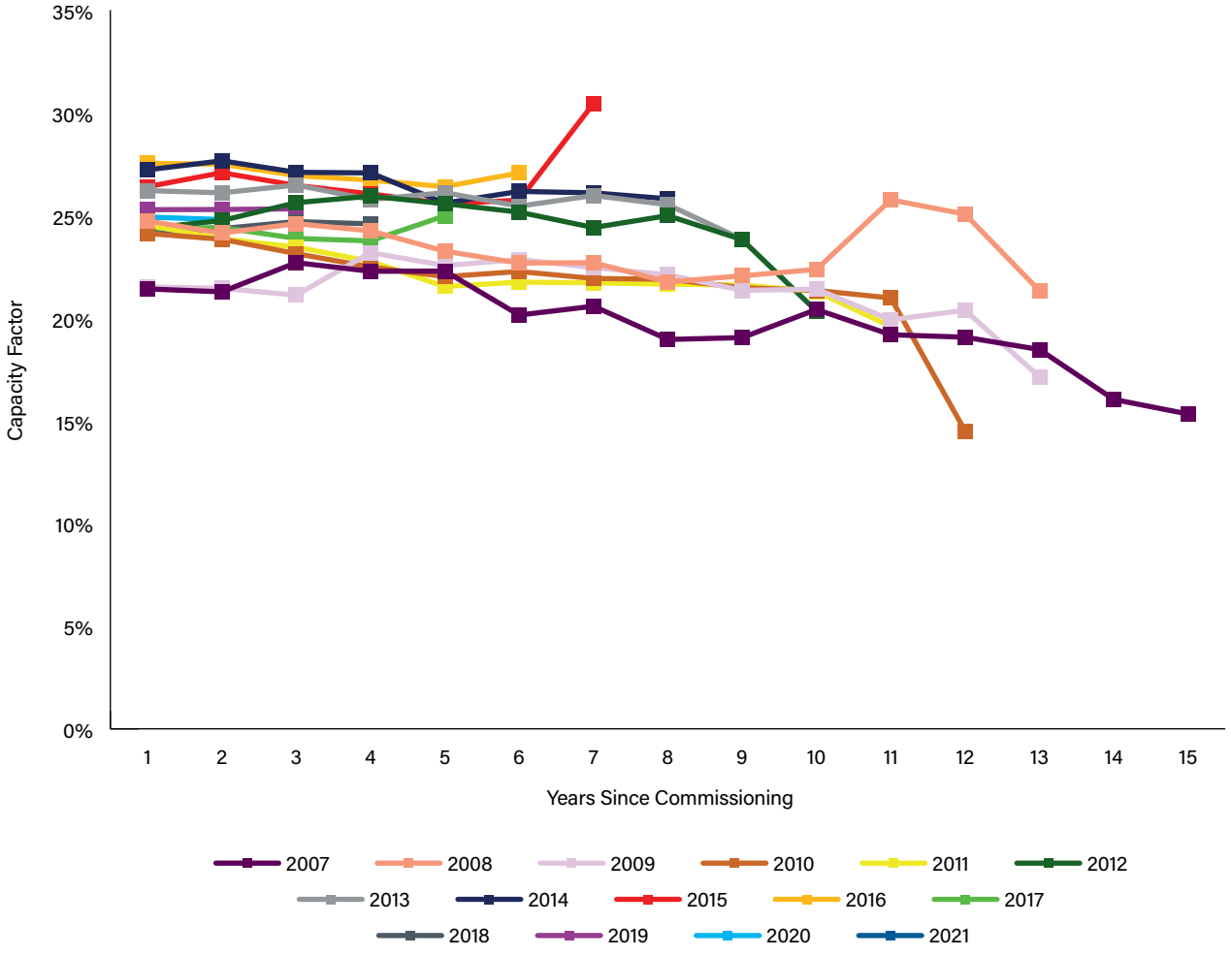
Source: EIA

Solar Capacity Factor Performance over Time

Solar performance generally declines modestly over time

- There is some inevitable reduction in performance of an aging solar power plant. Performance declines as solar cells experience degradation due to UV exposure and weather cycles.
- Modules can fail because of unavoidable elements like thermal cycling, damp heat, humidity, freezing, and UV exposure. Thermal cycling can cause solder bond failures and cracks in solar cells. UV exposure also contributes to discoloration and backsheet degradation.
- While some vintages of solar projects have seen sharp declines in capacity factors (such as in 2007, where the average annual capacity factor has fallen from 21.5% in their first full year of operation to 15.3% in 2022), others have experienced relatively flat production. For instance, projects built in 2016 have maintained annual average capacity factors between 26%-28% throughout their operation.
- In the 2008 vintage, a two-year increase in average capacity factor in 2020 and 2021 returned to historical trends in 2022, falling from 25.7% in 2020 to 21.3% in 2022.
- 2015 vintage projects saw a similar spike in 2022, increasing from 25.7% to 30.4%. These spikes may be the result of sample size issues, as just seven 2015 vintage projects were captured in the 2022 data, compared to 92 2015 vintage projects in the 2021 data.

Solar Project Vintage Capacity Factor Performance Over Time



Source: EIA

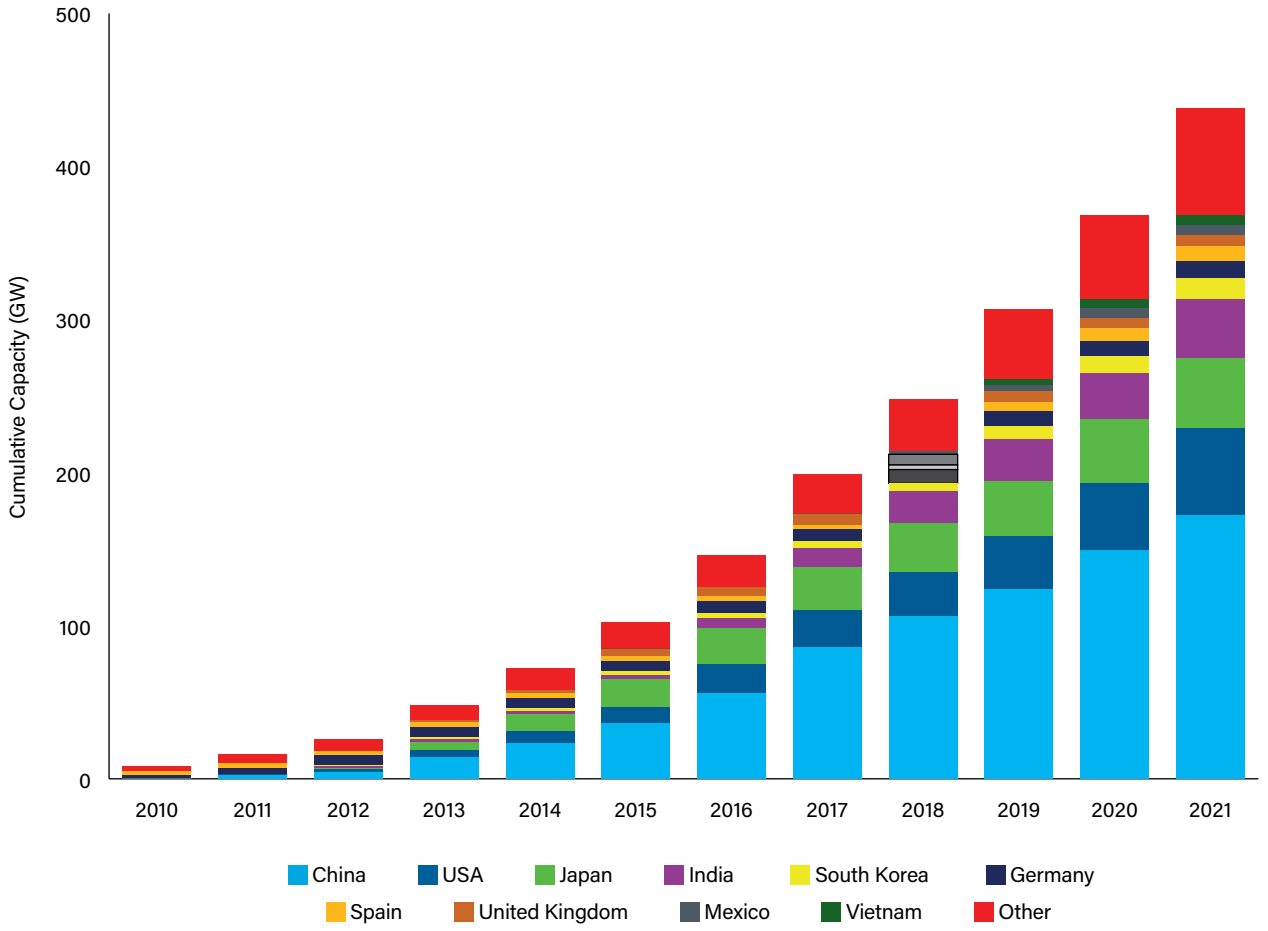
Utility-Scale Solar

Global Utility-Scale Solar Capacity

U.S. moves up in global utility-scale solar ranking to #2

- In 2021, according to BNEF, global utility-scale solar capacity reached 439 GW, increasing 19% from 2020.
- Global solar capacity has increased by 120% over the past five years, thanks to an average annual growth rate of over 20% between 2017 and 2021.
- While Spain and Germany were early leaders in the solar space, China has consistently had the most solar capacity operating since 2013.
- The U.S. has ranked third between 2013 and 2019 before moving into second place in 2020.
- Japan ranked second between 2014 and 2019 and now ranks third in terms of total operating solar capacity.

Cumulative Global Utility-Scale Solar Capacity by Country



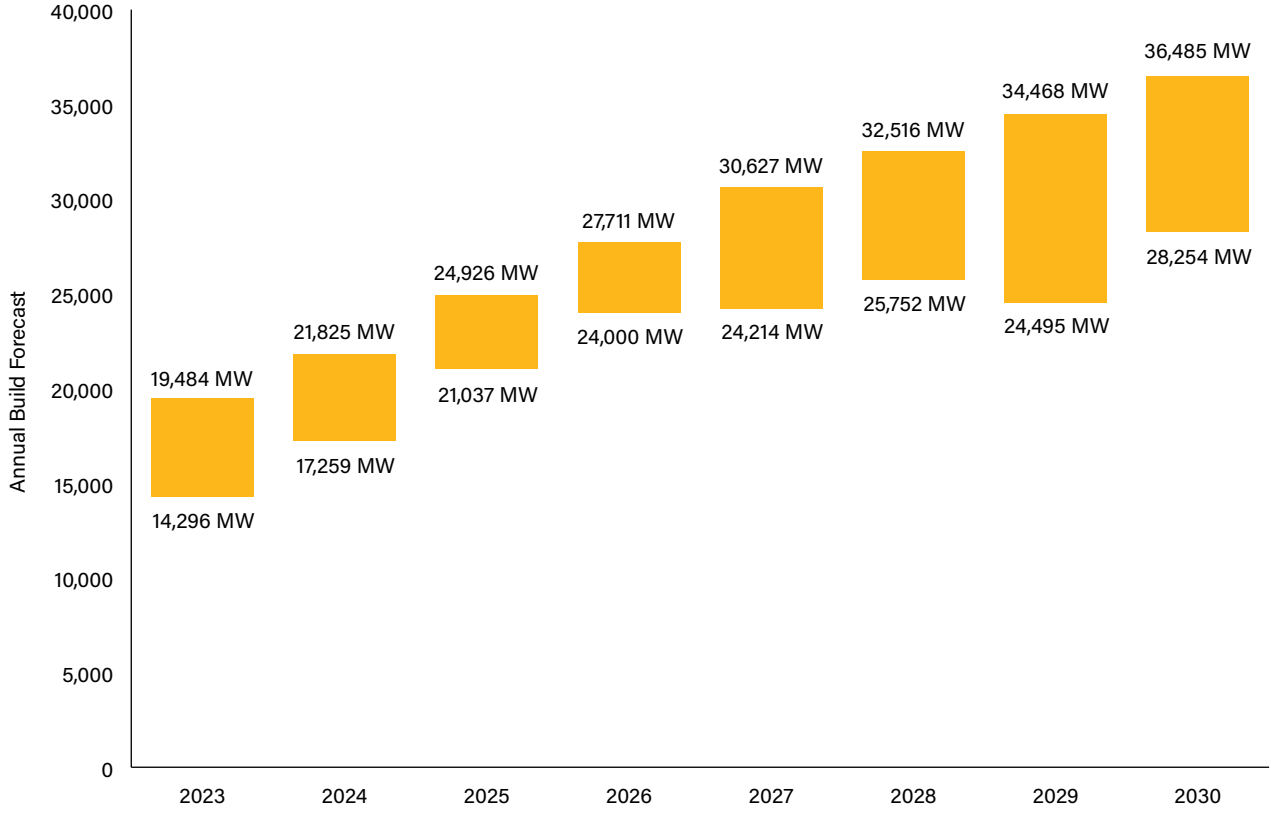
Source: BNEF
Note: 2022 data is not yet available at the time of this report publishing

Utility-Scale Solar Forecast

Trade restrictions threaten near-term prospects

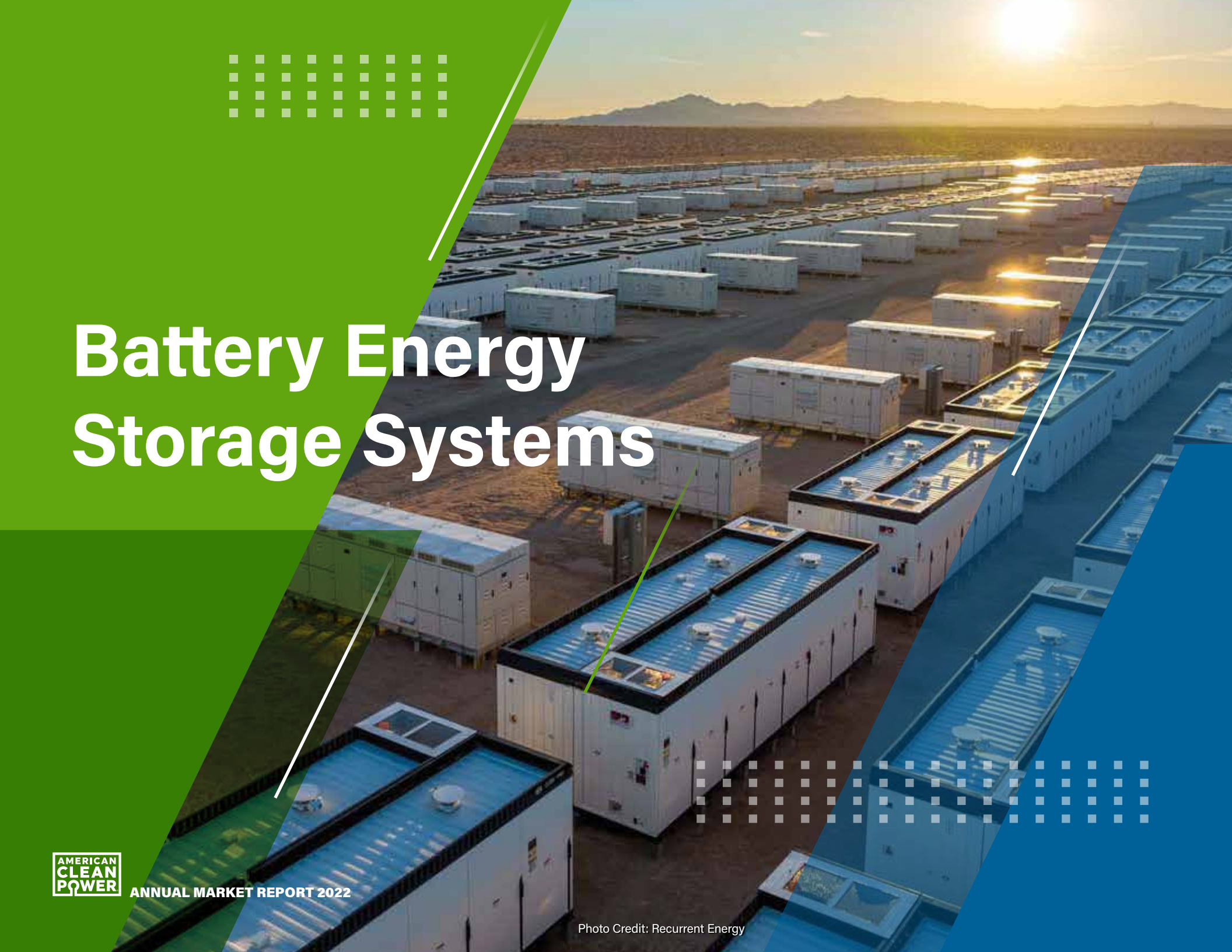
- Supply chain and trade-related pressures weighed heavily on the utility solar market in 2022. After years of sizable cost declines, solar projects experienced rising prices thanks to global supply chain constraints, high freight costs, and rising commodity prices. Fold in the trade restrictions that restricted module supply and the result is a year that fell far short of expectations. As the industry heads into 2023, these trends appear to be reversing.
- The passage of the IRA has had the largest impact on the utility solar forecast, boosting installation expectations between 2023 and 2030 by 37%. That means consultants are expecting 55 GW more utility solar compared to their forecasts last year. On average, forecasters project 206 GW to be built over the next eight years.
- All three consultants are relatively tight in their utility solar forecasts for the rest of the decade. The low forecast clocks in at 201 GW while the highest forecast calls for 227 GW.
- Annual solar build expectations grow to 33 GW by 2030, up from just 13 GW in 2022. In 2023, the build forecast ranges from 14 GW to 19 GW.
- All figures in AC units.

Industry Consultant Capacity Forecast for Utility-Scale Solar Forecast, 2023-2030



Source: BNEF, S&P, Wood Mackenzie

Battery Energy Storage Systems



AMERICAN CLEAN POWER

ANNUAL MARKET REPORT 2022

Photo Credit: Recurrent Energy

Battery Energy Storage Systems Highlights

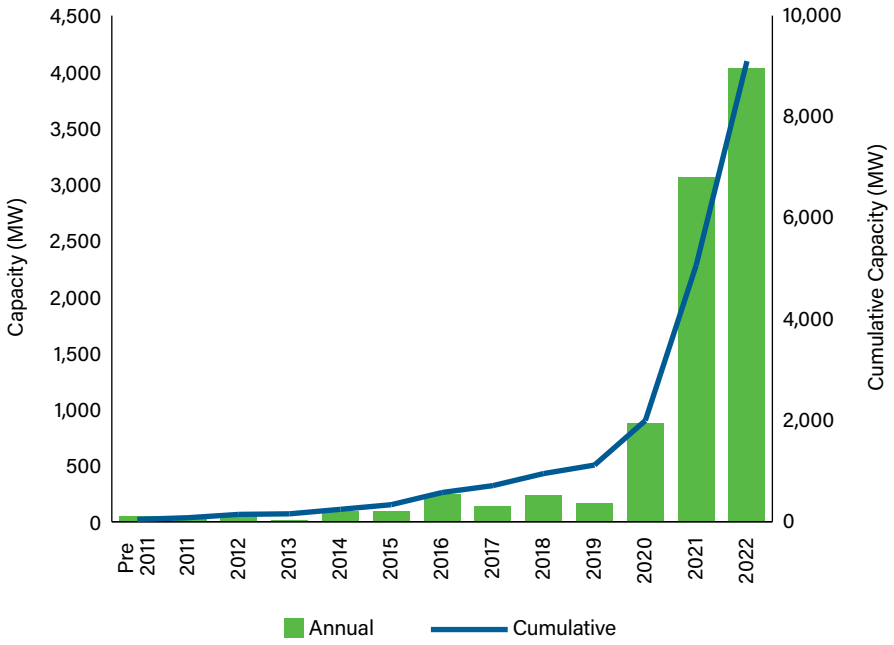
- Battery storage has been on a rapid upward trajectory over the past few years. 2022 represents a record year for battery storage, with 4,034 MW/12,149 MWh commissioned. Cumulative operating capacity, in MW, increased by 80% in 2022 and cumulative energy storage capacity, in MWh, increased by 93% in 2022.
- California and Texas led annual battery storage installs, commissioning 2.5 GW and 1 GW, respectively.
- For the first time, California installed more new battery storage capacity in 2022, facilitating the transition of solar generation to different times of day.
- The average duration of battery storage projects commissioned in 2022 was 3 hours, consistent with 2021.
- More than half, 56%, of operating battery storage capacity exists as standalone systems. The standalone portion of projects installed in 2022 is slightly higher at 59%.
- Hybrid projects have become increasingly popular. In 2022, nearly 6 GW of new hybrid project capacity came online, 88% of which is comprised of solar + storage projects. In total, nearly 18.5 GW of hybrid capacity is operational in the U.S.
- Average forecast estimates from Bloomberg, S&P Global, and Wood Mackenzie call for 89 GW of utility battery storage capacity to be built from 2023-2030. This represents a 15 GW boost from last year's estimates.

Battery Energy Storage Systems

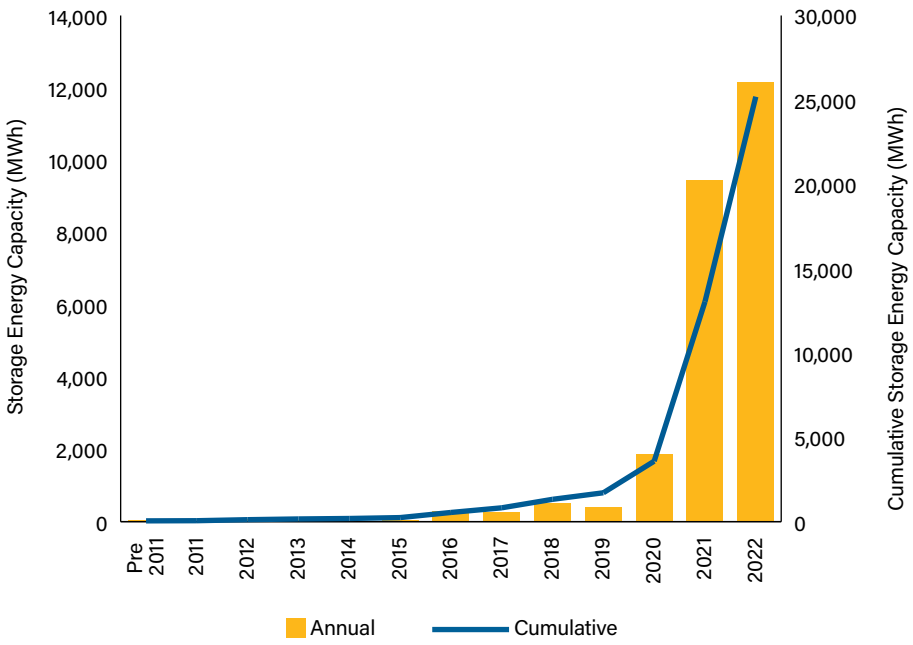
Annual and Cumulative Energy Storage Power Capacity

Record year for battery storage installations

U.S. Annual and Cumulative Battery Storage Capacity Growth (MW)



U.S. Annual and Cumulative Battery Storage Capacity Growth (MWh)



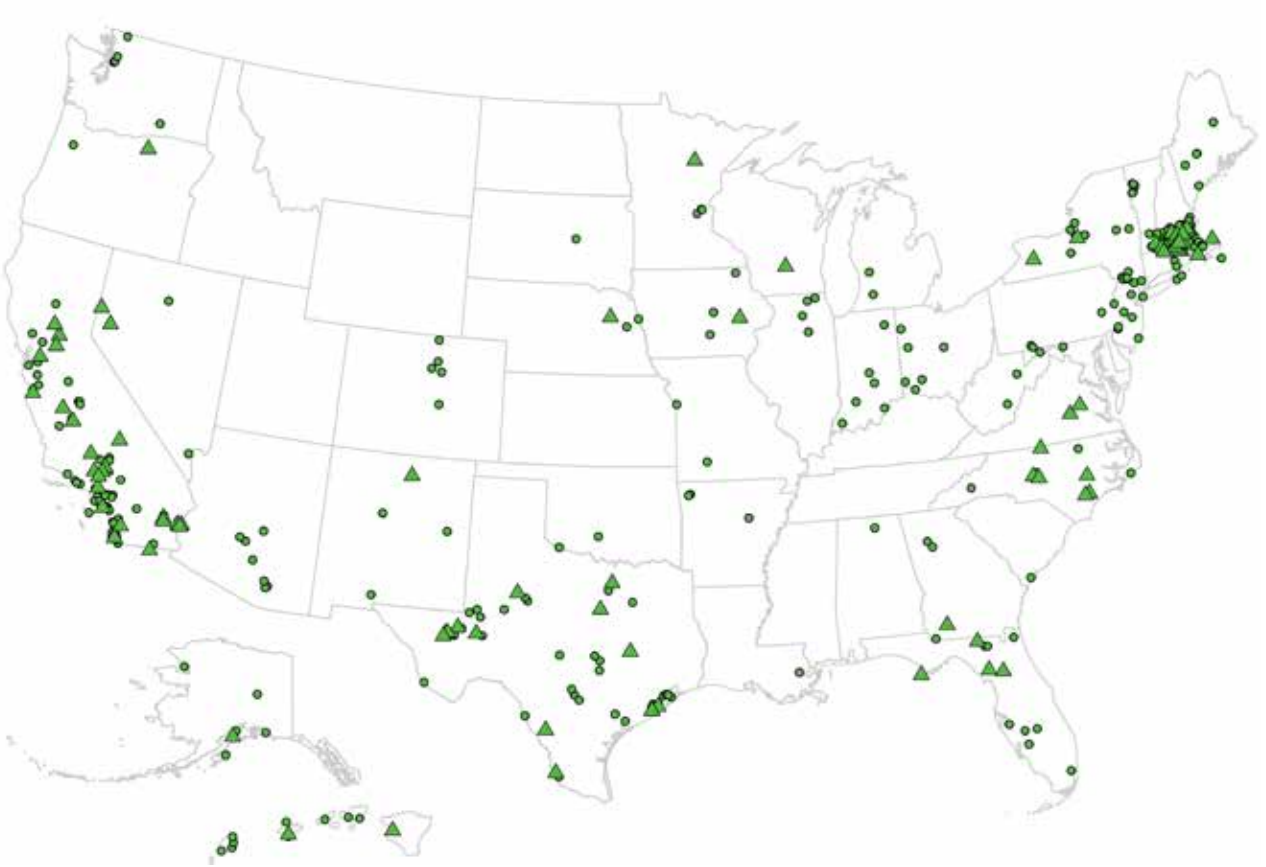
- ACP tracks the U.S. utility-scale battery storage market in terms of power capacity (MW), which is the total possible instantaneous discharge capability, and energy capacity (MWh), which is the maximum amount of stored energy.
- Battery storage has been on a rapid upward trajectory over the past few years. 2022 represents a record year for battery storage, with 4,034 MW/12,149 MWh commissioned. Cumulative operating capacity, in MW, increased by 80% in 2022 and cumulative energy storage capacity, in MWh, increased by 93% in 2022.
- Battery storage installations in 2022 outpaced 2021, the previous record year, by 32%.
- In total, there is 9,101 MW/25,187 MWh of battery storage operating across the country.

Battery Storage Projects

Developers installed over 4 GW of battery storage projects in 2022

- Battery storage developers brought 95 projects online, totaling nearly 4,034 MW in 2022. These projects were spread across 21 states, but much of the capacity was installed in California and Texas.
- California led all states in new utility-scale battery storage capacity, installing nearly 2.5 GW. Texas followed with over 1 GW and Massachusetts placed a distant third and just over 70 MW.
- The 350 MW/1,400 MWh Crimson Storage project built in California takes the top spot in terms of capacity and energy in 2022. In capacity terms, this was followed by the 260 MW DeCordova Energy Storage project in Texas and the 230 MW Desert Sunlight Storage project located in California.
- The DeCordova Energy Storage project has a duration of one hour (260 MWh total energy) while the Desert Sunlight Storage project has a four hour duration (920 MWh total energy).

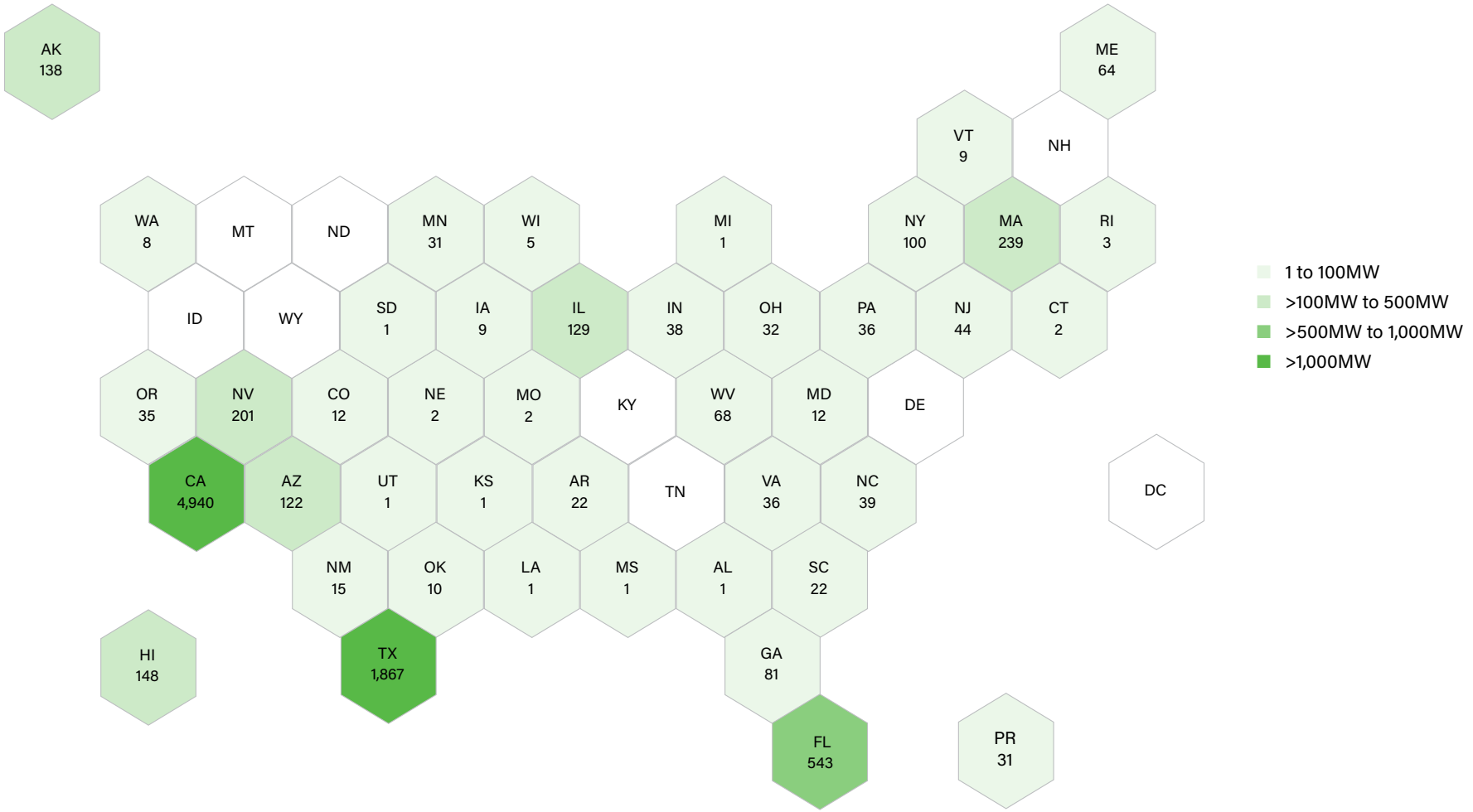
Operating Utility-Scale Battery Storage Projects



Operating Battery Storage Systems

There are 433 projects operating across 42 states and Puerto Rico

Operating Battery Storage Systems



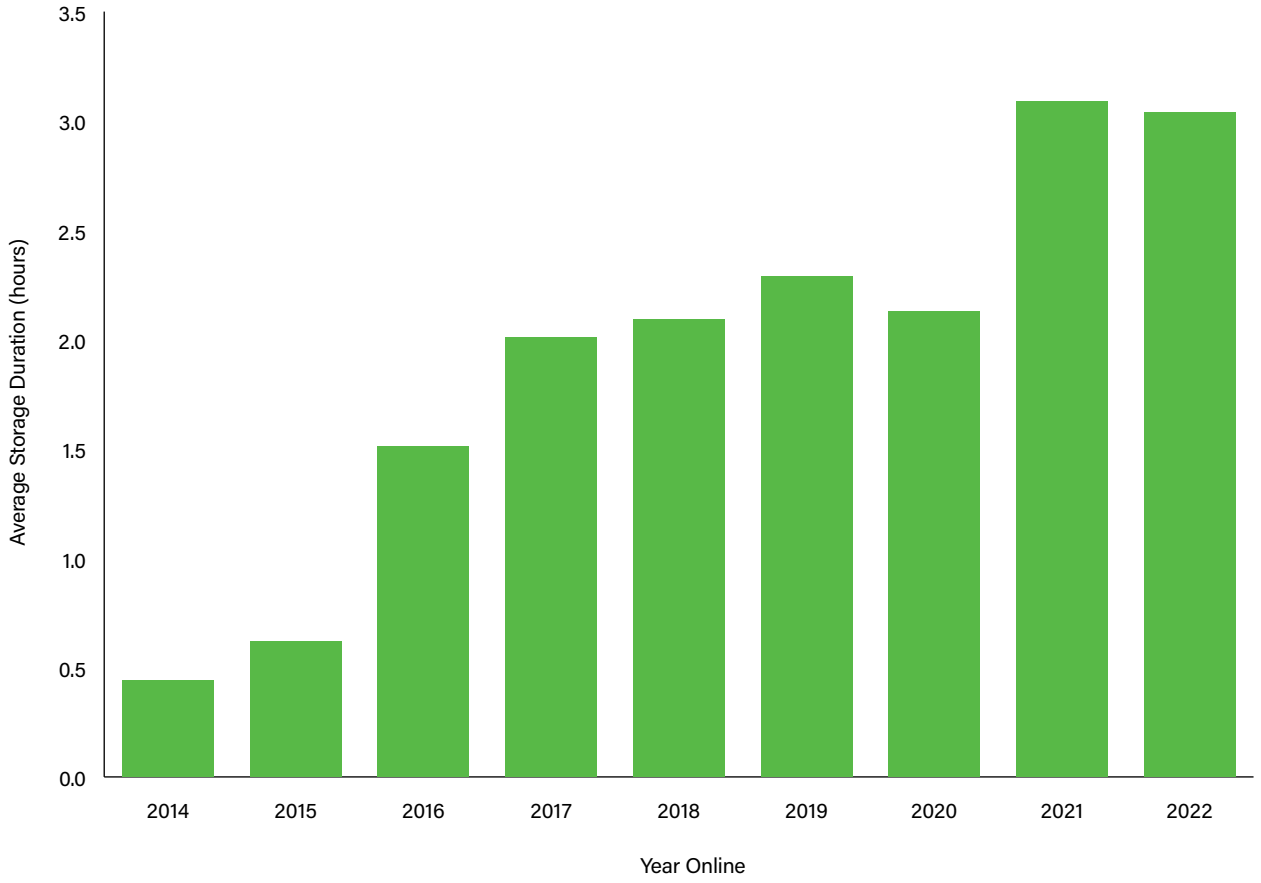
Battery Energy Storage Systems

Storage Duration by Install Year

Average duration increased by 45% over the past five years

- Storage duration is defined as the amount of time a storage system can discharge at its rated power capacity before depleting its energy. The average duration of battery storage projects commissioned in 2022 was 3.04 hours, consistent with 2021.
- The Solomon Energy Storage Center, located in Kansas, was the longest duration battery installed in 2022 at 5 hours. The project's storage capacity is 1 MW.
- In the past five years, the average duration of battery storage projects brought online has increased by 45%.
- As clean energy sources become more prevalent in the grid, energy storage is needed to balance the intermittent nature of those resources. Longer-duration batteries are able to store energy for longer periods of time to better support grid reliability. Advancements in battery technology, such as improvements in battery chemistries, energy density, and efficiency, are also enabling the development of longer duration battery storage projects.
- Currently there are only four battery projects with an 8-hour duration operating, each with capacities of 6 MW or smaller.

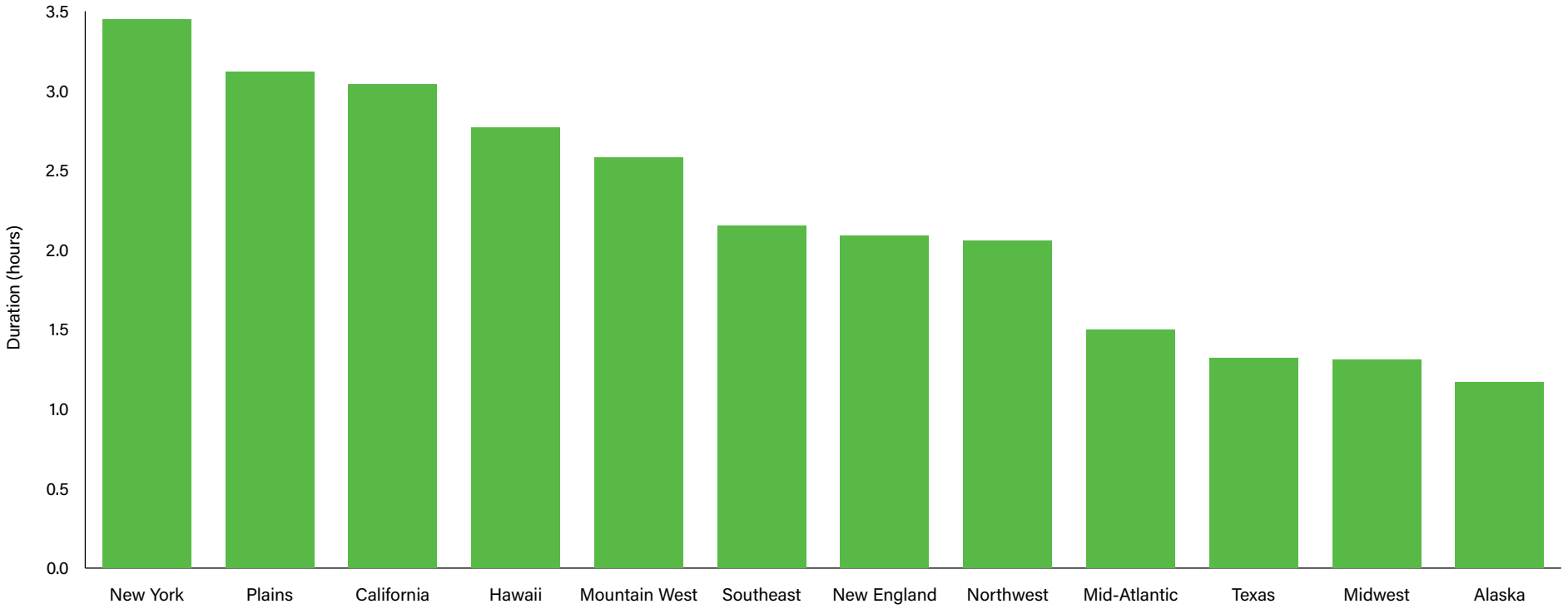
Capacity-Weighted Average Storage Duration by Date Installed



Storage Duration by Region

New York has the highest average durations for operating storage projects

Average Battery Storage Duration by Region



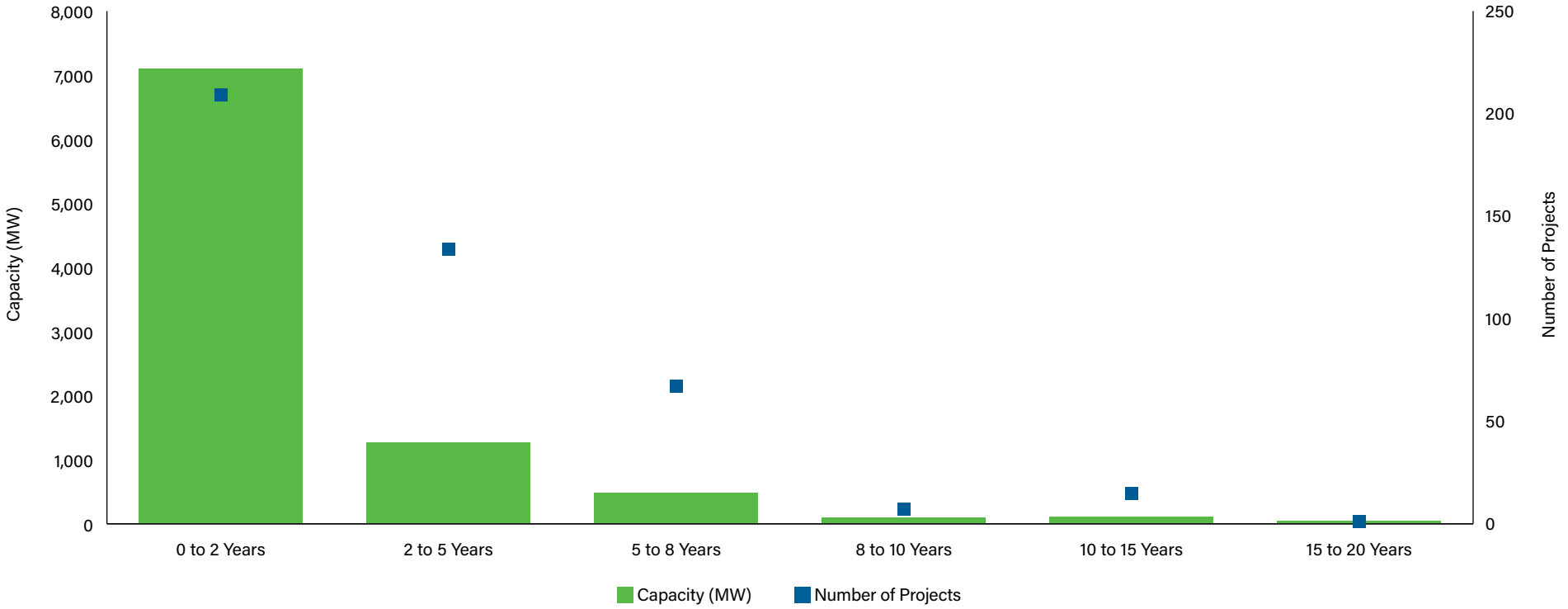
- There is significant variation in storage duration capabilities between regions. New York has the highest average storage duration at 3.45 hours, followed by the Plains at 3.12 hours and California at 3.04 hours.
- Texas, which ranks second in terms of total operating battery storage duration, has one of the lowest average storage durations at only 1.32 hours. This is due in part to how battery storage systems are used. Low duration battery storage systems are most often used to provide grid services such as grid stabilization and frequency regulation, as well as ancillary services, which include voltage regulation, reactive power support, and ramping services.

Battery Energy Storage Systems

Online Storage Project Age

Nearly 80% of battery storage capacity is less than two years old

Online Battery Storage Capacity by Project Age



- Battery storage is a relatively new technology, with the majority of operational capacity having been deployed in the past two years. Approximately 78% of the total operating storage capacity has been commissioned within the last two years, with an additional 14% installed between two and five years ago. Only a small portion, around 7%, of the operating battery storage capacity is over five years old.
- Only 16 battery storage projects operating in the U.S. are over 10 years old. These projects are all relatively small, with an average capacity of under 10 MW. These projects also utilize a much larger range of storage technologies, including sodium, lead acid, and nickel batteries. The vast majority of battery storage projects installed over the past few years use lithium-ion battery systems.

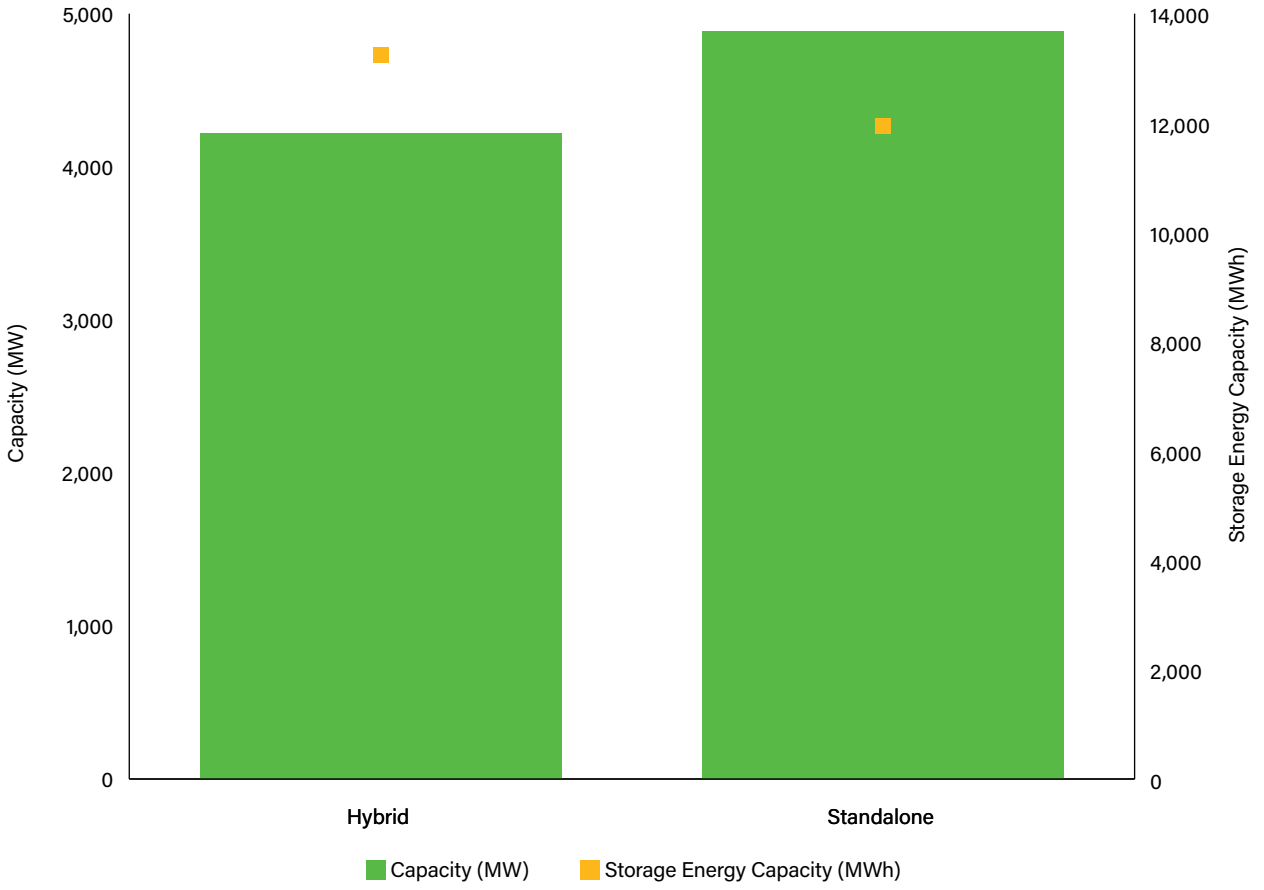
Battery Energy Storage Systems

Standalone versus Hybrid Storage Installations

Slightly more standalone battery storage capacity than hybrid systems

- Battery storage projects can either operate as standalone systems or be paired with other clean power technologies in hybrid systems.
- More than half, 56%, of operating battery storage capacity exists as standalone systems. The standalone portion of projects installed in 2022 is slightly higher at 59%.
- Regarding storage energy capacity (MWh), 53% of operating capacity are part of a hybrid system. This indicates that battery storage systems paired with wind or solar typically have longer durations than standalone systems.
- Over the past decade hybrid projects have become increasingly popular. This trend toward hybrid storage systems is largely due to the structure of federal tax credits. Previously excluded from ITC qualification, battery systems had to be paired with and charged from wind or solar resources to qualify. The IRA extends ITC qualification to standalone storage systems.

Standalone vs Hybrid Storage Operating Capacity

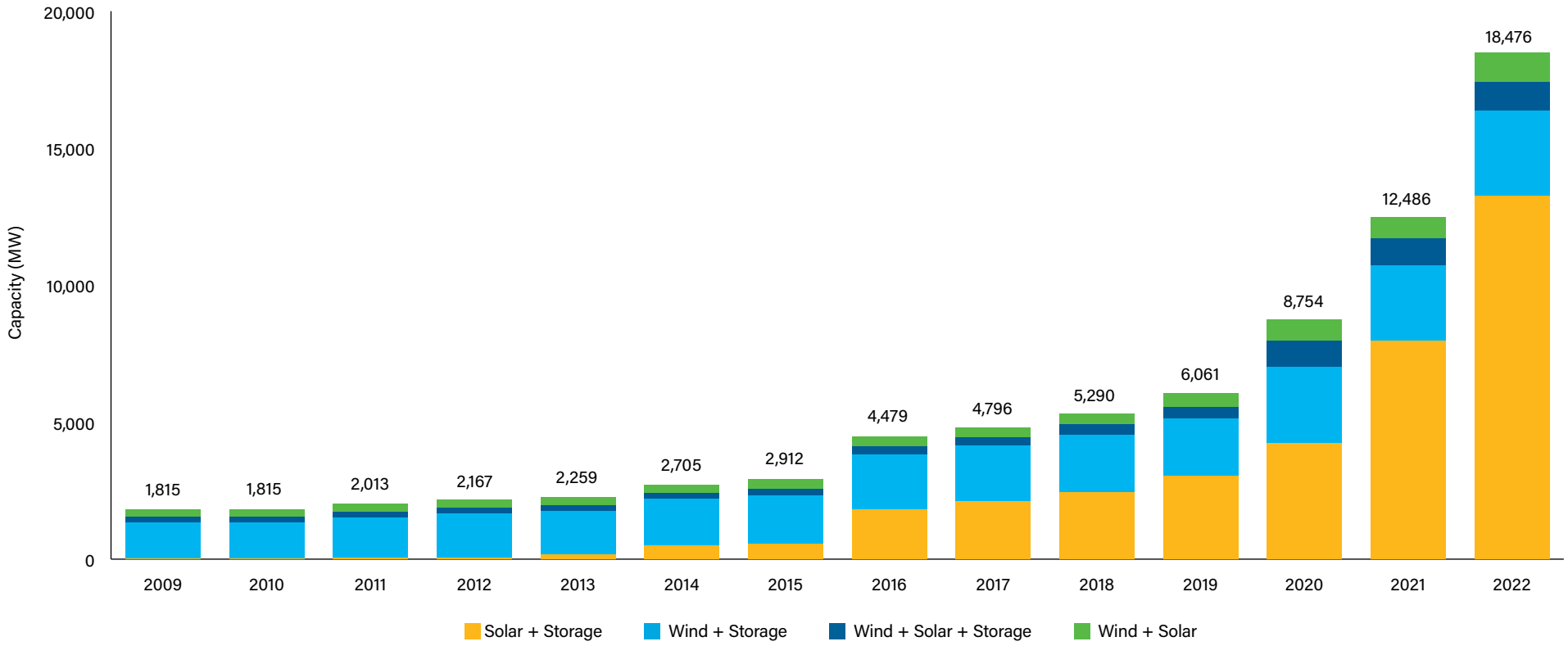


Battery Energy Storage Systems

Operational Hybrid Project Capacity

Nearly 6 GW of hybrid projects installed in 2022

Cumulative Operational Hybrid Capacity by Year



- Pairing battery storage with wind and solar power can enhance the integration, reliability, and flexibility of renewable energy, improve grid stability, and provide additional value-added services to the electricity grid.
- In 2022, nearly 6 GW of new hybrid project capacity came online, 88% of which is comprised of solar + storage projects. 2022 hybrid installations were 60% higher than 2021, setting a new record in the hybrid space.
- In total, nearly 18.5 GW of hybrid project capacity is operational in the U.S. solar + storage projects have become dominant over the past five years and now account for 72% of operating hybrid capacity. Wind + solar makes up 17% of operating hybrid capacity, wind + solar + storage 6%, and wind + solar the remaining 6%.

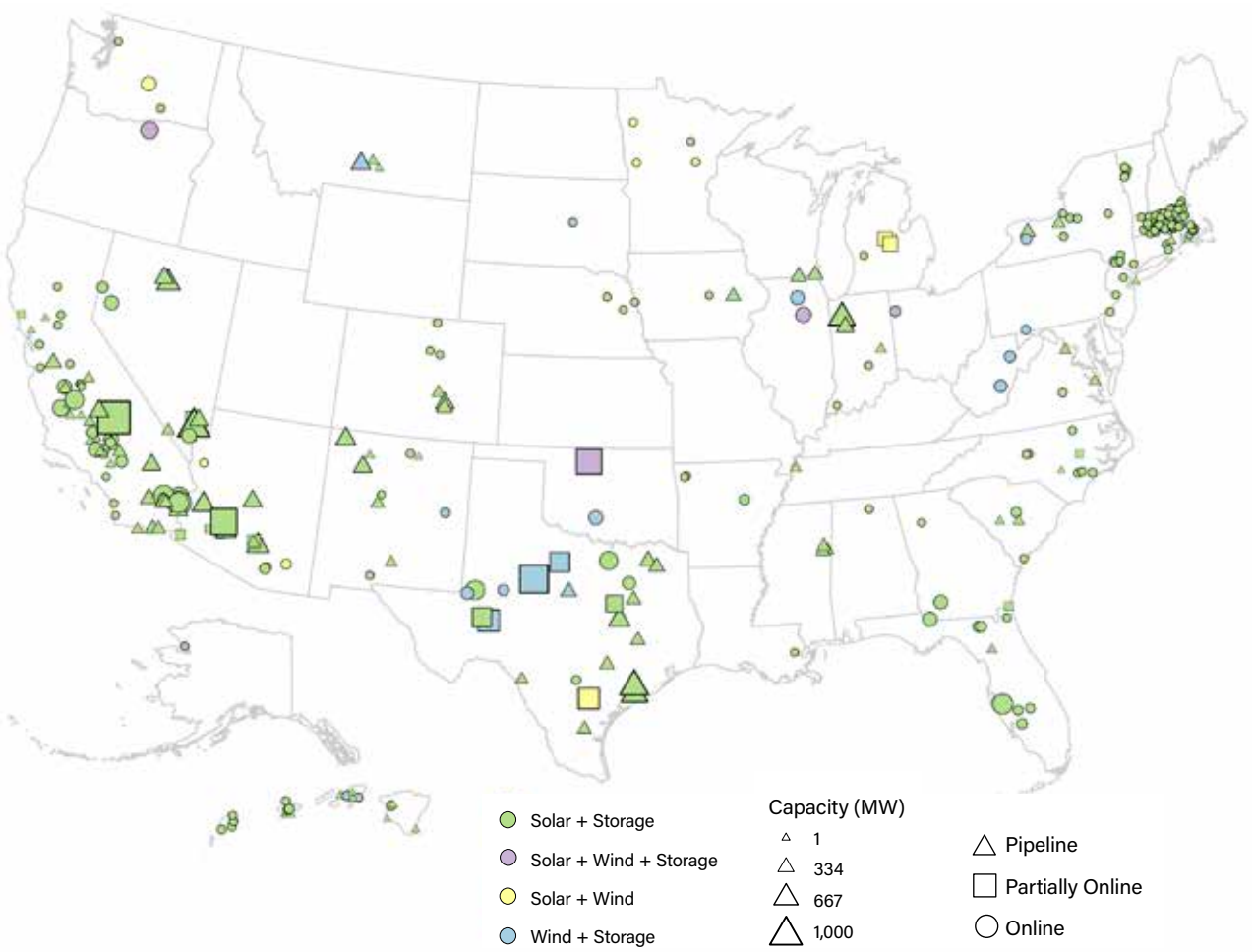
Battery Energy Storage Systems

Hybrid Projects

California leads all states with 5.3 GW of hybrid projects fully online

- California leads the nation with 5,299 MW of hybrid projects online, all of which are solar + storage projects.
- Texas follows California with 1,604 MW of hybrid project capacity fully online, including 1,292 MW of solar + storage and 313 MW of wind + storage capacity.
- While Massachusetts leads with the most hybrid projects operating at 75 projects, 74 of which are solar + storage, these projects are generally small in terms of capacity. The total capacity of fully online hybrid projects in Massachusetts is 427 MW.
- California also leads the pipeline with 1,493 MW of solar + storage partially online and another 7,488 MW of solar + storage capacity in the pipeline. Texas comes in a close second with 3,492 MW partially online and 4,939 MW in the pipeline.

Hybrid Clean Power Projects

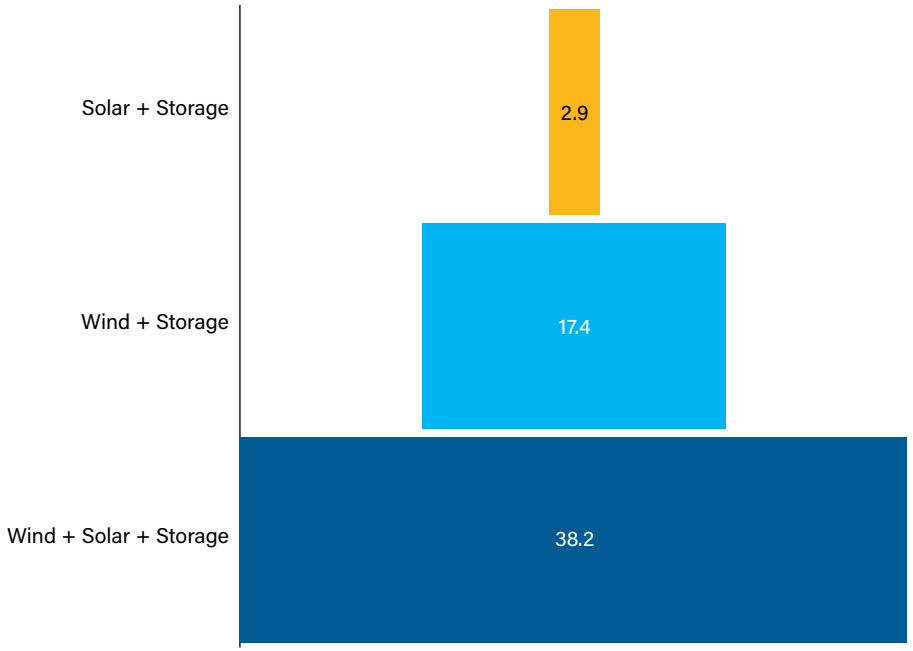


Battery Energy Storage Systems

Generation to Storage Ratios

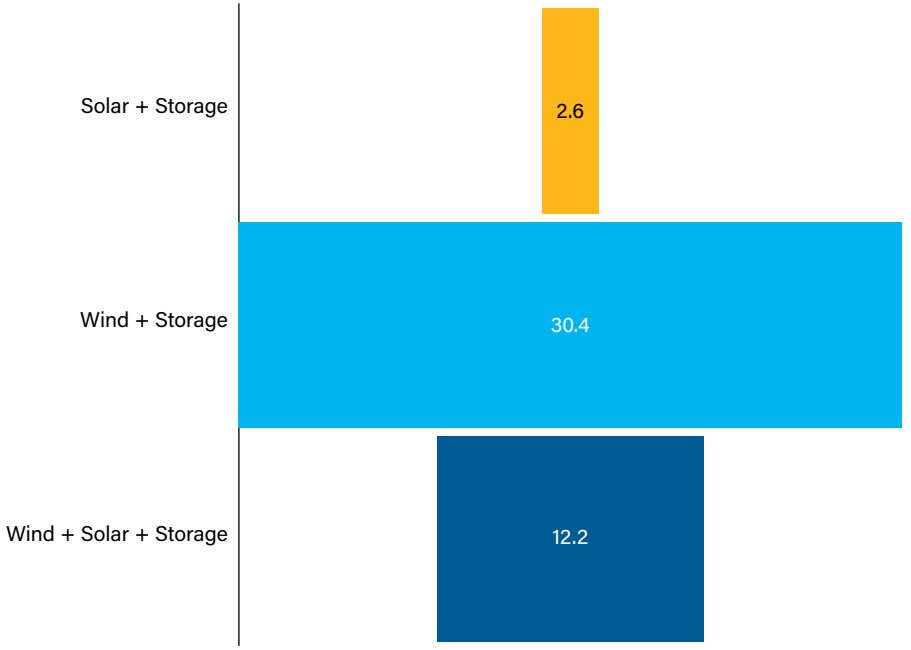
Solar + storage projects have the lowest generation to storage ratios

Average generation to storage (MWh) ratio



- The ratio of storage capacity paired with wind or solar capacity varies significantly depending on the type of hybrid project.
- Solar + storage projects, which are the most common type of hybrid projects, have the lowest generation to storage ratio in terms of both MW and MWh. On average, there is nearly three times more solar capacity (MW) than storage power capacity, and 2.6 MW of solar power for every MWh of storage energy capacity.

Average generation to storage (MW) ratio

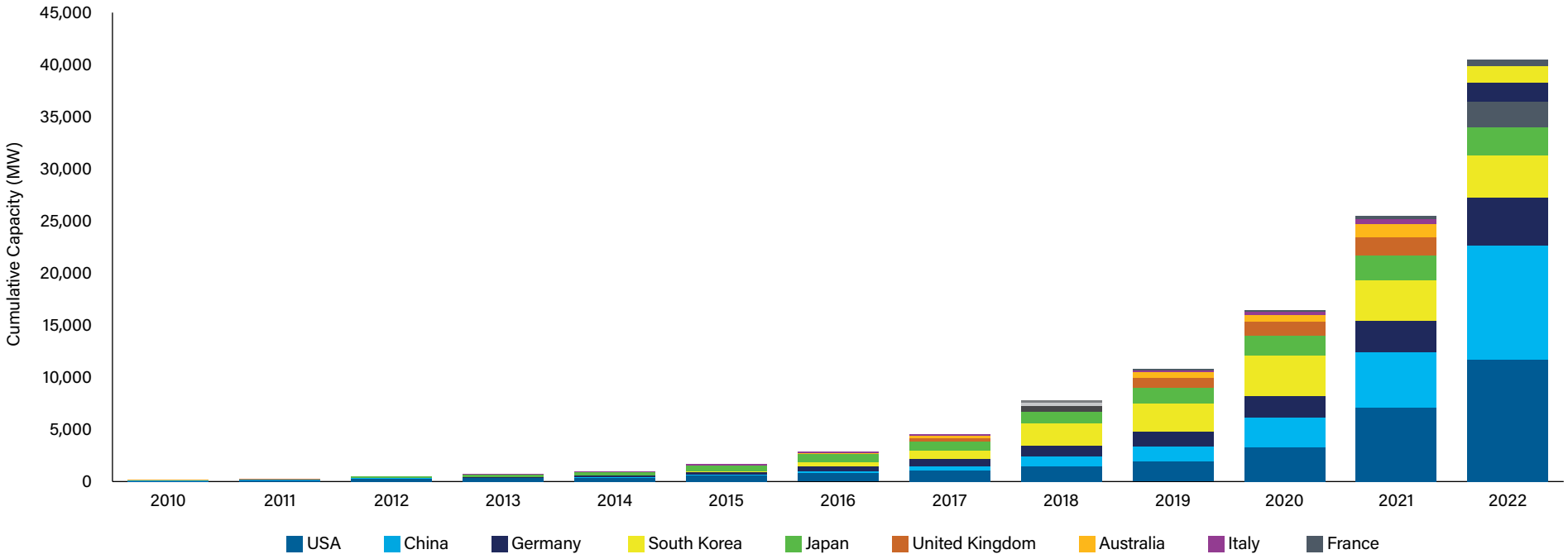


- Wind + storage hybrid projects have an average ratio of 17.4 MW of wind capacity for every MW of storage capacity, and 30.4 MW of wind for every MWh of storage energy capacity.
- Wind + Solar + Storage projects have the highest generation to storage power capacity ratio (38:1), but a lower average generation to storage energy capacity ratio (12:1), although the sample size is small.

Global Storage Capacity

The U.S. leads in global battery storage capacity

Cumulative Global Utility-Scale Storage Capacity by Country



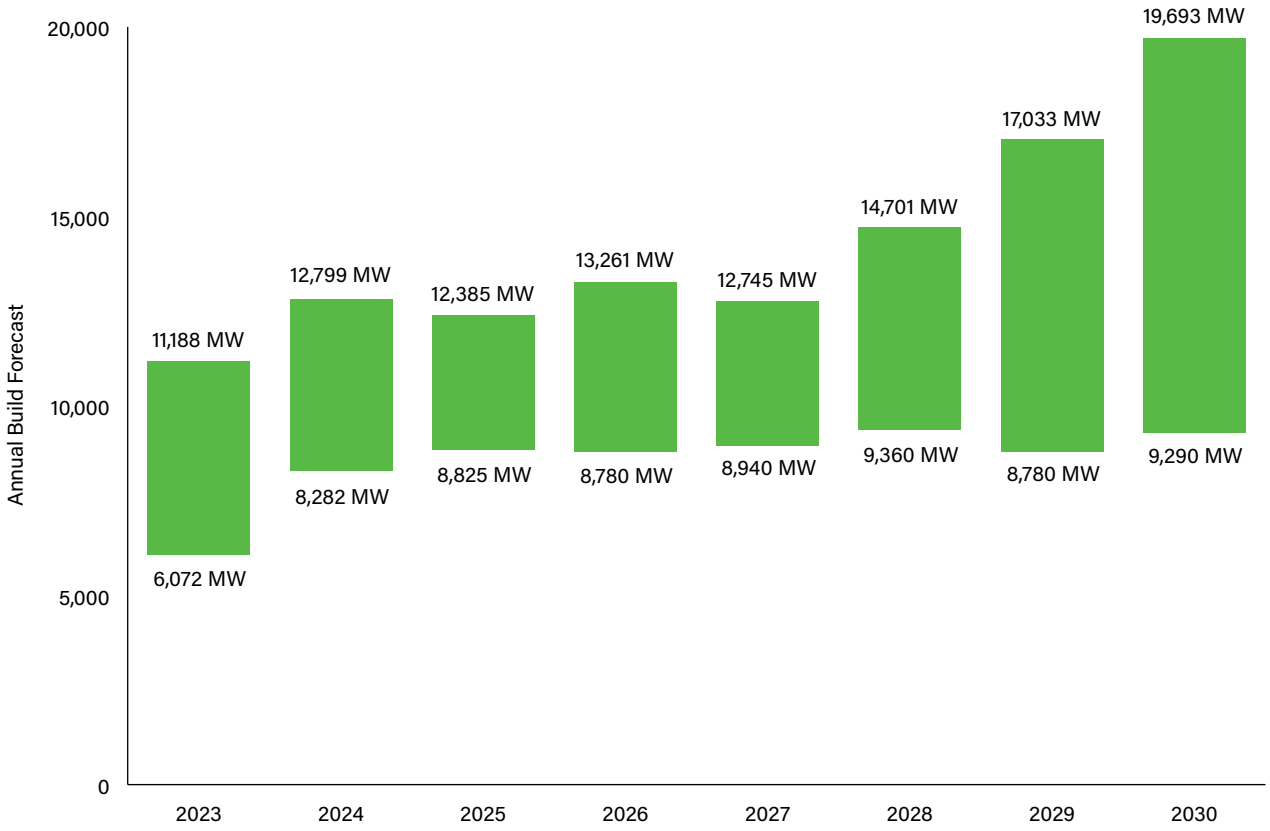
- In 2010, only 120 MW of battery storage capacity was operating globally. Just 12 years later, cumulative operating capacity is nearly 40,500 MW.
- Battery storage capacity surpassed 1 GW in 2015 and has grown at an average of 58% every year since.
- The United States is the global leader in operating battery storage capacity. The U.S. has consistently been in the top five since 2010, fighting for the top spot with Japan and South Korea.
- China moved up from fifth to third in 2019 after installing more than 500 MW in 2019. Since then, China added nearly 9.5 GW of battery storage capacity to claim second place after the U.S.
- The U.S. and Japan were among the earliest adopters of battery storage. Over the past five years Japan has increased its total operating capacity by an average of 24% each year, but has not kept up with the installation rates of the U.S., China, Germany, and South Korea.

Battery Energy Storage Forecast

Battery storage forecast grows 20%, calling for 80 GW over 8 years

- Battery storage costs have come down significantly in recent years, and now, thanks to the passage of the IRA, storage can take advantage of the Investment Tax Credit on a standalone basis. This change alone is reason enough for an upward revision in forecasts.
- Average forecast estimates from Bloomberg, S&P Global, and Wood Mackenzie call for 89 GW of utility battery storage capacity to be built from 2023-2030. This represents a 15 GW boost from last year's estimates.
- Despite increased projections, the battery storage outlook continues to be the most uncertain. There is a 44 GW difference between the most bullish consultant forecast (111 GW) and the most bearish (68 GW). Most of that separation occurs later in the decade.
- Long-term factors contributing to bullish sentiment for energy storage include advances in state renewable energy targets, further cost reductions and efficiency improvements, more avenues for market participation, grid resiliency applications, and increasing support for a standalone storage ITC.
- In the short term, battery storage faces many of the same constraints as wind and solar. Shipping delays and rising costs threaten project timelines and weigh on economics, while permitting and interconnect delays drag on project timelines.

Industry Consultant Battery Storage Power Capacity Forecast, 2023-2030



Source: BNEF, S&P, Wood Mackenzie

American Clean Power is the voice of companies from across the clean power sector that are powering America's future, providing cost-effective solutions to the climate crisis while creating jobs, spurring massive investment in the U.S. economy and driving high-tech innovation across the nation. We are uniting the power of America's renewable energy industry to advance our shared goals and to transform the U.S. power grid to a low-cost, reliable, and renewable power system. Learn more about the benefits clean power brings to America at **www.cleanpower.org**.

Twitter / @USCleanPower

LinkedIn / American Clean Power Association

AMERICAN CLEAN POWER