U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Offshore Wind Market Report: 2023 Edition

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Data and Methodology

Multiple Data Sources Ensure Accuracy and Alignment With Global Research Organizations

- The scope covers the global fleet of projects in the pipeline through December 31, 2022, and recent U.S. developments and events through May 31, 2023.
- Primary source: U.S. Department of Energy's (DOE's) National Renewable Energy Laboratory's (NREL's) internal offshore wind database, which is built on internal research and a wide variety of data sources, including peer-reviewed literature, press releases, industry news reports, manufacturer specification sheets, and global offshore wind energy project announcements.

NREL has verified and sourced data from the following publications:

- The 4C Offshore Wind Database (4C Offshore 2022)
- BloombergNEF (BNEF) Renewable Energy Project Database (BNEF 2022a)
- 4C Offshore Vessel Database (4C Offshore 2022)
- Wood Mackenzie Wind Turbine Trends (Wood Mackenzie 2023).

Note: All dollar amounts are reported in 2022 U.S. dollars, unless indicated otherwise.

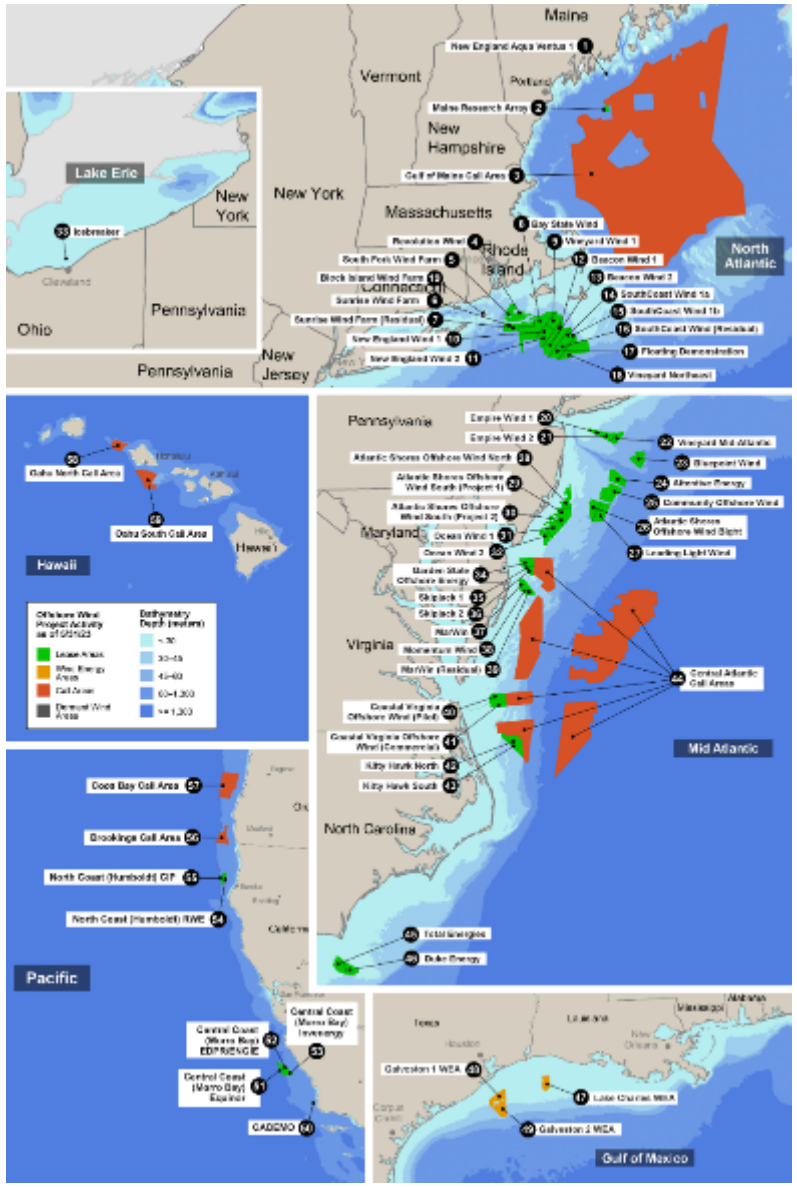
Project Pipeline Classification System Uses the Public U.S. Regulatory Framework To Assess Project Status

Step	Phase Name	Start Criteria	End Criteria
1	Planning	Starts when a developer or regulatory agency initiates the formal site control process (e.g., designation of a wind energy area [WEA])	Ends when a developer obtains control of a site (e.g., through competitive auction or a determination of no competitive interest in an unsolicited lease area (United States only)
2	Site Control	Starts when a developer obtains site control (e.g., a lease or other contract)	Ends when the developer files major permit applications (e.g., a Construction and Operations Plan [COP] for projects in the United States)
3	Permitting = Site Control + Offtake Pathway	Starts when the developer files major permit applications (e.g., a COP or an offtake agreement for electricity sales)	Ends when regulatory entities authorize the project to proceed with construction and certify its offtake agreement
4	Approved	Starts when a project receives regulatory approval for construction activities and offtake agreement certification	Ends when the sponsor announces a “financial investment decision” and has signed contracts for construction work packages
5	Financial Close	Starts when the sponsor announces a financial investment decision and has signed contracts for major construction work packages	Ends when the project begins major construction work
6	Under Construction	Starts when construction is initiated	Ends when all wind turbines have been installed and the project is connected and generating power to an electrical grid
7	Operating	Starts when all wind turbines are installed and transmitting power to the grid; commercial operation date marks the official transition from construction to operation	Ends when the project has begun a formal process to decommission and stops feeding power to the grid
8	Decommissioned	Starts when the project has begun the formal process to decommission and stops transmitting power to the grid	Ends when the site has been fully restored and lease payments are no longer being made

U.S. Offshore Wind Energy Data

Economic and Policy Indicators Suggest Long-Term U.S. Market Growth as of May 31, 2023, While Inflationary Cost Increases May Hinder Near-Term Growth

- U.S. offshore wind energy target set in March 2021 for 30 gigawatts (GW) by 2030 with pathway to 110 GW by 2050
- 42,730 megawatts (MW) of policy commitments from seven eastern states by 2040
- 52,687 MW is estimated in total project pipeline
- 42 MW of installed capacity.



Locations of U.S. offshore wind energy pipeline activity and Call Areas as of May 31, 2023. ***Map created by John Frenzl, National Renewable Energy Laboratory (NREL)***

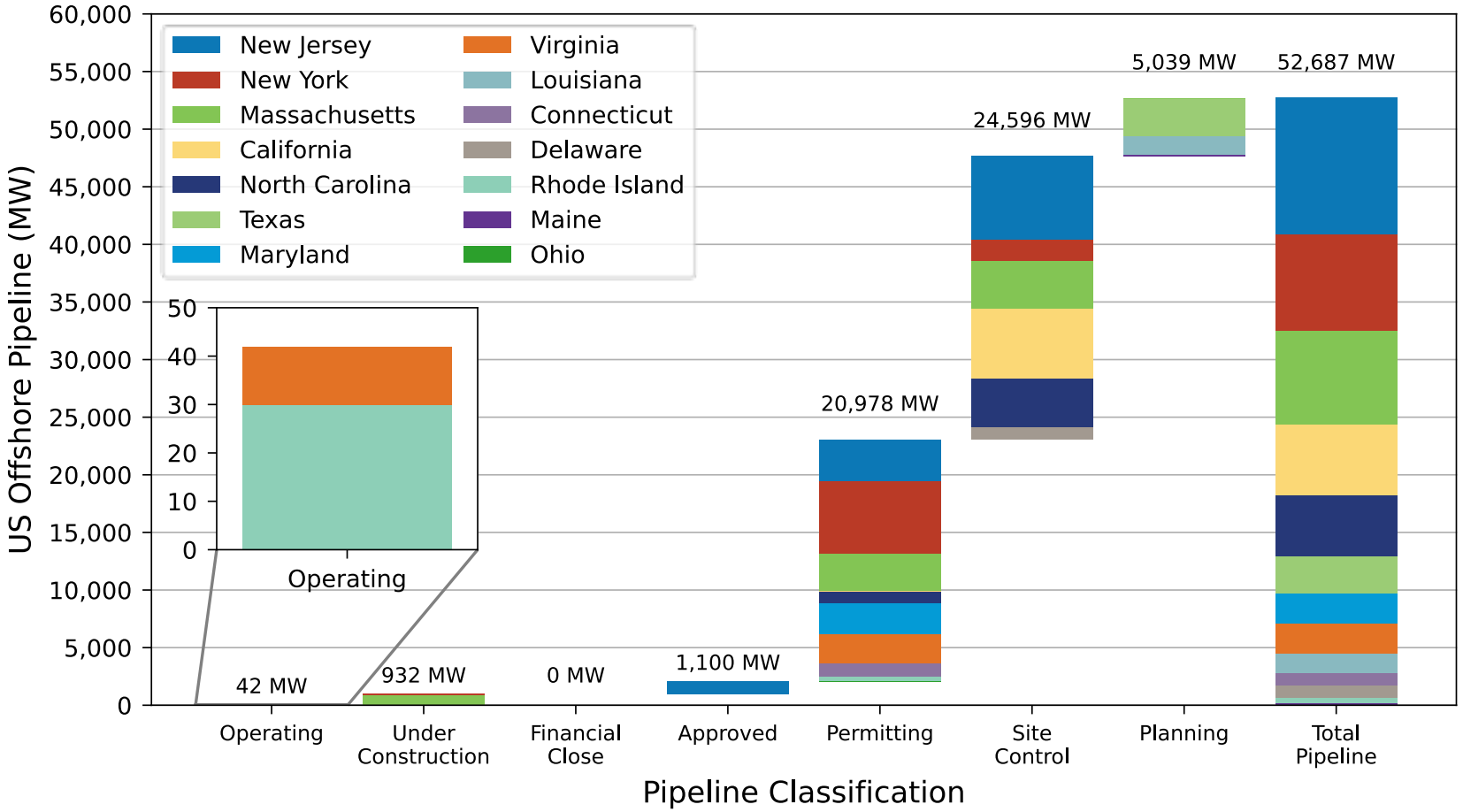
U.S. Offshore Wind Energy Pipeline by Classification Status

Status	Description	Total (Megawatts)
Operating	The project is fully operational with all wind turbines generating power to the grid.	42
Under Construction	All permitting processes completed. Wind turbines, substructures, and cables are in the process of being installed. Onshore upgrades are underway.	932
Financial Close	All permitting processes completed; begins when sponsor announces final investment decision and has signed contracts.	0
Approved	Bureau of Ocean Energy Management (BOEM) and other federal agencies reviewed and approved a project's Construction and Operations Plan (COP). The project has received all necessary state and local permits as well as acquired an interconnection agreement to inject power to the grid.	1,100
Permitting	The developer has site control of a lease area, has received an offtake contract or submitted a COP to BOEM, and BOEM has published a Notice of Intent to prepare an Environmental Impact Statement on the project's COP. If project development occurs in state waters, permitting is initiated with relevant state agencies.	20,978
Site Control	The developer has acquired the right to develop a lease area and has begun surveying the site. If available, developers' announced project capacities are used. If a developer has not announced a specific capacity, it is estimated using a 4-MW/km^2 wind turbine density.	24,596
Planning	The rights to a lease area have yet to be auctioned to offshore wind energy developers. Capacity is estimated using a 4-MW/km^2 wind turbine density assumption.	5,039

Data reflect recent Record of Decision for Ocean Wind 1

The 2023 U.S. Project Pipeline Contains Over 23 GW of Capacity that has Advanced to the Permitting Stage or Beyond

- The U.S. offshore wind pipeline has an estimated capacity of 52,687 MW, a growth of 15% from May 31, 2022.
- The 40,083 MW reported in 2022 was revised upward to 45,772 MW due to an increase in the capacity density metric from 3 MW/square kilometer (km^2) to 4 MW/km^2.
- The 15% growth was driven by the Bureau of Ocean Energy Management's (BOEM's) new leasing activity.

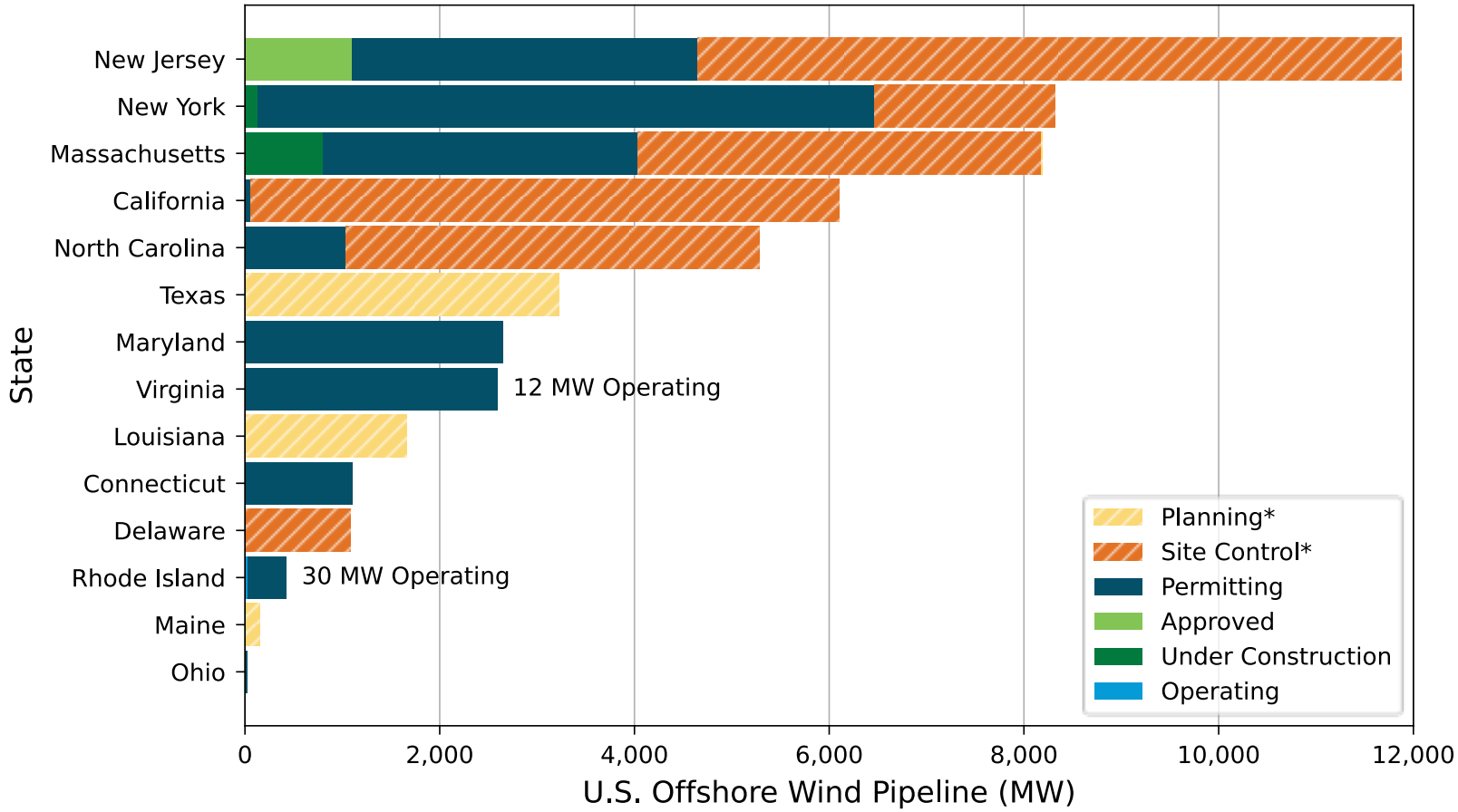


U.S. project pipeline classification by status.

Note: The approval of Ocean Wind occurred on July 5, 2023, after the stated cutoff date of May 31, 2023.

New Jersey, New York, and Massachusetts Account for Over 50% of the Capacity in the U.S. Project Pipeline

- State capacity for “site control” and “planning” (hashed colored bars) are assigned to the state where the wind energy area is located.
- State capacity for “permitting” and more advanced classification categories (solid colors) are based on where the energy will be delivered under a contracted offtake agreement.



U.S. project pipeline by state.

Note: Planning and site control pipeline capacity is subject to reallocate pipeline capacity to a different state after offtake agreements are negotiated.

U.S. Offshore Wind Energy Pipeline Projects in the North Atlantic and Great Lakes, Including the Gulf of Maine Call Area

Refer to table on next slide for details

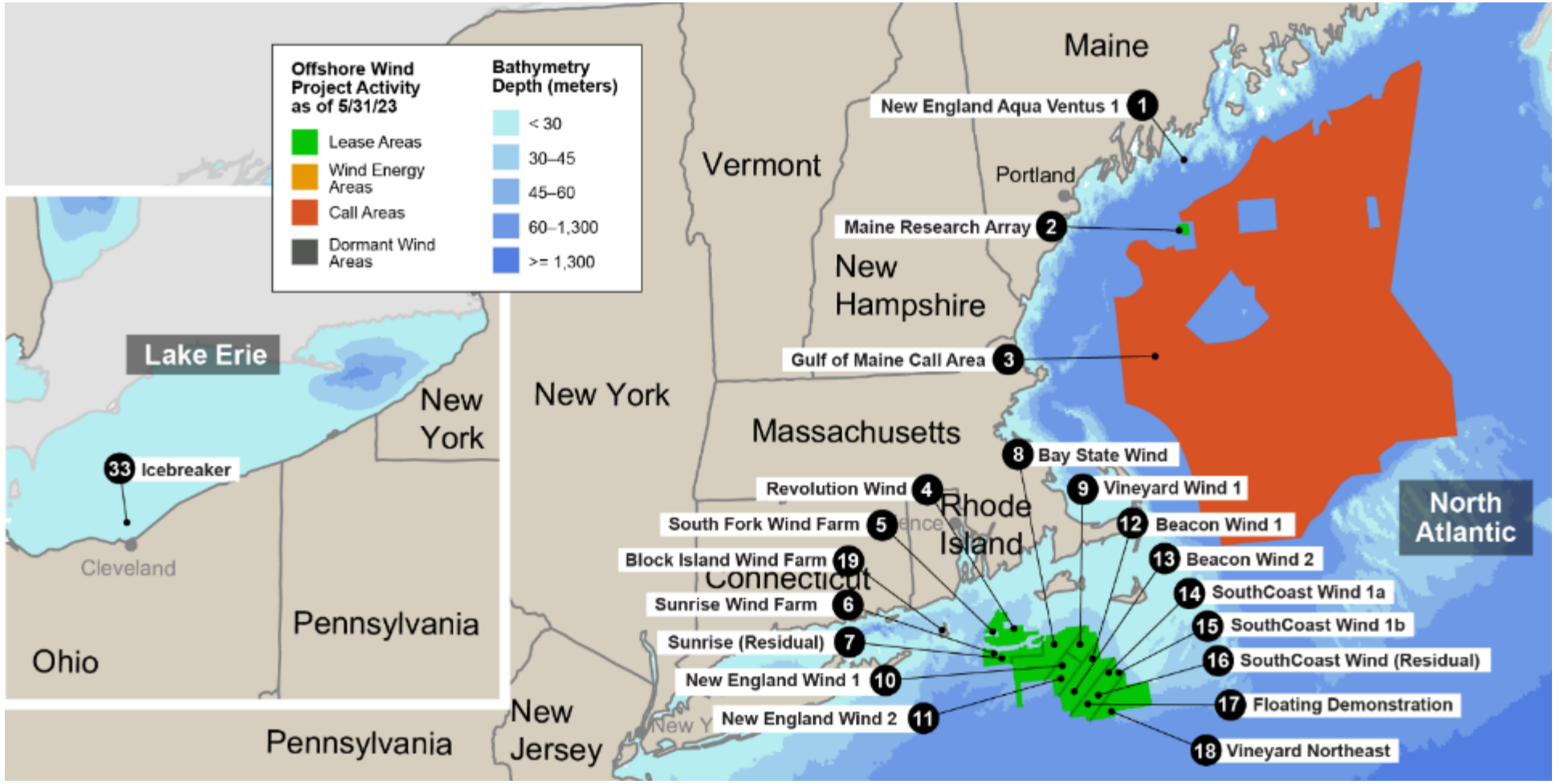


Image by John Frenzl, NREL

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U.S. Offshore Wind Energy Pipeline Projects in the North Atlantic and Great Lakes

#	Location	Name	Developer	Lease Area	Offtake Agreement	Estimated Commercial Operation Date (COD)	Current Status	Capacity (MW)	Potential Point of Interconnection (POI) Location
1	Maine (ME)	New England Aqua Ventus 1	Univ. of Maine/Diamond Offshore/RWE	State Lease	Power purchase agreement (PPA)-ME	2024	Permitting	12	To be determined (TBD)
2	ME	Maine Research Array	TBD	TBD	TBD	TBD	Planning	144	TBD
3	ME	Gulf of Maine Call Area	Not applicable (N/A)	N/A	N/A	N/A			N/A
4	Rhode Island (RI)/Massachusetts (MA)	Revolution Wind	Ørsted/Eversource	OCS-A 0486	PPA-RI & Connecticut (CT)	2026	Permitting	704	NG Davisville 115 kilovolts (kV)
5	RI/MA	South Fork Wind Farm	Ørsted/Eversource	OCS-A 0517	PPA-New York (NY)	2024	Under Construction	132	East Hampton (69-kV bus)
6	RI/MA	Sunrise Wind Farm	Ørsted/Eversource	OCS-A 0487	Offshore renewable energy certificate (OREC)-NY	2026	Permitting	924	Holbrook 138 kV
7	RI/MA	Sunrise Wind Farm (Residual)	Ørsted/Eversource	OCS-A 0487	TBD	TBD	Permitting	900	Holbrook 138 kV
8	RI/MA	Bay State Wind	Ørsted	OCS-A 0500	TBD	TBD	Site Control	2,000	TBD
9	MA	Vineyard Wind 1	Avangrid	OCS-A 0501	PPA - MA	2024	Under Construction	800	West Barnstable 345 kV
10	MA	New England Wind 1	Avangrid	OCS-A 0534	PPA-CT	2027	Permitting	800	West Barnstable 345 kV
11	MA	New England Wind 2	Avangrid	OCS-A 0534	PPA-MA	2027	Permitting	1,232	West Barnstable 345 kV
12	MA	Beacon Wind 1	Equinor Wind US/BP	OCS-A 0520	OREC-NY	2029	Permitting	1,230	Astoria 138 kV
13	MA	Beacon Wind 2	Equinor Wind US/BP	OCS-A 0520	TBD	TBD	Permitting	1,200	Astoria 138 kV
14	MA	SouthCoast Wind 1a	Shell/EDPR/ENGIE	OCS-A 0521	PPA-MA	2028	Permitting	804	Falmouth, Brayton Point 345 kV
15	MA	SouthCoast Wind 1b	Shell/EDPR/ENGIE	OCS-A 0521	PPA-MA	2029	Permitting	400	Falmouth, Brayton Point 345 kV
16	MA	SouthCoast Wind (Residual)	Shell/EDPR/ENGIE	OCS-A 0521	TBD	TBD	Permitting	800	Falmouth, Brayton Point 345 kV
17	MA	Floating Demonstration	Shell/ Kent HOE/Ocergy	N/A	TBD	TBD	Planning	10	TBD
18	MA	Vineyard Northeast	Avangrid	OCS-A 0522	TBD	TBD	Site Control	2,143	TBD
19	RI	Block Island Wind Farm	Ørsted	State Lease	PPA-RI	2016	Installed	30	New Shoreham NG 34.5 kV
33	Ohio (OH)	Icebreaker	LEEDCo	State Lease	PPA-OH	2024	Permitting	21	TBD

U.S. Offshore Wind Energy Pipeline Projects for the Mid- and South Atlantic, Including Call Areas in the Mid-Atlantic.

- Ocean Wind 1, a 1,100-MW project off the coast of New Jersey, received approval for construction from BOEM in July 2023.
- On July 31, 2023, BOEM announced 356,550 acres (1443 km2) would be designated as wind energy areas (WEAs) in the Central Atlantic region.
- The three new Central Atlantic WEAs can collectively support approximately 5.8 GW of fixed-bottom offshore wind (assuming 4 MW/km^2 capacity density).

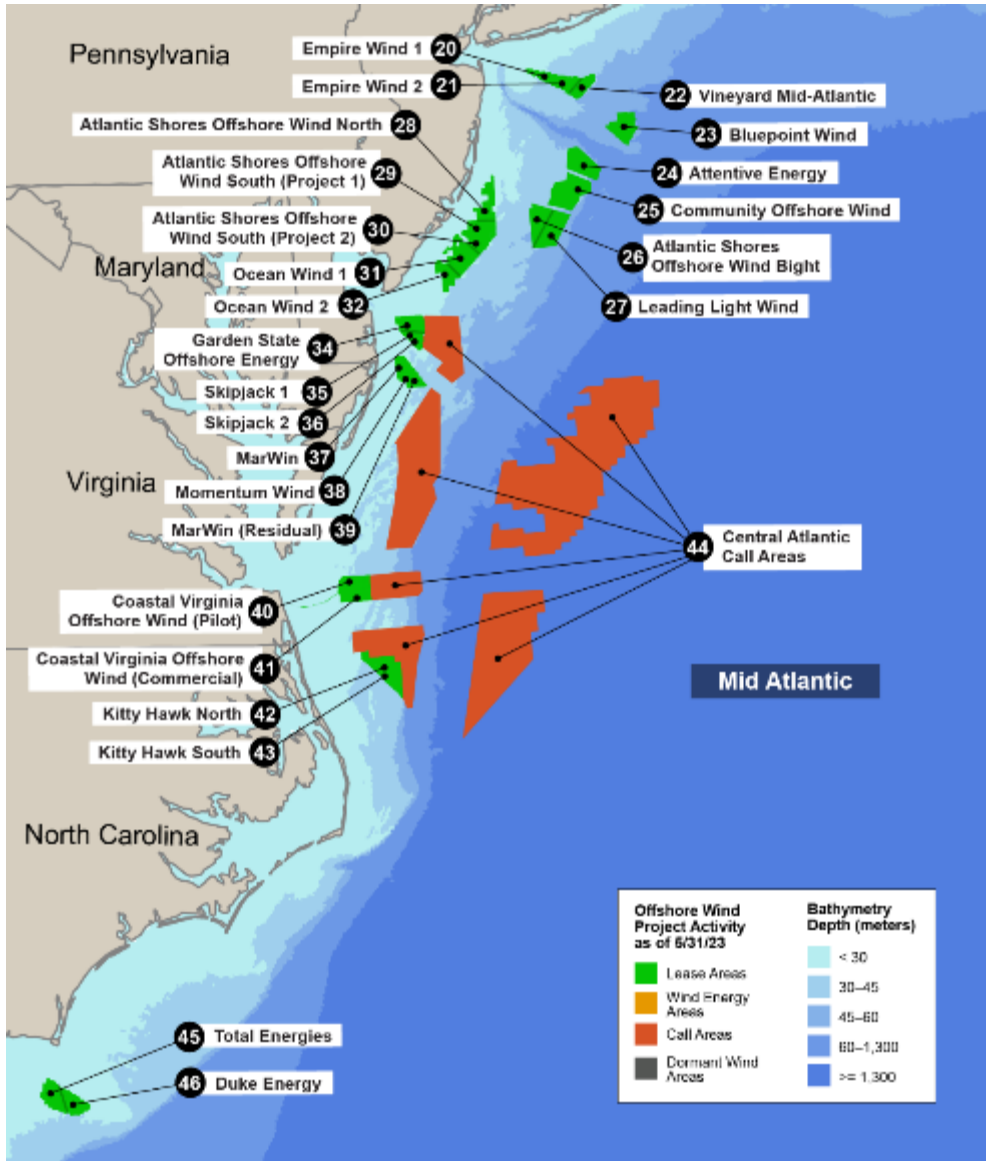


Image by John Frenzl, NREL

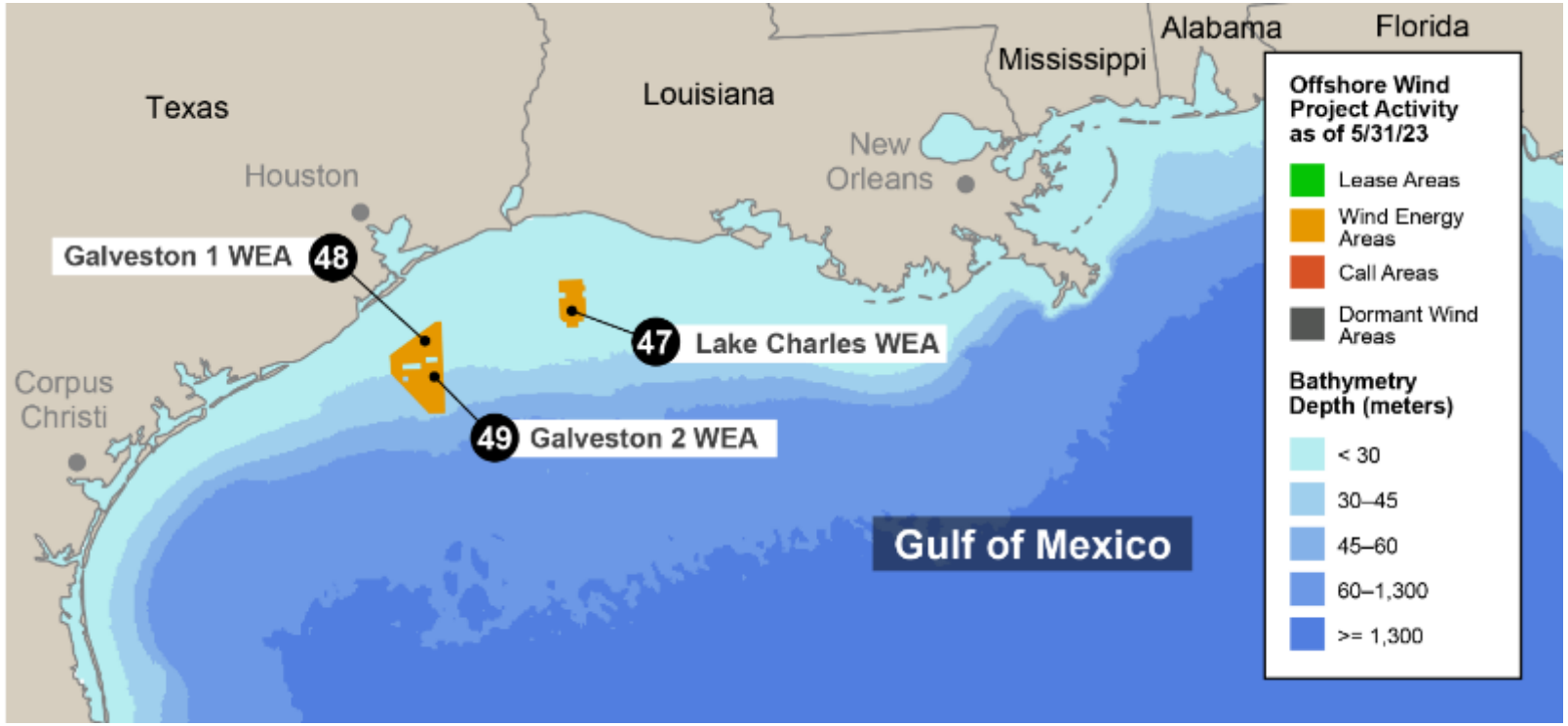
Refer to table on next slide for details

U.S. Offshore Wind Energy Pipeline for Projects in the Mid- and South Atlantic

#	Location	Name	Developer	Lease Area	Offtake Agreement	Estimated COD	Current Status	Capacity (MW)	Potential POI Location
20	NY	Empire Wind 1	Equinor Wind US/BP	OCS-A 0512	OREC-NY	2026	Permitting	816	ConEd Gowanus
21	NY	Empire Wind 2	Equinor Wind US/BP	OCS-A 0512	OREC-NY	2027	Permitting	1,260	Oceanside
22	NY/New Jersey (NJ)	Vineyard Mid-Atlantic	Avangrid	OCS-A 0544	TBD	TBD	Site Control	697	TBD
23	NY/NJ	Bluepoint Wind	EDPR/ENGIE	OCS-A 0537	TBD	TBD	Site Control	1,158	TBD
24	NY/NJ	Attentive Energy	Total Energies	OCS-A 0538	TBD	TBD	Site Control	1,365	TBD
25	NY/NJ	Community Offshore Wind	RWE/National Grid	OCS-A 0539	TBD	TBD	Site Control	2,039	TBD
26	NY/NJ	Atlantic Shores Offshore Wind Bight	EDF/Shell	OCS-A 0541	TBD	TBD	Site Control	1,284	TBD
27	NY/NJ	Leading Light Wind	Invenergy	OCS-A 0542	TBD	TBD	Site Control	1,359	TBD
28	NJ	Atlantic Shores Offshore Wind North	EDF/Shell	OCS-A 0549	TBD	TBD	Site Control	1,182	TBD
29	NJ	Atlantic Shores Offshore Wind South (Project 1)	EDF/Shell	OCS-A 0499	OREC-NJ	2027	Permitting	1,510	Cardiff Substation, Larrabee Substation
30	NJ	Atlantic Shores Offshore Wind South (Project 2)	EDF/Shell	OCS-A 0499	TBD	TBD	Permitting	890	Cardiff Substation, Larrabee Substation
31	NJ	Ocean Wind 1	Ørsted	OCS-A 0498	OREC-NJ	2025	Approved	1,100	BL England, Oyster Creek Substation
32	NJ	Ocean Wind 2	Ørsted	OCS-A 0532	OREC-NJ	2028	Permitting	1,148	TBD
34	Delaware (DE)	Garden State Offshore Energy	Ørsted	OCS-A 0482	TBD	TBD	Site Control	1,080	TBD
35	DE	Skipjack 1	Ørsted	OCS-A 0519	OREC-Maryland (MD)	2026	Permitting	120	Bethany 138 kV
36	DE	Skipjack 2	Ørsted	OCS-A 0519	OREC-MD	2027	Permitting	846	Indian River 230 kV, Milford-Cartanza 230 kV, Cool Spring 230 kV
37	MD	MarWin	US Wind	OCS-A 0490	OREC-MD	2025	Permitting	270	Indian River 230 kV
38	MD	Momentum Wind	US Wind	OCS-A 0490	OREC-MD	2028	Permitting	809	Indian River 230 kV
39	MD	MarWin (Residual)	US Wind	OCS-A 0490	TBD	TBD	Permitting	600	Indian River 230 kV
40	Virginia (VA)	Coastal Virginia Offshore Wind (CVOW) (Pilot)	Dominion Energy	OCS-A -0497	Utility-Owned VA	2020	Installed	12	Birdneck 34.5 kV
41	VA	CVOW (Commercial)	Dominion Energy	OCS-A 0483	Utility-Owned VA	2026	Permitting	2,587	Birdneck-Landstown 230 kV, Oceana 230 kV
42	North Carolina (NC)	Kitty Hawk North	Avangrid	OCS-A 0508	TBD	TBD	Permitting	1,035	Virginia Beach Substation, Birdneck Substation, Corporate Landing Substation Site, Landstown Substation, Fentress Substation
43	NC	Kitty Hawk South	Avangrid	OCS-A 0508	TBD	TBD	Site Control	2,465	TBD
44	DE, MD, VA, NC	Central Atlantic Call Areas	N/A	N/A	N/A	N/A			TBD
45	NC	Total Energies	Total Energies	OCS-A 0545	TBD	TBD	Site Control	889	TBD
46	NC	Duke Energy	Duke Energy	OCS-A 0546	TBD	TBD	Site Control	893	TBD

BOEM Plans To Auction Three Lease Areas in the Gulf of Mexico in August 2023

#	Location	Name	Developer	Lease Area	Offtake Agreement	Estimated COD	Current Status	Capacity (MW)	Potential POI Location
47	Louisiana	Lake Charles WEA	TBD	OCS-G 37336	TBD	TBD	Planning	1,659	TBD
48	Texas (TX)	Galveston 1 WEA	TBD	OCS-G 37334	TBD	TBD	Planning	1,659	TBD
49	TX	Galveston 2 WEA	TBD	OCS-G 37335	TBD	TBD	Planning	1,567	TBD



U.S. offshore wind energy pipeline (Gulf of Mexico). ***Image by John Frenzl, NREL***

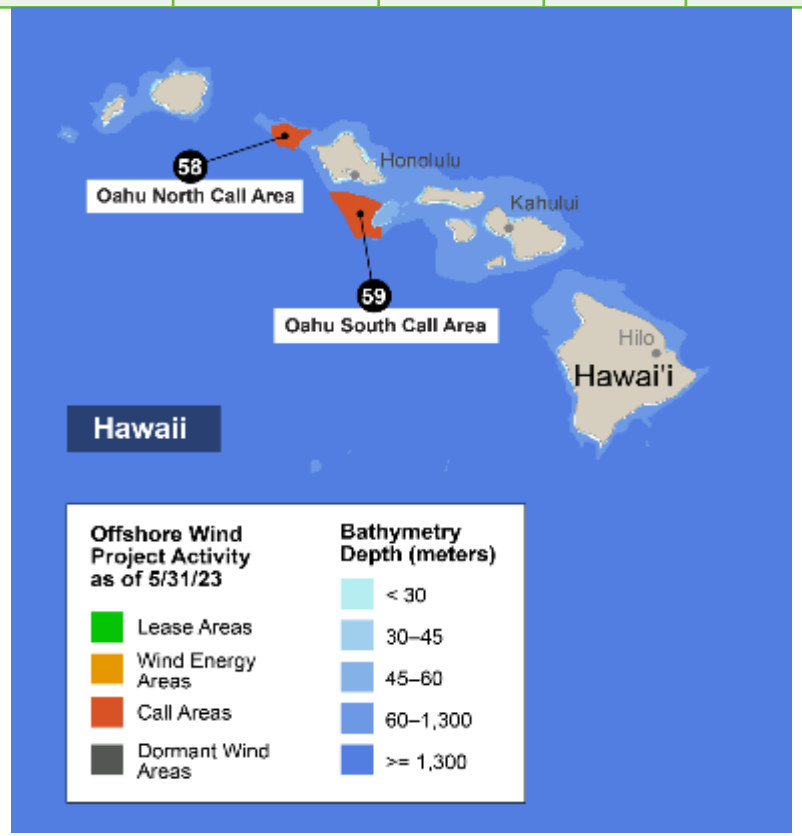
California Auction in December 2022 Advanced First Five Floating Lease Areas to Site Control Status; Two Oregon Wind Energy Areas Were Announced in August 2023 (not shown).

#	Location	Name	Developer	Lease Area	Offtake Agreement	Estimated COD	Current Status	Capacity (MW)	Potential POI Location
50	California (CA)	CADEMO	Floventis (Cierco/SBM)	Proposed State Lease	TBD	TBD	Permitting	60	TBD
51	CA	Central Coast (Morro Bay) Equinor	Equinor	OCS-P 0563	TBD	TBD	Site Control	1,296	TBD
52	CA	Central Coast (Morro Bay) EDPR/ENGIE	EDPR/ENGIE	OCS-P 0564	TBD	TBD	Site Control	1,302	TBD
53	CA	Central Coast (Morro Bay) Invenergy	Invenergy	OCS-P 0565	TBD	TBD	Site Control	1,302	TBD
54	CA	North Coast (Humboldt) RWE	RWE	OCS-P 0561	TBD	TBD	Site Control	1,025	TBD
55	CA	North Coast (Humboldt) CIP	CIP	OCS-P 0562	TBD	TBD	Site Control	1,117	TBD
56	Oregon (OR)	Brookings Call Area	N/A	N/A	N/A	N/A	N/A	N/A	N/A
57	OR	Coos Bay Call Area	N/A	N/A	N/A	N/A	N/A	N/A	N/A

U.S. offshore wind energy pipeline (Pacific). ***Image by John Frenzl, NREL***

Two Hawaiian Call Areas for Floating Offshore Wind Are Not Yet Counted Toward U.S. Offshore Wind Pipeline Capacity

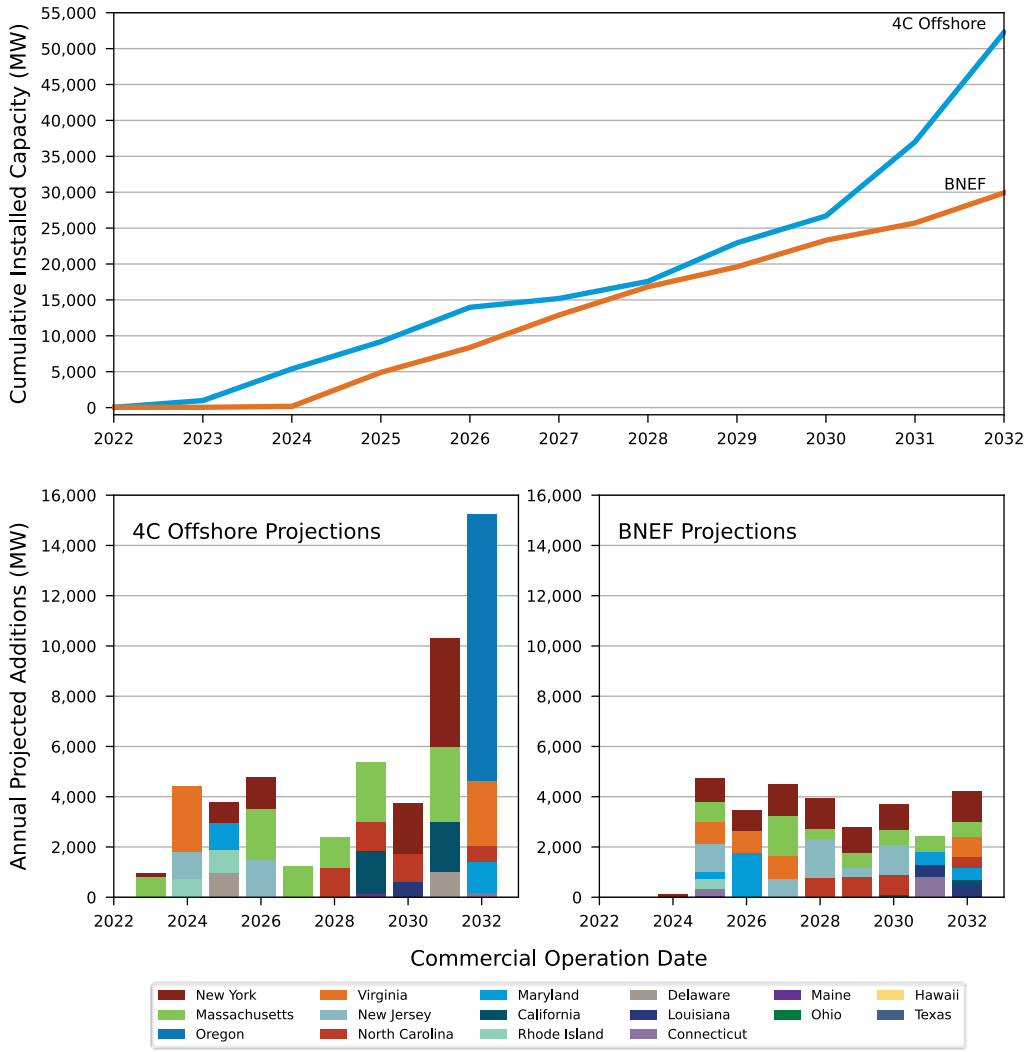
#	Location	Name	Developer	Lease Area	Offtake Agreement	Estimated COD	Current Status	Capacity (MW)	Potential POI Location
58	Hawaii (HI)	Oahu North Call Area	N/A	N/A	N/A	N/A	N/A	N/A	N/A
59	HI	Oahu South Call Area	N/A	N/A	N/A	N/A	N/A	N/A	N/A



U.S. offshore wind energy pipeline (Hawaii).
Image by John Frenzl, NREL

Industry Forecasts for U.S. Offshore Wind Market Indicate Continued Long-Term Growth

- 4C Offshore (2022) and BNEF provide independent forecasts of U.S. offshore wind energy deployment out to 2032.
- Forecasts estimate that the U.S. offshore wind market will cumulatively reach 52 GW and 30 GW by 2032.
- 4C and BNEF forecasts in 2022 are lower than 2021 and may reflect recent cost increases and project cancellations.



Industry offshore wind energy U.S. development projections through 2032

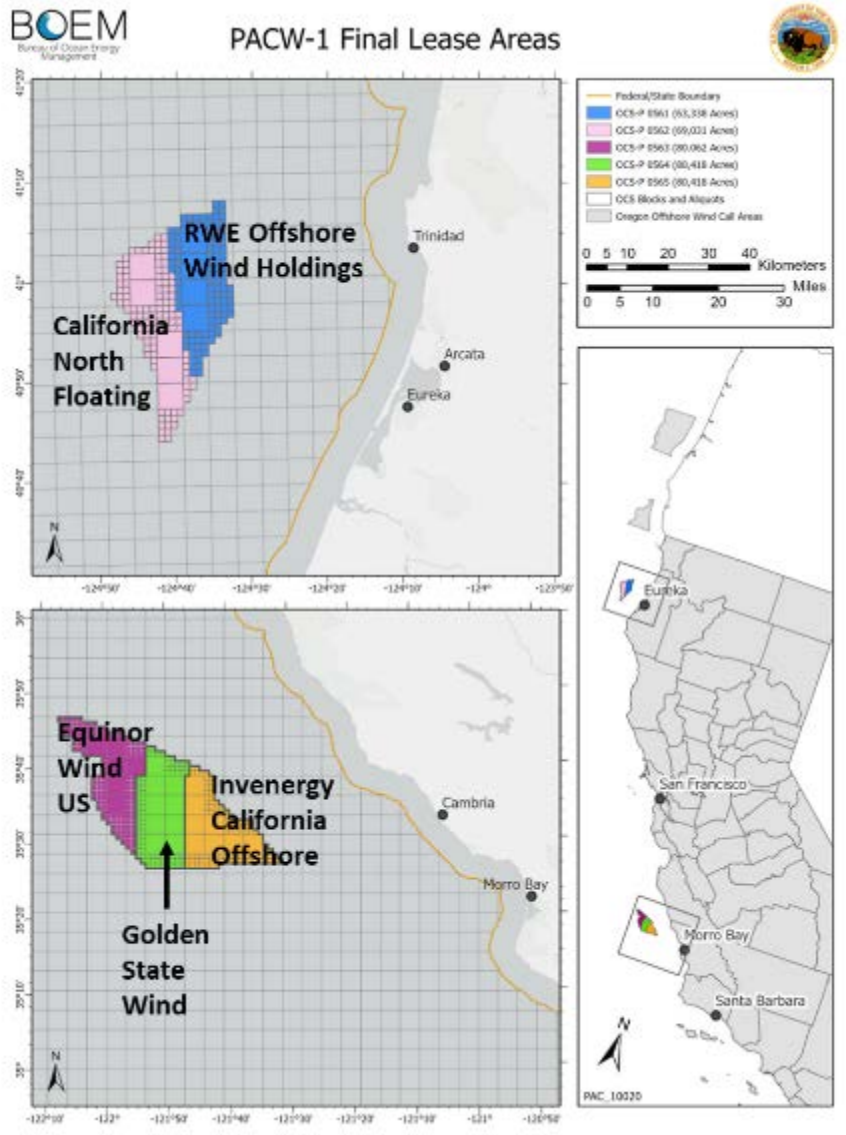
U.S. Federal Offshore Wind Energy Project Permitting Status as of May 31, 2023

Location	Lease Number	Area (km^2)	Date Issued	Project(s) Being Developed in Lease Area	Status
DE	OCS-A 0482	284	2012	Garden State Offshore Wind	Site assessment Plan (SAP) Approved (Construction and Operations Plan (COP) Not Submitted)
RI/MA	OCS-A 0486		2013	Revolution Wind	COP Submitted – Draft Environmental Impact Statement (EIS)
RI/MA	OCS-A 0 517	55	2013	South Fork Wind Farm	ROD Approved – Under Construction
RI/MA	OCS-A 0487	445	2013	Sunrise Wind 1	COP Submitted – Draft EIS
VA	OCS-A 0483	456	2013	CVOW (Commercial)	COP Submitted – Draft EIS
MD	OCS-A 0490	323	2014	MarWin Momentum Wind MarWin (Residual)	COP Submitted – Notice of Intent (NOI) for EIS
MA	OCS-A 0500	759	2015	Bay State Wind	COP Submitted
MA	OCS-A 0501	264	2015	Vineyard Wind 1	ROD Approved – Under Construction
MA	OCS-A 0534	411	2015	New England Wind (Commonwealth Wind) New England Wind (Park City Wind)	COP Submitted – Draft EIS
NJ	OCS-A 0498	306	2016	Ocean Wind 1	COP Submitted – Final EIS
NJ	OCS-A 0532	344	2016	Ocean Wind 2	COP Not Submitted
NJ	OCS-A 0499	348	2016	Atlantic Shores Offshore Wind South (Project 1) Atlantic Shores Offshore Wind South (Project 2)	COP Submitted – Draft EIS
NJ	OCS-A 0549	394	2016	Atlantic Shores Offshore Wind North	COP Submitted
NY	OCS-A 0512	321	2017	Empire Wind 1 Empire Wind 2	COP Submitted – Draft EIS
NC	OCS-A 508	495	2017	Kitty Hawk	COP Submitted – NOI for EIS
DE	OCS-A 519	107	2018	Skipjack 1 Skipjack 2	COP Not Submitted
MA	OCS-A 0520	521	2019	Beacon Wind 1 Beacon Wind (Residual)	COP Submitted
MA	OCS-A 0521	516	2019	SouthCoast Wind	COP Submitted – Draft EIS
MA	OCS-A 0522	536	2019	Vineyard Northeast	SAP Approved (COP Not Submitted)
NY/NJ	OCS-A 0537	289	2022	Bluepoint Wind	SAP or COP Not Submitted
NY/NJ	OCS-A 0538	341	2022	Attentive Energy	SAP or COP Not Submitted
NY/NJ	OCS-A 0539	510	2022	Community Offshore Wind	SAP or COP Not Submitted
NY/NJ	OCS-A 0541	321	2022	Atlantic Shores Offshore Wind Bight	SAP or COP Not Submitted
NY/NJ	OCS-A 0542	340	2022	Leading Light Wind	SAP or COP Not Submitted
NY/NJ	OCS-A 0544	174	2022	Vineyard Mid-Atlantic	SAP or COP Not Submitted
NC	OCS-A 0545	222	2022	Total Energies (Carolina Long Bay)	SAP or COP Not Submitted
NC	OCS-A 0546	223	2022	Duke Energy (Carolina Long Bay)	SAP or COP Not Submitted
CA	OCS-P 0561	256	2022	North Coast (Humboldt) RWE	SAP or COP Not Submitted
CA	OCS-P 0562	279	2022	North Coast (Humboldt) CIP	SAP or COP Not Submitted
CA	OCS-P 0563	324	2022	Central Coast (Morro Bay) Equinor	SAP or COP Not Submitted
CA	OCS-P 0564	325	2022	Central Coast (Morro Bay) EDPR/ENGIE	SAP or COP Not Submitted
CA	OCS-P 0565	325	2022	Central Coast (Morro Bay) Invenergy	SAP or COP Not Submitted

California Auction Yields Over $750 Million From Five Leases, Adding Over 6 GW of Generating Capacity Potential and Launching the U.S. Commercial Floating Offshore Wind Industry

California Commercial Offshore Wind Energy Auction Results

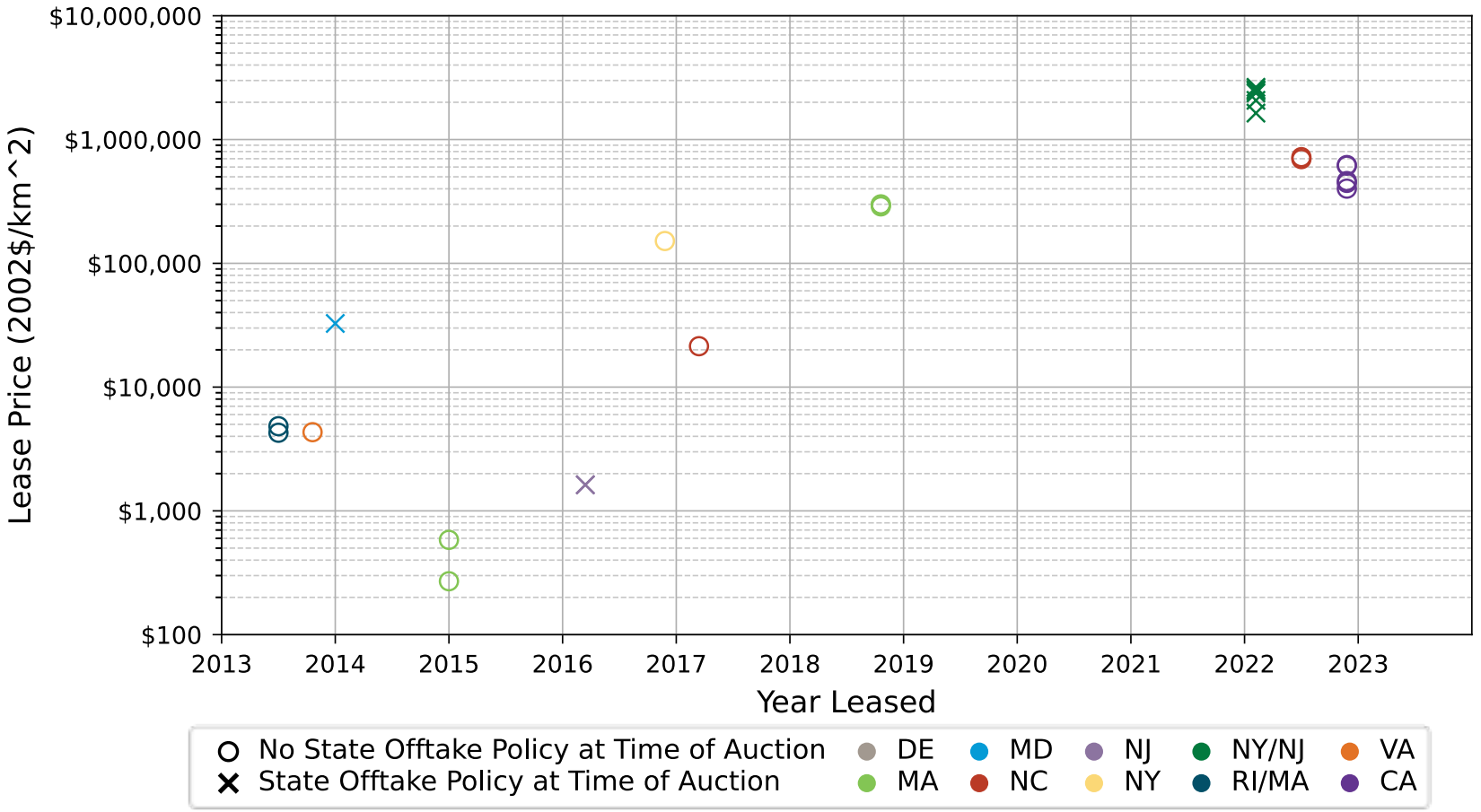
Lease Number	Location	Developer	Area (km²)	Capacity (MW)	Price	Price per km²
OCS-A 0561	Humboldt	RWE Offshore Wind	256	1,025	$157,700,000	$616,016
OCS-A 0562	Humboldt	California North Floating (CIP)	279	1,117	$173,800,000	$622,939
OCS-A 0563	Morro Bay	Equinor Wind US	324	1,296	$130,000,000	$401,235
OCS-A 0564	Morro Bay	Central California Offshore Wind (EDPR/ENGIE)	325	1,302	$150,300,000	$461,836
OCS-A 0565	Morro Bay	Invenergy California Offshore	325	1,302	$145,300,00	$447,077



California lease areas. ***Image from BOEM***

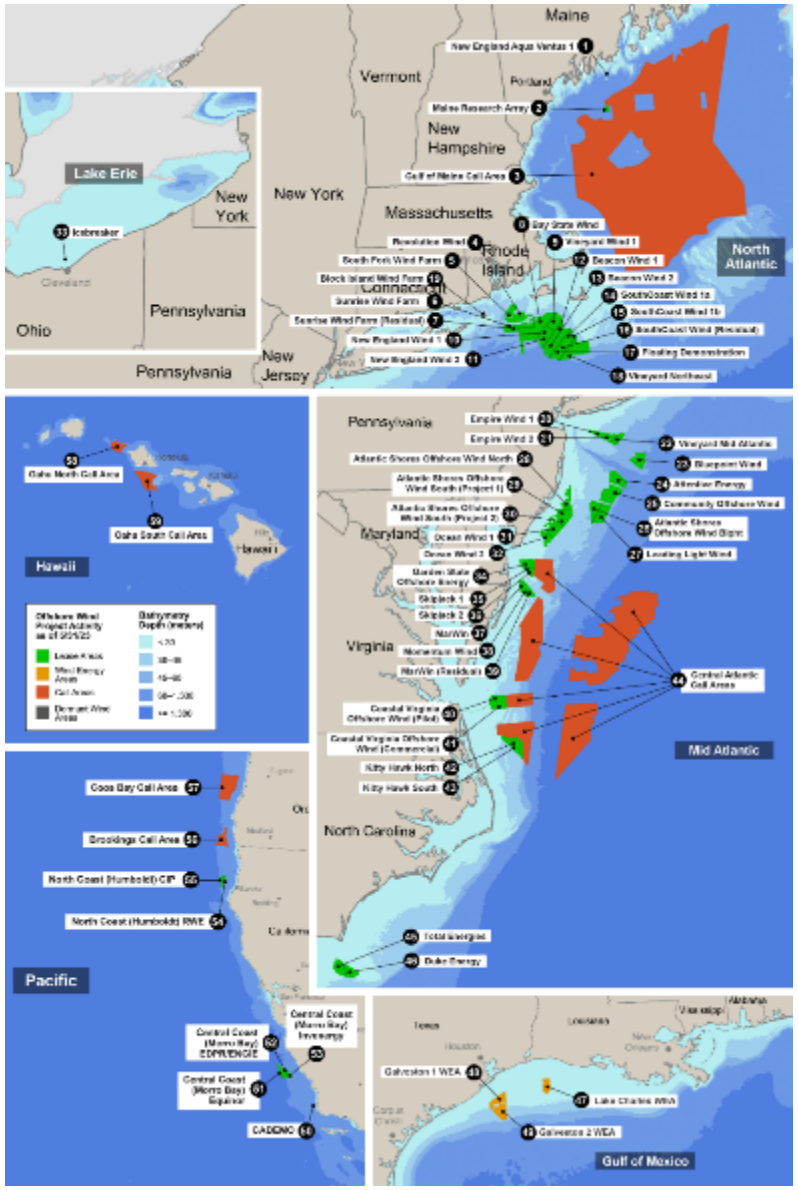
U.S. Offshore Wind Lease Prices Have Grown Logarithmically, With Significantly Higher Lease Prices in States With Strong Procurement Policies

- Lease area auction prices have increased logarithmically since 2013.
- States with strong procurement policies and deployment mandates have higher lease prices.
- December 2022 floating lease sales in California indicate slightly lower prices, possibly due to higher risk from floating wind and no clear offtake mechanisms.



U.S. offshore wind energy lease prices

U.S. Offshore Wind Energy Lease Prices in Order Sold (Indicated by Green Areas on the Map)



Year	State	Lease	Lease Price 2022$	$/km^2	Substructure
2012	DE	OCS-A 0482/OCS-A 0519	$ -	$-	Fixed
2013	RI/MA	OCS-A 0486/OCS-A 0517	$ 1,903,181	$ 4,830	Fixed
2013	RI/MA	OCS-A 0487	$ 1,903,181	$ 4,277	Fixed
2013	VA	OCS-A 0483/OCS-A 0497	$ 1,971,276	$ 4,323	Fixed
2014	MD	OCS-A 0490	$ 10,553,535	$ 32,673	Fixed
2015	MA	OCS-A 0500	$ 341,474	$ 583	Fixed
2015	MA	OCS-A 0501/OCS-A 0534	$ 182,336	$ 270	Fixed
2016	NJ	OCS-A 0498/OCA-A 0532	$ 1,054,690	$ 1,625	Fixed
2016	NJ	OCS-A 0499	$ 1,205,011	$ 1,624	Fixed
2016	NY	OCS-A 0512	$ 48,611,290	$ 151,437	Fixed
2017	NC	OCS-A 0508	$ 10,592,835	$ 21,400	Fixed
2018	MA	OCS-A 0520	$ 154,525,000	$ 296,593	Fixed
2018	MA	OCS-A 0521	$ 154,525,000	$ 299,467	Fixed
2018	MA	OCS-A 0522	$ 154,639,500	$ 288,507	Fixed
2022	NY/NJ	OCS-A 0537	$ 765,000,000	$ 2,643,039	Fixed
2022	NY/NJ	OCS-A 0538	$ 795,000,000	$ 2,472,980	Fixed
2022	NY/NJ	OCS-A 0539	$ 1,100,000,000	$ 2,378,569	Fixed
2022	NY/NJ	OCS-A 0541	$ 780,000,000	$ 2,531,449	Fixed
2022	NY/NJ	OCS-A 0542	$ 645,000,000	$ 2,072,760	Fixed
2022	NY/NJ	OCS-A 0544	$ 285,000,000	$ 1,635,660	Fixed
2022	NC	OCS-A 0545	$ 160,000,000	$ 720,721	Fixed
2022	NC	OCS-A 0546	$ 155,000,000	$ 695,067	Fixed
2022	CA	OCS-P 0561	$ 157,700,000	$ 615,247	Floating
2022	CA	OCS-P 0562	$ 173,800,000	$ 622,139	Floating
2022	CA	OCS-P 0563	$ 130,000,000	$ 401,235	Floating
2022	CA	OCS-P 0564	$ 150,300,000	$ 461,836	Floating
2022	CA	OCS-P 0565	$ 145,300,000	$ 446,472	Floating

Three Gulf of Mexico Offshore Wind Energy Areas Are Expected To Be Auctioned on August 29, 2023, Which Will Add More Than 4.9 GW of New Generating Capacity

Lease Number	Location	Area (km^2)	Capacity (MW)
OCS-G 37334	Lake Charles	415	1,659
OCS-G 37335	Galveston 1	415	1,659
OCS-G 37336	Galveston 2	392	1,567

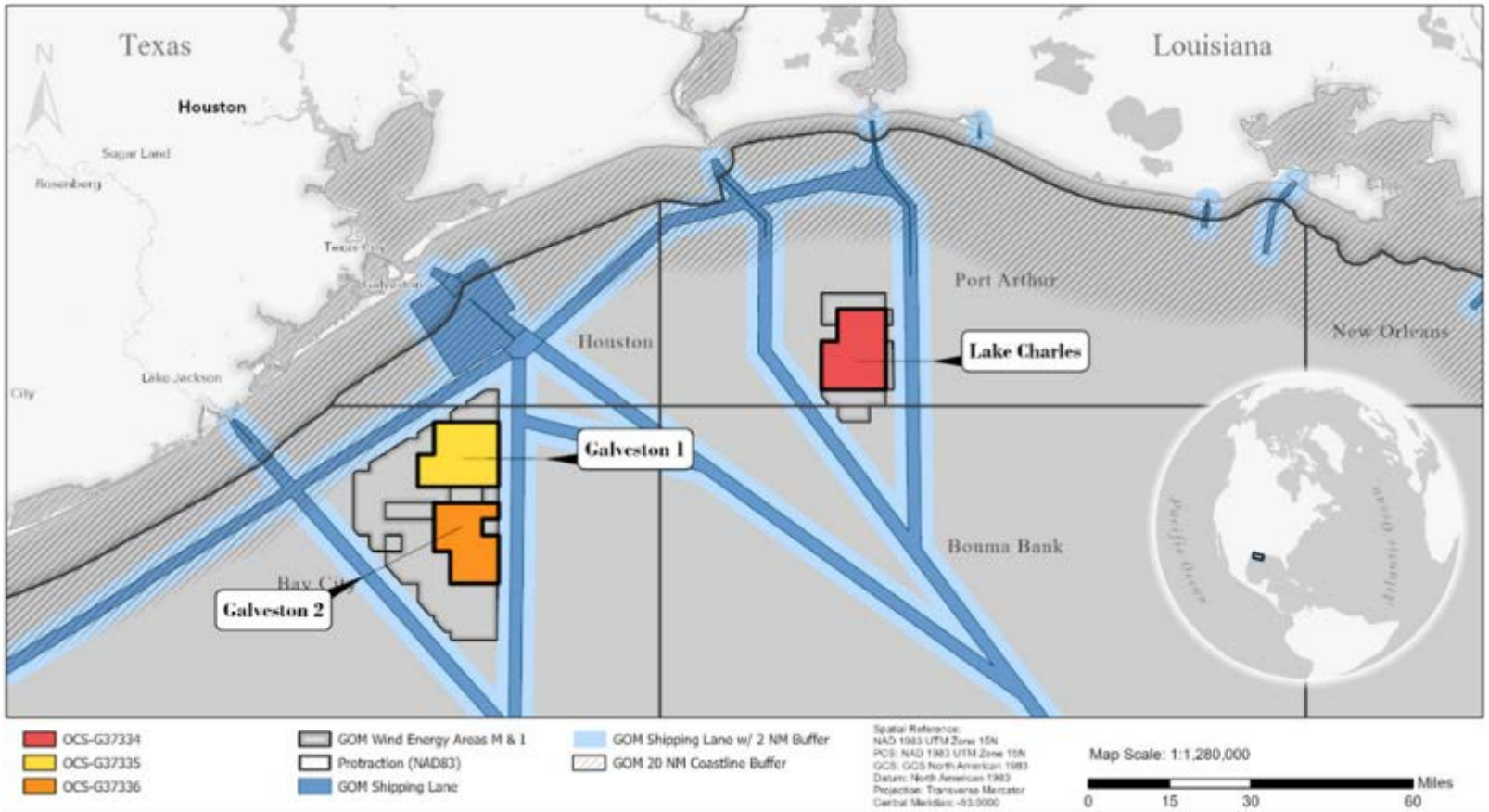
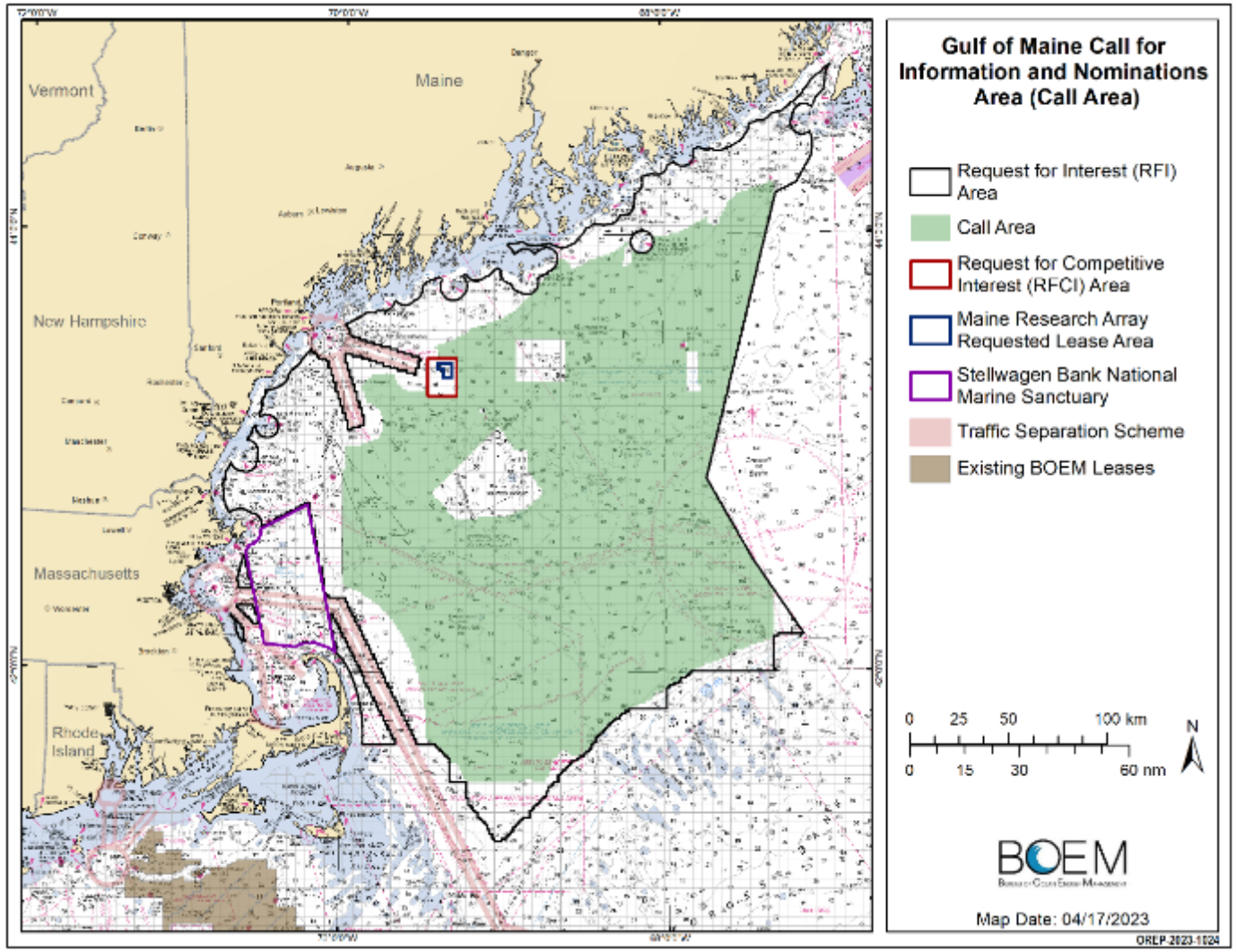


Image from BOEM

Gulf of Maine Call Area and Maine Research Lease Moved Closer to Commercial Leasing in 2022 and 2023, With a Competitive Auction Expected by Early 2025

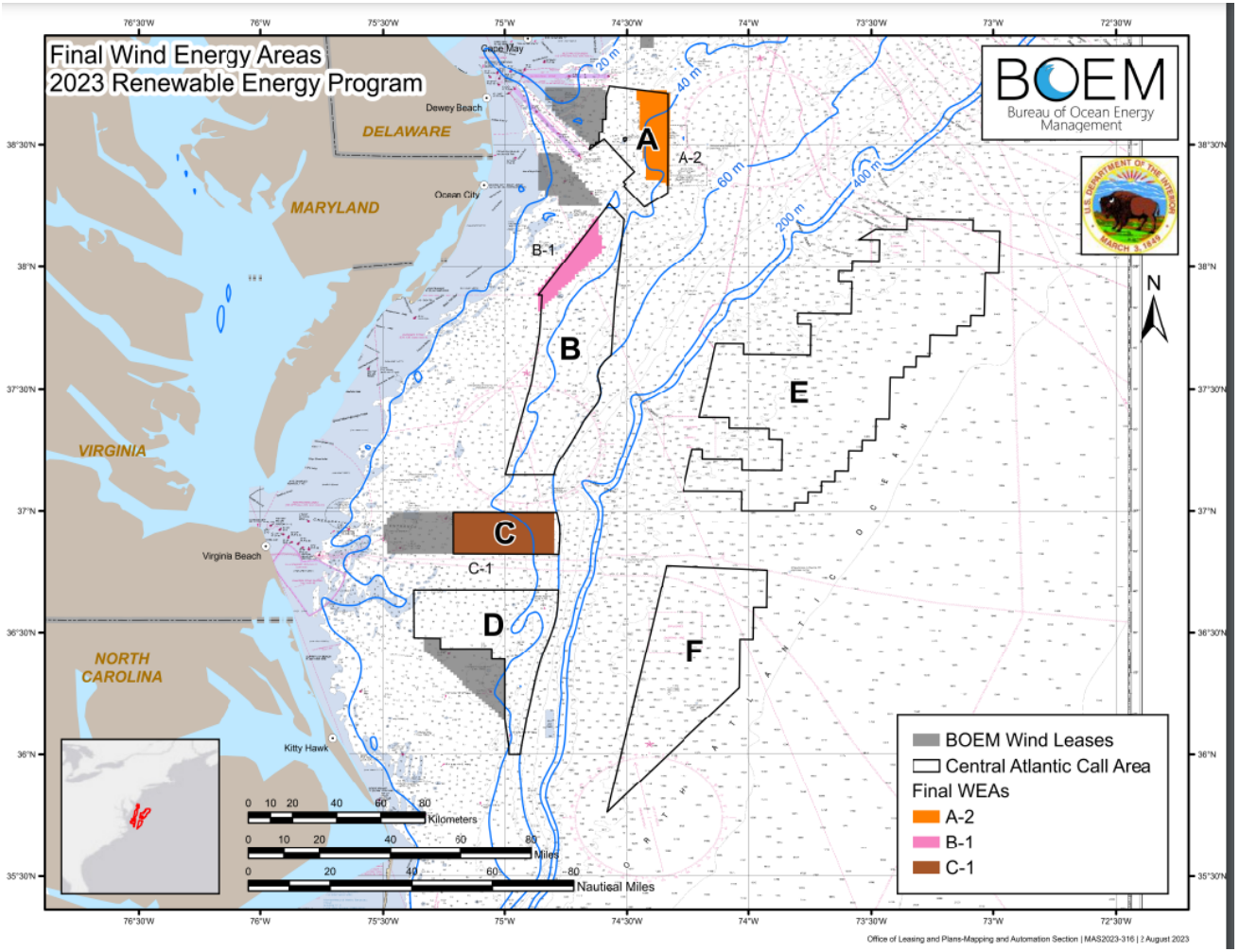
- The Gulf of Maine Call Area (green shading) represents about 9.8 million acres with ~159 GW of floating offshore wind resource potential scheduled for lease auctions in late 2024 or early 2025.
- The Maine Research Lease is a 9,900-acre area (inside red “Request for Competitive Interest (RFCI) Area” rectangle on map.
- The research lease can support up to 144 MW of offshore wind energy to study the potential environmental and co-use impacts of floating offshore wind and is intended to be installed in advance of commercial projects.



Gulf of Maine Call Area. ***Image from BOEM***

Three Offshore Wind Energy Areas Were Announced in the Central Atlantic Region in Late July 2023 With the Potential To Support About 5.8 GW

- On July 31, 2023, BOEM announced 356,550 acres (1443 km^2) would be designated as wind energy areas (WEAs) in the Central Atlantic region.
- These three WEAs, designated A-2, B-1, and C-1 could collectively support approximately 5.8 GW of fixed-bottom offshore wind (assuming 4 MW/km^2 capacity density).
- These future lease areas were reported too late to be included in this year's market report pipeline totals but will be added to the pipeline in the 2024 edition.



New wind energy areas (WEAs) in the Central Atlantic region. ***Image from BOEM***

Note: This slide was updated based on the July 31, 2023, announcement of the three Central Atlantic WEAs. These new WEAs are not yet counted in the U.S. project pipeline.

There Are Thirteen Call Areas on the U.S. Outer Continental Shelf Undergoing BOEM Evaluation

- BOEM Call Areas are precursors to wind energy areas and a mandatory step toward commercial leasing.
- Call Areas are not counted in the offshore wind energy pipeline generating capacity estimates because they are subject to major revisions.
- Three WEAs within the Central Atlantic Call Areas were designated on July 31, 2023.

State	Name	Year Designated	Area (km^2)	Likely Substructure Type
HI	O'ahu North Call Area	2016	1,331	Floating
HI	O'ahu South Call Area	2016	626	Floating
OR	Brookings Call Area	2022	1,160	Floating
OR	Coos Bay Call Area	2022	3,528	Floating
ME	Gulf of Maine Call Area	2022	39,677	Floating
DE/MD/VA/NC	Central Atlantic Draft WEA A	2022	710	Fixed
DE/MD/VA/NC	Central Atlantic Draft WEA B1	2022	128	Fixed
DE/MD/VA/NC	Central Atlantic Draft WEA B2	2022	1,176	Fixed
DE/MD/VA/NC	Central Atlantic Draft WEA C	2022	741	Fixed
DE/MD/VA/NC	Central Atlantic Draft WEA D	2022	849	Fixed
DE/MD/VA/NC	Central Atlantic Draft WEA E1	2022	1,904	Floating
DE/MD/VA/NC	Central Atlantic Draft WEA E2	2022	1,392	Floating
DE/MD/VA/NC	Central Atlantic Draft WEA F	2022	170	Floating

Power Offtake Contracts for U.S. Offshore Wind Energy Projects Face Increasing Uncertainty As Developers Struggle With Cost Increases Due To Inflation

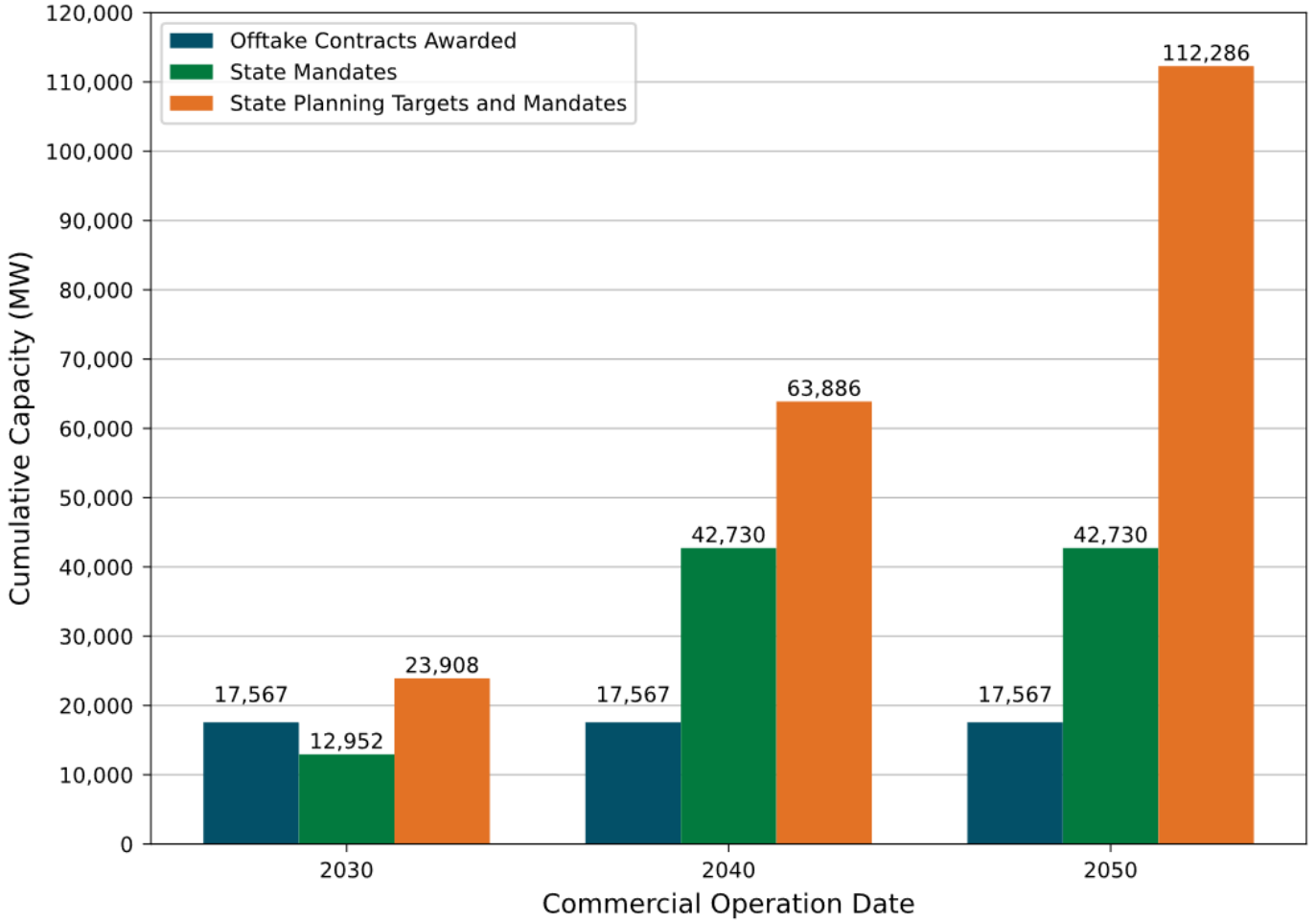
Project	Year Awarded	Size (MW)	Duration (Years)	Offtake Type	Regulator Approved	Levelized Nominal Price ($/megawatt-hour [MWh])	Power Delivery Year
Block Island Wind Farm	2010	30	20	PPA	Yes	244	2016
South Fork Wind Farm	2017	132	20	PPA	Yes	141	2024
MarWin	2017	270	20	MD OREC	Yes	131.9	2026
Skipjack 1	2017	120	20	MD OREC	Yes	131.9	2026
Vineyard Wind 1	2018	400	20	PPA	Yes	74	2024
Vineyard Wind 1	2018	400	20	PPA	Yes	65	2024
CVOW (Pilot)	2018	12	12	Utility Owned	Yes	780	2020
Revolution Wind	2018	400	20	PPA	Yes	99.5	2026
Revolution Wind	2018	200	20	PPA	Yes	98.4	2026
Revolution Wind	2019	104	20	PPA	Yes	98.4	2026
Ocean Wind 1	2019	1,100	20	NJ OREC	Yes	116.8	2025
Empire Wind 1	2019	816	25	NY OREC	Yes	99	2026
Sunrise Wind 1	2019	924	25	NY OREC	Yes	110	2026
New England Aqua Ventus I	2019	12	20	PPA	Yes	Undisclosed	2024
SouthCoast Wind 1a	2020	400	20	PPA	Yes	58.4	2028
SouthCoast Wind 1a	2020	404	20	PPA	Yes	58.4	2029
Icebreaker	2020	21	20	PPA	Yes	Undisclosed	2024
New England Wind 1a	2021	800	20	PPA	Yes	79.8	2027
Empire Wind 2	2021	1,260	25	NY OREC	Yes	107.5	2027
Beacon Wind 1	2021	1,230	25	NY OREC	Yes	118	2029
Ocean Wind 2	2021	1,148	20	NJ OREC	Yes	42.3	2028
Atlantic Shores Offshore Wind South Project 1	2021	1,510	20	NJ OREC	Yes	58.8	2027
Skipjack 2	2021	846	20	MD OREC	Yes	71.6	2027
Momentum Wind	2021	809	20	MD OREC	Yes	54.17	2028
SouthCoast Wind 1b	2021	400	20	PPA	Yes	77	2027
New England Wind 1b	2021	1,232	20	PPA	Yes	72	2027
CVOW (Commercial)	2021	2,587	20	Utility Owned	Yes	87	2026

State Planning Goals and Mandated State Procurements Combined Total More Than 112 GW by 2050

State	Planning Goal		Mandated Procurement		Offtake Contracts Awarded (MW)	Awarded Projects (MW)	Open/Pending Procurement (MW)	Supporting Policies and Documents
	Capacity (MW)	Year	Capacity (MW)	Year				
Maine	156	2030	-	-	12	Aqua Ventus (12)		Maine Wind Energy Development Assessment (2012)
Massachusetts	23,000	2050	5,600	2035	3,236	Vineyard Wind 1 (800) SouthCoast Wind 1 (804) South Coast Wind 2 (400) New England Wind (1,232)	400–3,600 (closes 1/31/2024)	Act to Promote Energy Diversity (2016) Act to Advance Clean Energy (2018) Massachusetts 2050 Decarbonization Roadmap (2020) Act Creating a Next Generation Roadmap for Massachusetts Climate Policy (2021)
Rhode Island	1,430	2030	1,430	2030	430	Block Island Wind Farm (30) Revolution Wind (400)	600–1,000 (closed 3/13/23)	Request for Proposals for Long-Term Contracts for Offshore Wind Energy (2022)
Connecticut	2,000	2030	2,000	2030	1,104	Revolution Wind (304) New England Wind (800)	Draft request for proposal for 1,196	Public Act No. 19-71 (2019)
New York	20,000	2050	9,000	2035	4,362	South Fork Wind (132) Empire Wind 1 (816) Sunrise Wind 1 (924) Empire Wind 2 (1,260) Beacon Wind 1 (1,230)	1,000–2,000 (closed 1/26/2023)	Case 18-E-0071 (2018) Climate Leadership & Community Protection Act (2019) New York State Climate Action Council Scoping Plan (2022)
New Jersey	11,000	2040	11,000	2040	3,758	Ocean Wind 1 (1,100) Ocean Wind 2 (1,148) Atlantic Shores Offshore Wind South (Project 1) (1,510)	1,200–4,000 (closes 6/23/23)	Offshore Wind Economic Development Act (2010) Executive Order 8 (2018) Executive Order 92 (2019) Executive Order 307 (2022)
Maryland	8,500	2031	8,500	2031	2,045	Skipjack 1 (120) MarWin (270) Momentum Wind (808) Skipjack 2 (846)		Maryland Offshore Wind Energy Act (2013) Clean Energy Jobs Act (2019) Promoting Offshore Wind Energy Resource Act (2023)
Virginia	5,200	2034	5,200	2034	2,599	CVOW Pilot (12) CVOW Commercial (2,587)		Virginia Clean Economy Act (2021)
North Carolina	8,000	2040	-	-	-			Executive Order 218 (2021)
California	25,000	2045	-	-	-			AB 525 (2021) Offshore Wind Energy Development off the California Coast: Maximum Feasible Capacity and Megawatt Planning Goals for 2030 and 2045 (2022)
Ohio	-	-	-	-	21	LEEDCo (21)		None
Louisiana	5,000	2035	-	-	-			Louisiana Action Plan (2022)
Oregon	3,000	2030	-	-	-			HB 3375 (2021)
Totals	**112,286**	**2050**	**42,730**	**2040**	**17,567**			

U.S. Offshore Wind State Planning Goals, Procurement Mandates, and Offtake Contracts Awarded Show 112 GW of Commitments Based on Planning Targets and Mandates Across Thirteen States

- State mandates are currently in place for seven states where laws have been passed to require long-term deployment of about 42,730 MW of offshore wind energy.
- As of May 31, 2023, there were 27 offtake agreements that total 17,567 MW; however, some projects are canceling their contracts due to rising costs.
- Ohio does not have policy to support Great Lakes based wind energy but LEEDCo's 21-MW project in Lake Erie is counted as a target because there is an offtake agreement.

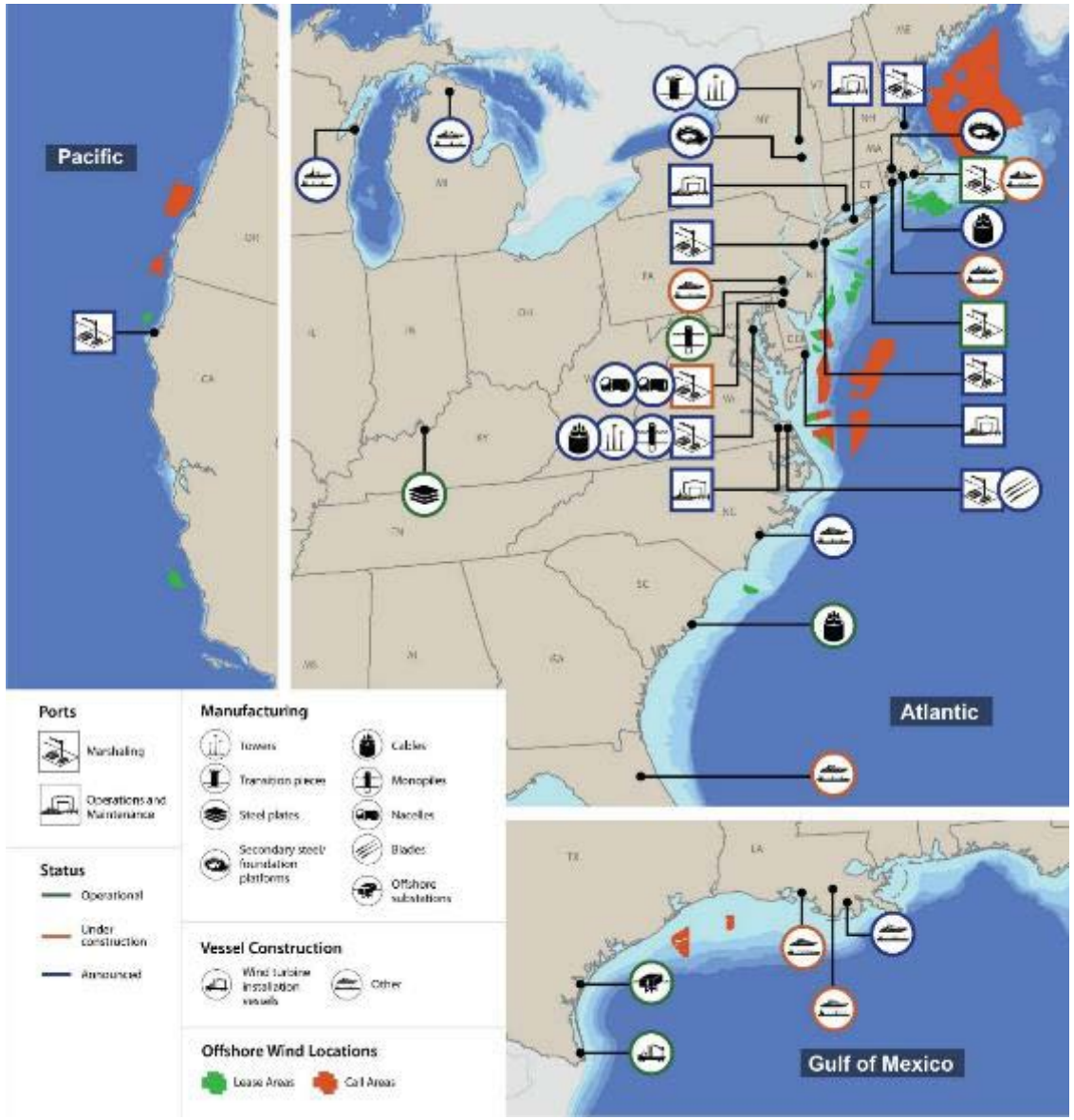


U.S. offshore wind energy state planning goals, procurement mandates, and offtake agreements awarded.

Note: The state planning targets combine the statutory state procurement mandates with the planning goals that are not binding.

Offshore Wind Ports, Vessels, and Manufacturing Supply Chain Facilities Emerging Near Project Development Sites Indicate Regional Economic Development and Domestic Supply Chain Growth

- About $17 billion has been announced or invested in the U.S. offshore wind energy industry since 2014.
- About $2.7 billion was invested in ports, supply chain, vessels, and transmission in 2022 (Business Network for Offshore Wind 2023).
- NREL estimates at least $22 billion in ports, large installation vessels, and major manufacturing facilities will be needed to achieve the 30-GW-by-2030 target (Shields et al. 2023).



Announced and active port, vessel, and supply chain activity in the United States. Announced facilities that are conditional on winning a power offtake agreement are not shown. *Image created by John Frenzl, NREL*

U.S.-Flagged Vessels Have Been Commissioned To Serve Early-Stage U.S. Projects, But Many More Vessels Are Needed

Installation of first monopile foundation at South Fork Wind Farm. *Photo courtesy of South Fork/Boskalis*

Vessel Category (Vessel Name)	Companies Backing	Project Contracts	Commissioning	Source(s)
Crew transfer vessel (CTV) (Gaspee)	McAllister Towing	CVOW Pilot	1990	McAllister Towing, (n.d); American Clean Power (2023b); Dominion Energy (2020a)
CTV (Atlantic Pioneer)	Atlantic Wind Transfers, Blount Boats Inc., Chartwell Marine Ltd.	Block Island Wind Farm	2016	Chartwell Marine (n.d)
CTV (Atlantic Endeavor)	Atlantic Wind Transfers, Blount Boats Inc., Chartwell Marine Ltd.	CVOW	2020	Chartwell Marine (n.d.)
CTV	Atlantic Wind Transfers, Chartwell Marine Ltd.	Not listed	2020	Chartwell Marine (n.d.)
CTV (Odyssey)	Windserve Marine, Ørsted	CVOW	2020	Ørsted (2019)
CTV (Windserve Odyssey)	Senesco Marine, Ørsted	Revolution Wind	Not listed	Ørsted (2019)
CTV	Atlantic Wind Transfers, Dominion Energy	Not listed	Not listed	Power and Energy Solutions (n.d.)
Walk-to-work vessel	US Otto Candies, LLC	South Fork Wind	2018	Blenkey (2021)

Significant Numbers of U.S.-Flagged Vessels Have Been Announced or Are Under Construction To Serve the U.S. Offshore Wind Energy Industry

Vessel Category (Vessel Name)	Companies Backing	Project Contracts	Commissioning	Source(s)
Barge	Maersk Supply Service, BP/Equinor	Empire Wind	2030	WorkBoat (2022a)
Barge	Maersk Supply Service, BP/Equinor	Empire Wind	2030	WorkBoat (2022a)
Crew transfer vessel (CTV)	Patriot Offshore Maritime Services, Vineyard Wind	Vineyard Wind	2023	WorkBoat (2022b)
CTV	Atlantic Wind Transfers, Chartwell Marine, UK	Not listed	2023	Memija (2022)
CTV	WINDEA CTV LLC, GE	Vineyard Wind	2023	WINDEA (2022)
CTV	WINDEA CTV LLC, GE	Vineyard Wind	2023	WINDEA (2022)
CTV	Gladding-Hearn Shipbuilding/Duclos Corporation, Shell New Energies, Ocean Winds	Mayflower Wind	2023	Professional Mariner (2021)
CTV	WINDEA CTV LLC, GE	Vineyard Wind	2023	WINDEA (2022)
CTV	Blount Boats and Shipyard, American Offshore Services, Ørsted, Eversource	Revolution Wind, South Fork Wind, Sunrise Wind	2023	Ørsted (2022)
CTV	Blount Boats and Shipyard, American Offshore Services	Not listed	2024	WorkBoat (2021b)
CTV	Blount Boats and Shipyard, Vineyard Wind	Vineyard Wind	2024	Vineyard Wind (2022)
CTV	WindServe Marine, LLC, Ørsted, Eversource	Revolution Wind, South Fork Wind, Sunrise Wind	2024	Durakovic (2022)
CTV	Atlantic Wind Transfers, Chartwell Marine, United Kingdom (UK)	Not listed	2024	Memija (2022)
CTV	Blount Boats and Shipyard, American Offshore Services, Ørsted, Eversource	Revolution Wind, South Fork Wind, Sunrise Wind	2024	Ørsted (2022)
CTV	WindServe Marine, LLC, Ørsted, Eversource	Revolution Wind, South Fork Wind, Sunrise Wind	2025	Durakovic (2022)
CTV	WindServe Marine, LLC, Ørsted, Eversource	Revolution Wind, South Fork Wind, Sunrise Wind	2025	Durakovic (2022)
CTV	Atlantic Wind Transfers, Chartwell Marine, UK	Not listed	2026	Memija (2022)
CTV	Atlantic Wind Transfers, Chartwell Marine, UK	Not listed	2028	Memija (2022)
CTV	Atlantic Wind Transfers, Chartwell Marine, UK	Not listed	2030	Memija (2022)
CTV	Atlantic Wind Transfers, Chartwell Marine, UK	Not listed	2032	Memija (2022)
Multipurpose (Eleanor)	Moran Ironworks Shipyard, Green Shipping Line, DEKC Maritime, Keystone Shipping Company, DEKC Maritime	Not listed	2023	Durakovic (2021)
Rock installation (Great Lakes Dredge and Dock Corporation)	Philly Shipyard, Inc., Great Lakes Dredge and Dock Corporation, Ulstein Design & Solutions B.V.	Empire Wind	2024	The Waterways Journal (2020); Ulstein (2020, 2021); Great Lakes Dredge and Dock (2020)
Service operation vessel (SOV) (Eco Edison)	Edison Chouest Offshore, Ørsted, Eversource	Revolution Wind, South Fork Wind and Sunrise Wind	2024	Schuler (2020)
SOV	Edison Chouest Offshore, Equinor/BP	Empire Wind	2026	Equinor 2022
SOV	Crowley, CREST (Crowley/ESVAGT), HAV Design AS	CVOW - Commercial	2026	Crowley (2023)
Tug	Maersk Supply Service, BP/Equinor	Empire Wind	2030	WorkBoat (2022a)
Tug	Maersk Supply Service, BP/Equinor	Empire Wind	2030	WorkBoat (2022a)
Wind turbine installation vessel (Charybdis)	Keppel AmFELS, Dominion Energy, GustoMSC	Revolution Wind, Sunrise Wind, CVOW	2023	Dominion Energy (2020b); The Maritime Executive (2020); Skopljak (2020)

Investments in Offshore Wind Ports and Manufacturing Facilities for Major Components From January 1, 2022, to May 2023 Total More Than $2.6 Billion

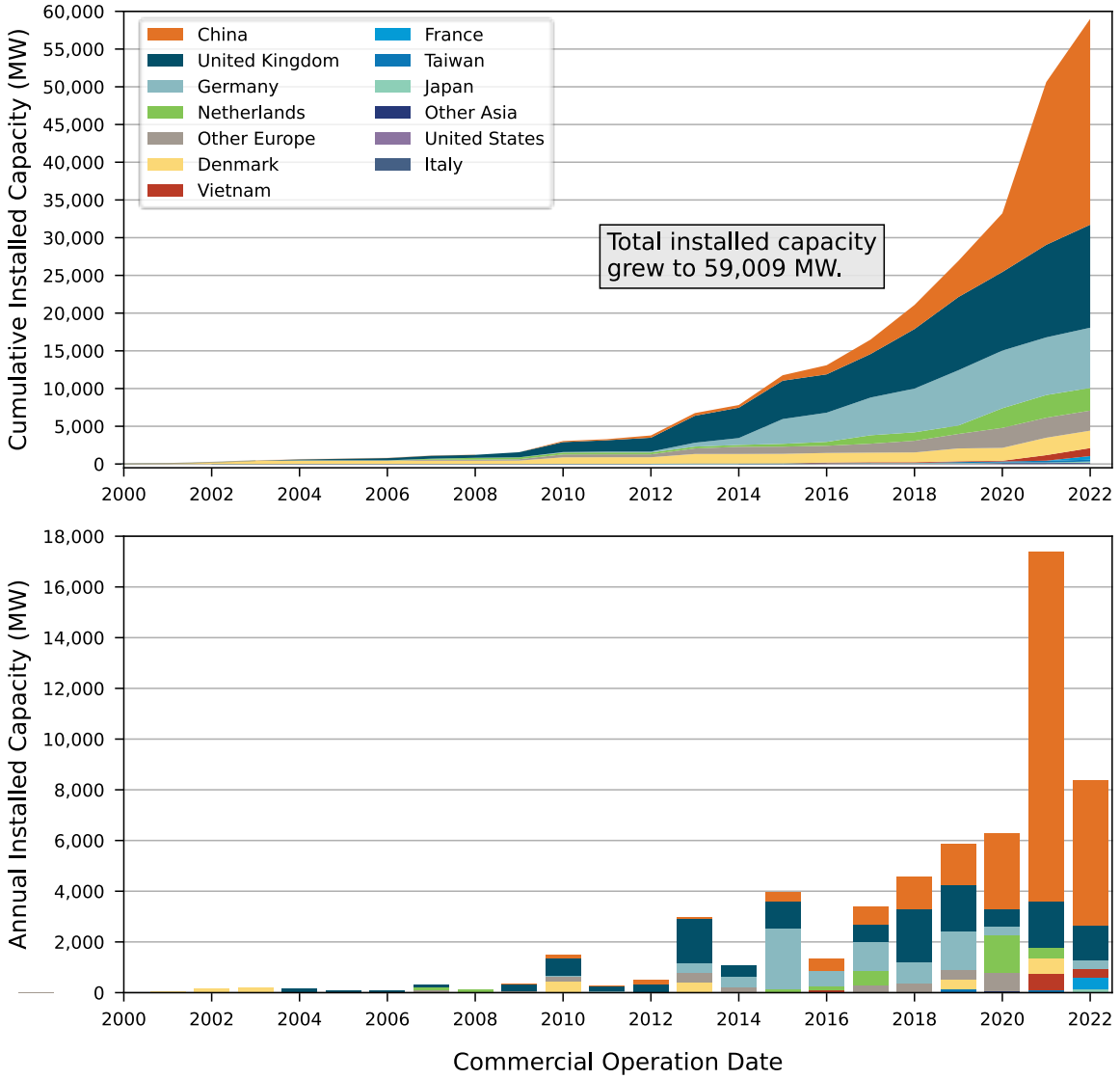
First offshore wind substation in the United States at Providence, Rhode Island, ready for installation at South Fork in June 2023. *Photo courtesy of South Fork Wind Farm*

Port	State	Type of Investment	Announced Investment ($ million)	Funding Source
New Bedford Marine Commerce Terminal	MA	Marshaling port	45	Massachusetts Clean Energy Center (MassCEC)
Salem Wind Port	MA	Marshaling port	108.8	MassCEC U.S. Department of Transportation Maritime Administration Port Infrastructure Development Program (PIDP)
New Bedford Foss Marine Terminal	MA	Operations and maintenance (O&M) port	15	MassCEC
Prysmian Marine Terminal at Brayton Point	MA	Subsea cable manufacturing	225	Prysmian MassCEC
Bridgeport	CT	O&M port	10.5	PIDP
South Brooklyn Marine Terminal	NY	Marshaling port	200	Equinor, bp
Arthur Kill Terminal	NY	Marshaling port	48	PIDP
Quonset State Airport	RI	Helicopter operations	1.8	Ørsted Eversource
Tradepoint Atlantic	MD	Monopile and tower manufacturing	Not disclosed	Not disclosed
Portsmouth Marine Terminal	VA	Marshaling port	223	Virginia Port Authority
Norfolk	VA	Operations and logistics center	100	Fairwinds LLC
Nucor	KY	Steel plate manufacturing	1,700	Not disclosed
Port of Humboldt	CA	Marshaling port	10.5	California Energy Commission
Total announced investment in 2022-2023:			2,687.6	

Global Offshore Wind Energy Data

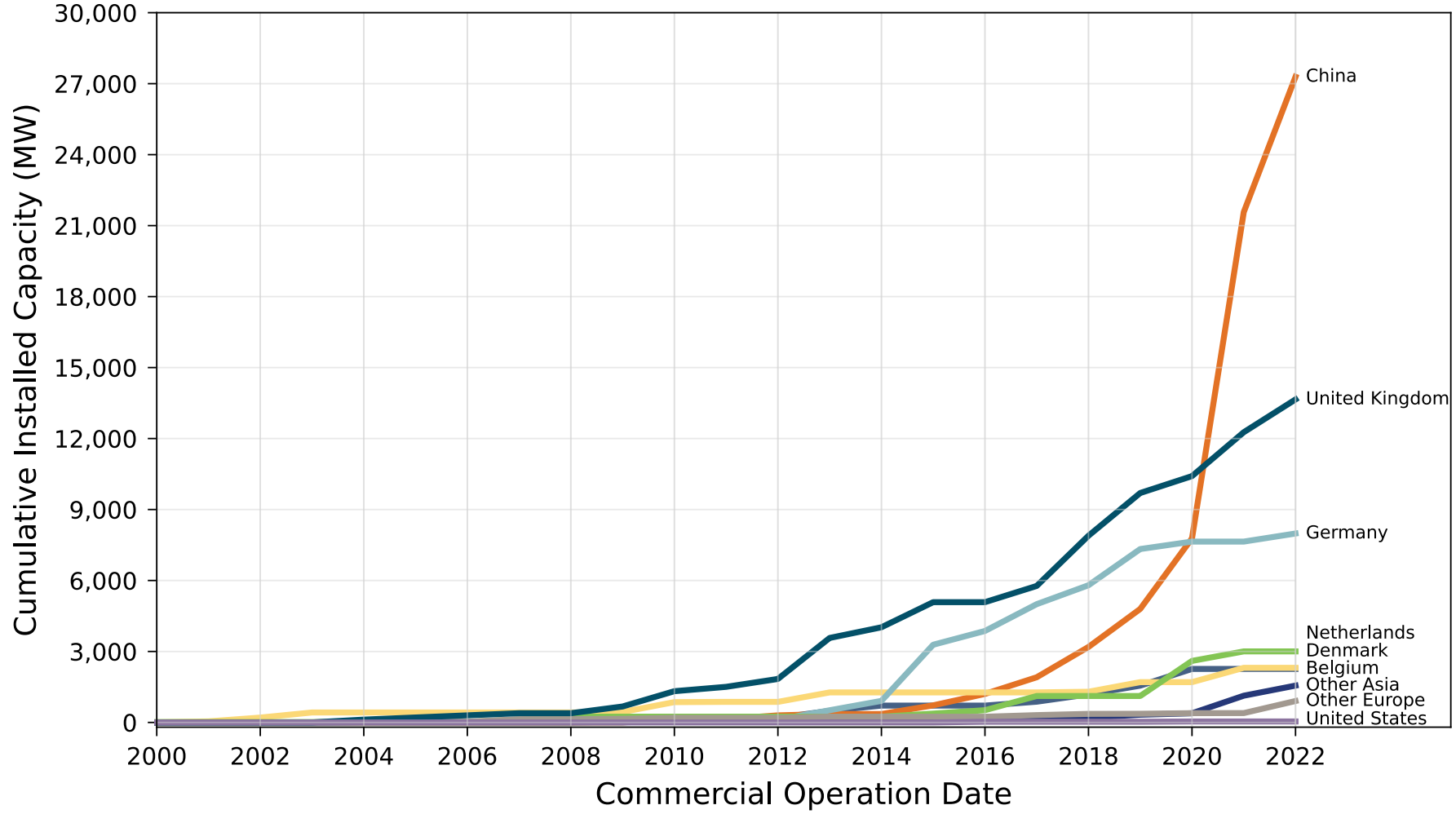
Global Cumulative Offshore Wind Energy Deployment Reaches 59 GW, With More Than 8 GW of Annual Capacity Additions in 2022

- Global cumulative offshore wind capacity reached 59,009 MW with 8,385 MW deployed in 2022.
- Up to 257 operating projects contribute to those totals.



Global cumulative offshore wind energy deployment (top) and annual capacity additions (bottom) through December 31, 2022

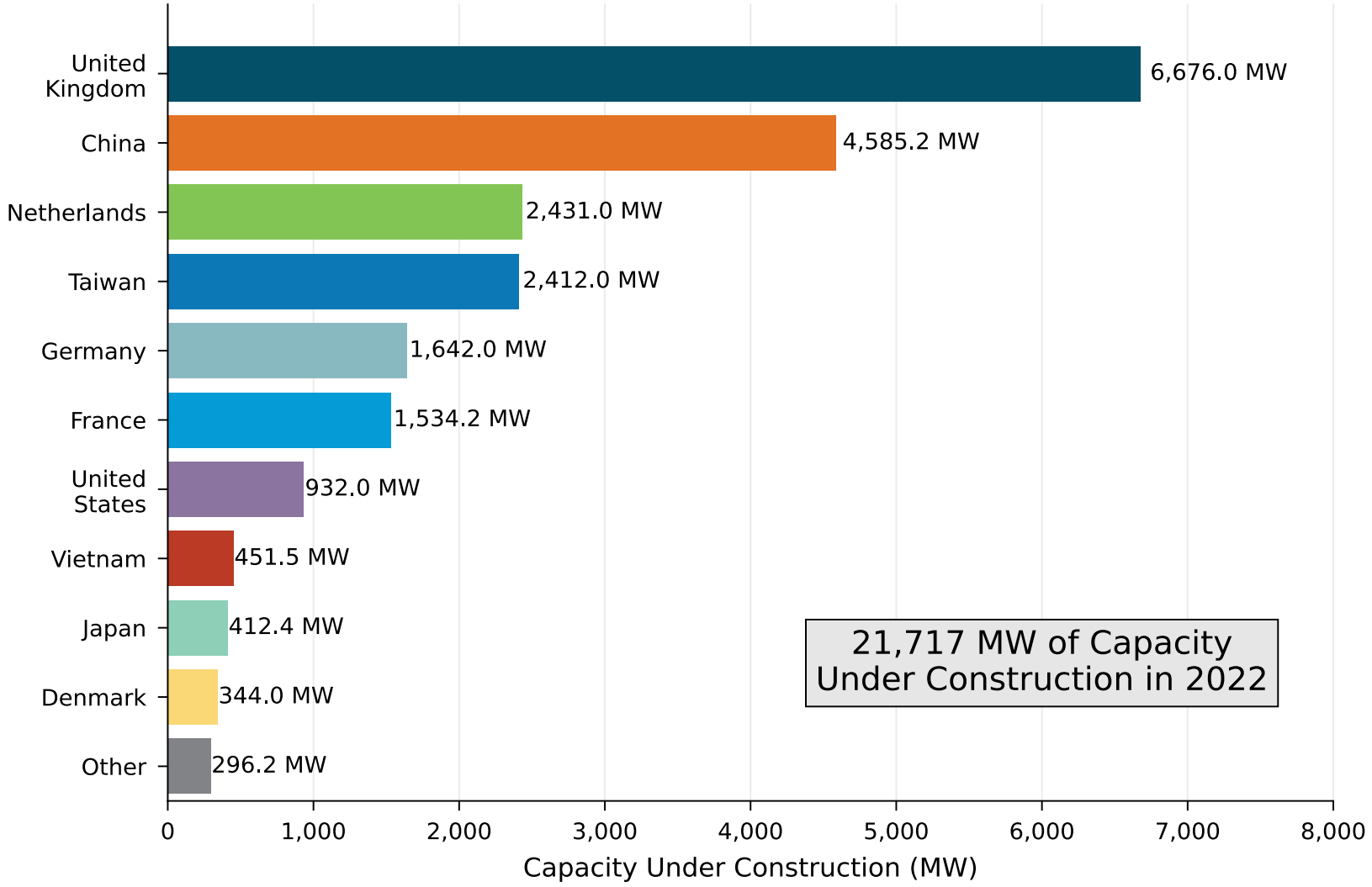
China Continues To Lead the World in Cumulative Installed Offshore Wind Capacity After Surpassing the United Kingdom in 2021



Cumulative installed offshore wind energy capacity by country

Nearly 22 GW of Offshore Wind Capacity Under Construction Worldwide as of December 31, 2022

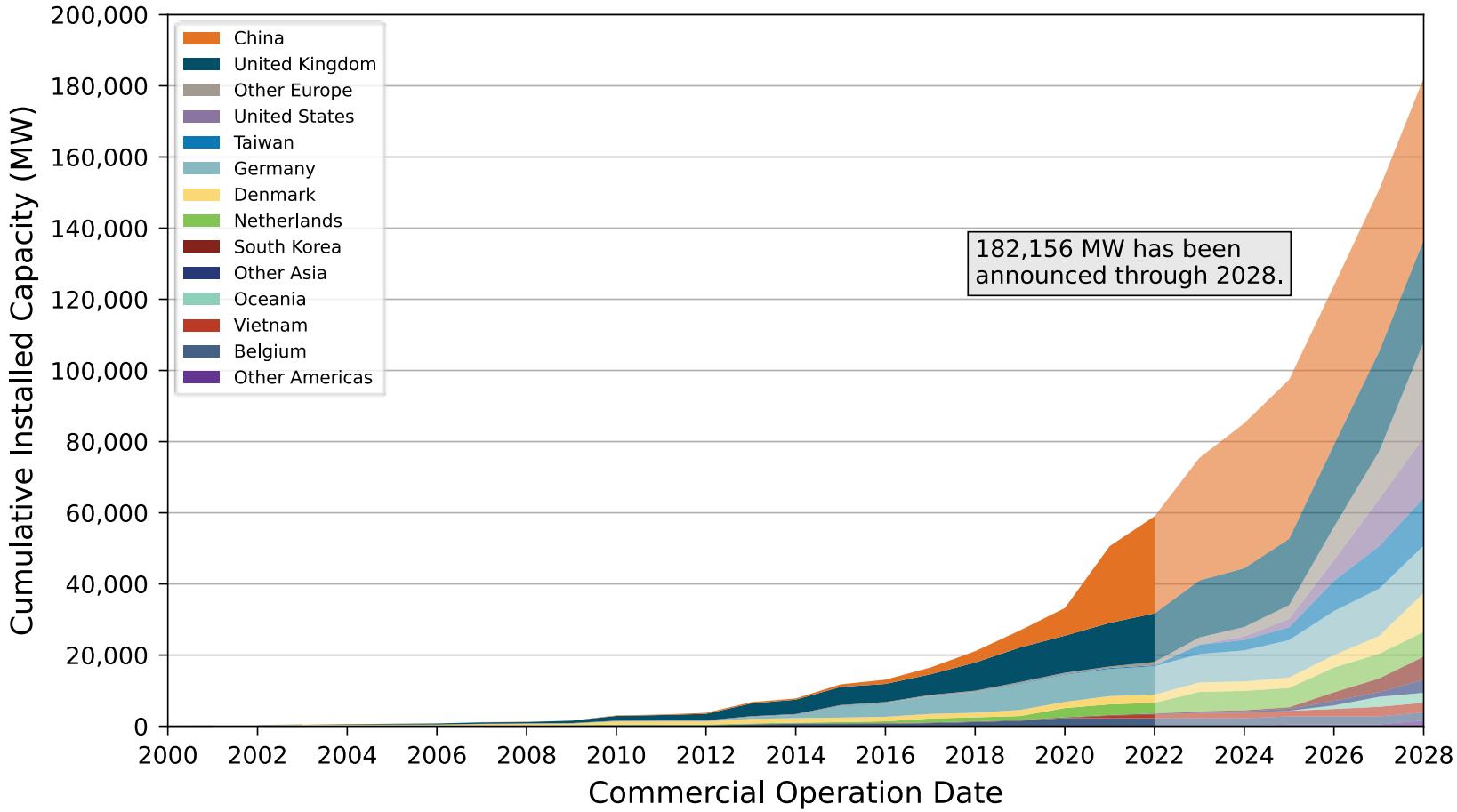
- Projects under construction are a good indicator of near-term deployment.
- The United States is expected to commission its first two commercial projects in 2024.



Offshore wind capacity under construction by country as of 2022

Developer-Announced Offshore Wind Indicates Cumulative Offshore Development Could Reach 182 GW by 2028

- While Asia and Europe are expected to have the largest offshore wind capacities by 2028, near-term growth may also come from new markets.
- Some new offshore wind energy markets are enabled by commercialization of floating offshore wind energy, especially after 2030 (see next slide).

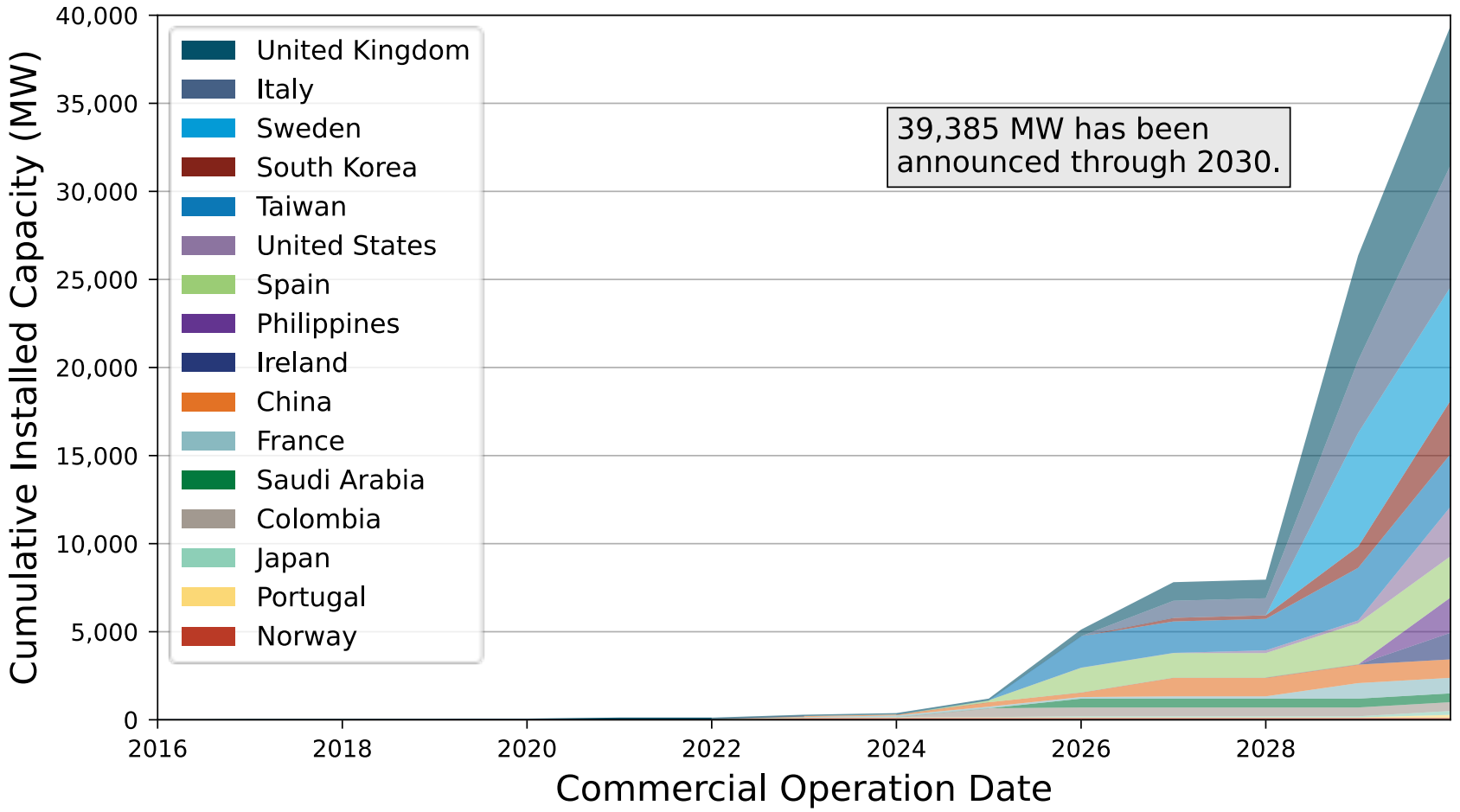


Estimated cumulative offshore wind capacity by country based on developer-announced commercial operation dates (CODs).

Note: the darker areas represent existing deployed capacity, and the lighter areas represent projected deployments.

Floating Offshore Wind Capacity Could Reach More Than 39 GW by 2030 Based on Developer-Announced Commercial Operation Dates

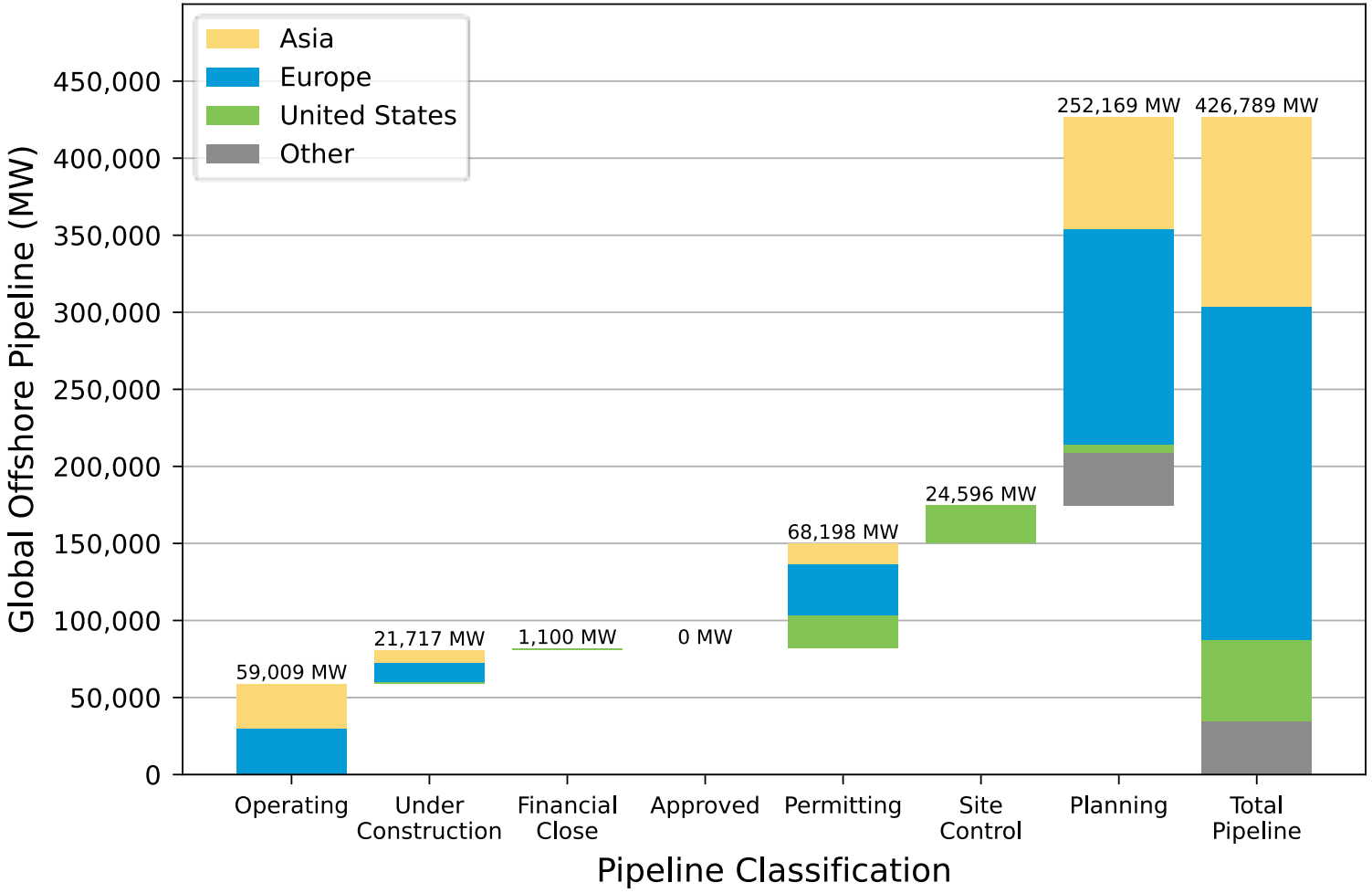
- Up to 123 MW of floating offshore wind was operational as of December 31, 2022.
- Most of the floating offshore wind pipeline is in the planning phase.



Cumulative floating offshore wind capacity by country based on announced CODs through 2030

Global Offshore Wind Energy Pipeline Expands to More Than 426 GW

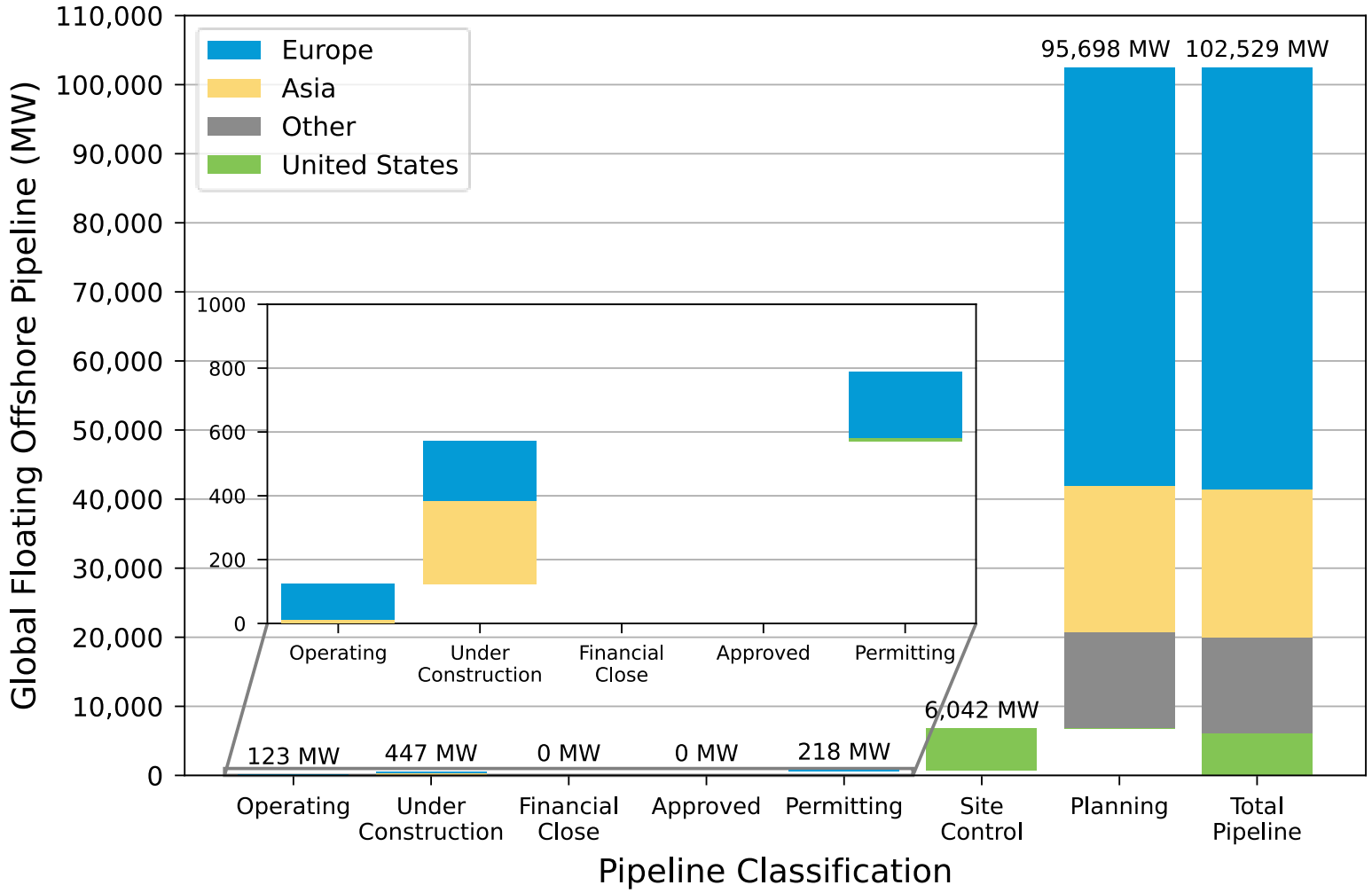
- As of December 31, 2022, the global pipeline increased to 426 GW–15.4% over the 369 GW reported at the end of 2021.
- Most of this uptick is attributed to nearly 50 GW of projects entering the planning phase worldwide.



Total global offshore wind energy pipeline by regulatory status

Global Floating Offshore Wind Energy Pipeline Increases to More Than 102 GW

- The global floating offshore wind pipeline increased by nearly 42 GW to over 102 GW, representing an increase of 69% over the pipeline reported at the end of 2021.
- Over 6,000 MW in the United States moved to the site control phase because of the December 2022 lease auction in California.



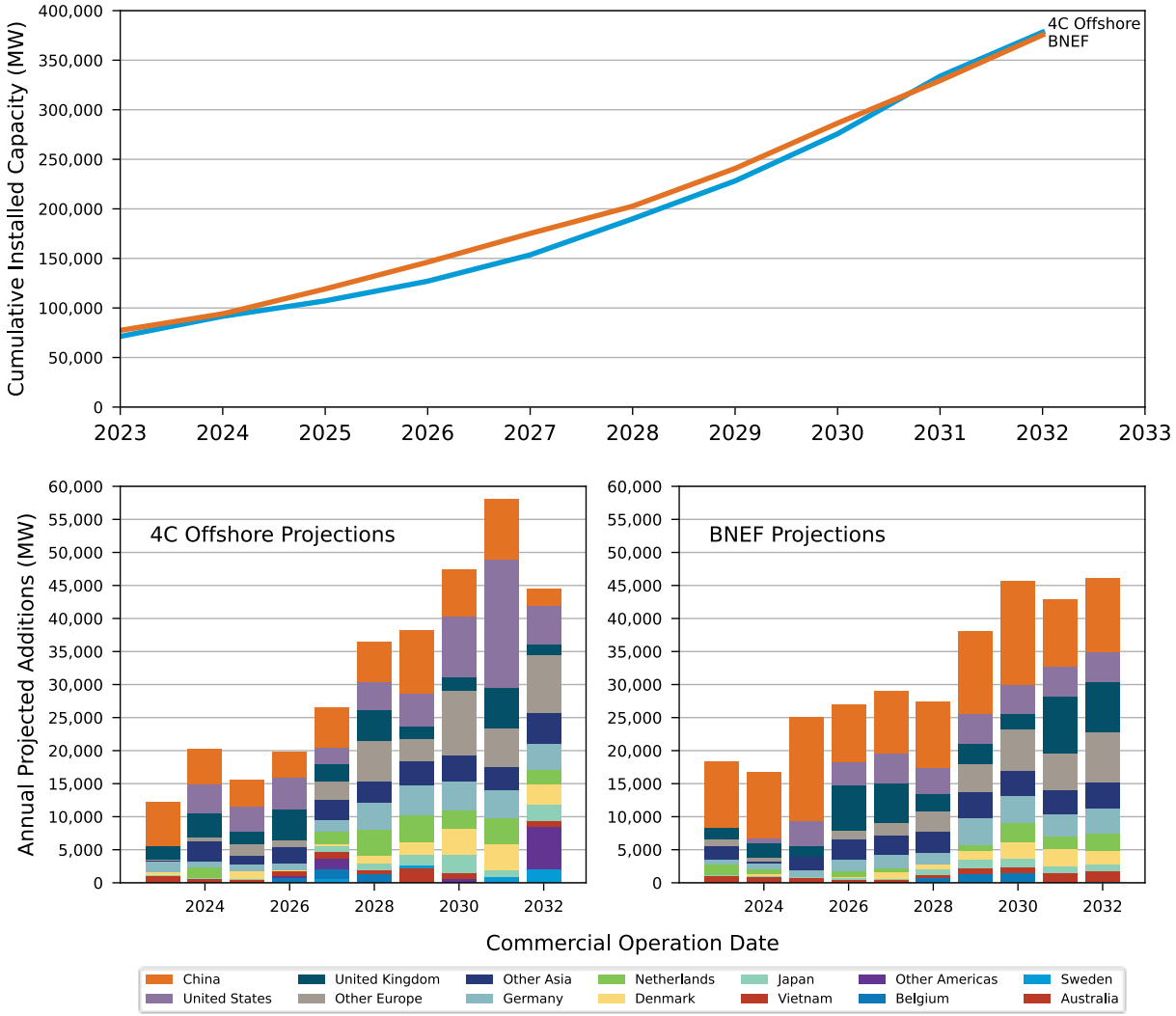
Total global floating offshore wind energy pipeline by regulatory status

Global Floating Offshore Wind Energy Pipeline Breakdown

Country	Operating (MW)	Under Construction (MW)	Permitting (MW)	Site Control (MW)	Planning (MW)	Total (MW)
Australia					11,250	11,250
China	5.5	242.8			1,800	2,048
Colombia					500	500
France	2.0	90.2			1,790	1,882
Ireland					5,510	5,510
Italy					6,915	6,915
Japan	5.0	16.8			195	216
New Zealand					2,000	2,000
Norway	5.9	95.0	1.0		6	108
Philippines					7,425	7,425
Portugal	25.0				350	375
Saudi Arabia					500	500
South Korea					3,855	3,855
Spain		2.3			2,341	2,343
Sweden					14,650	14,650
Taiwan					7,486	7,486
United States			12.0	6,042.0	154	6,268
United Kingdom	80.0		205.0		28,981	29,266
Total	**123.4**	**447.1**	**218.0**	**6,042.0**	**95,698**	**102,529**

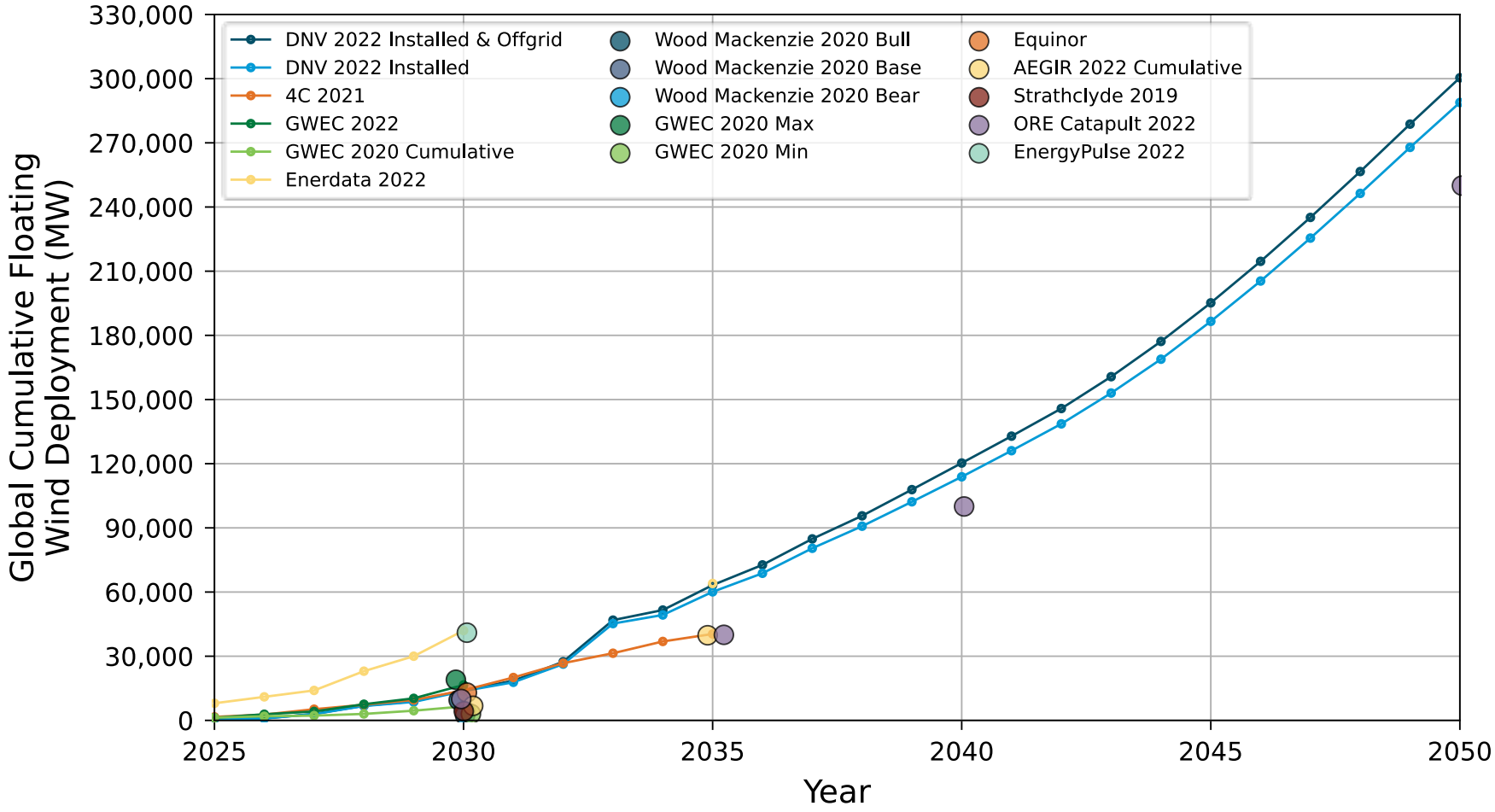
Industry Forecasts for Global Offshore Wind Energy Deployment Predict Between 380 GW and 394 GW by 2032

- BNEF and 4C Offshore forecast global offshore wind energy deployment to reach 379.5 GW and 394.4 GW by 2032, respectively.
- Differences in these forecasts indicate some uncertainty, but both suggest a fivefold increase in global market growth by 2032.



Industry forecasts for global offshore wind energy deployment to 2032

Long-Term Cumulative Floating Offshore Wind Energy Deployment Projections Suggest That Floating Offshore Wind Will Become a Significant Contributor After 2035

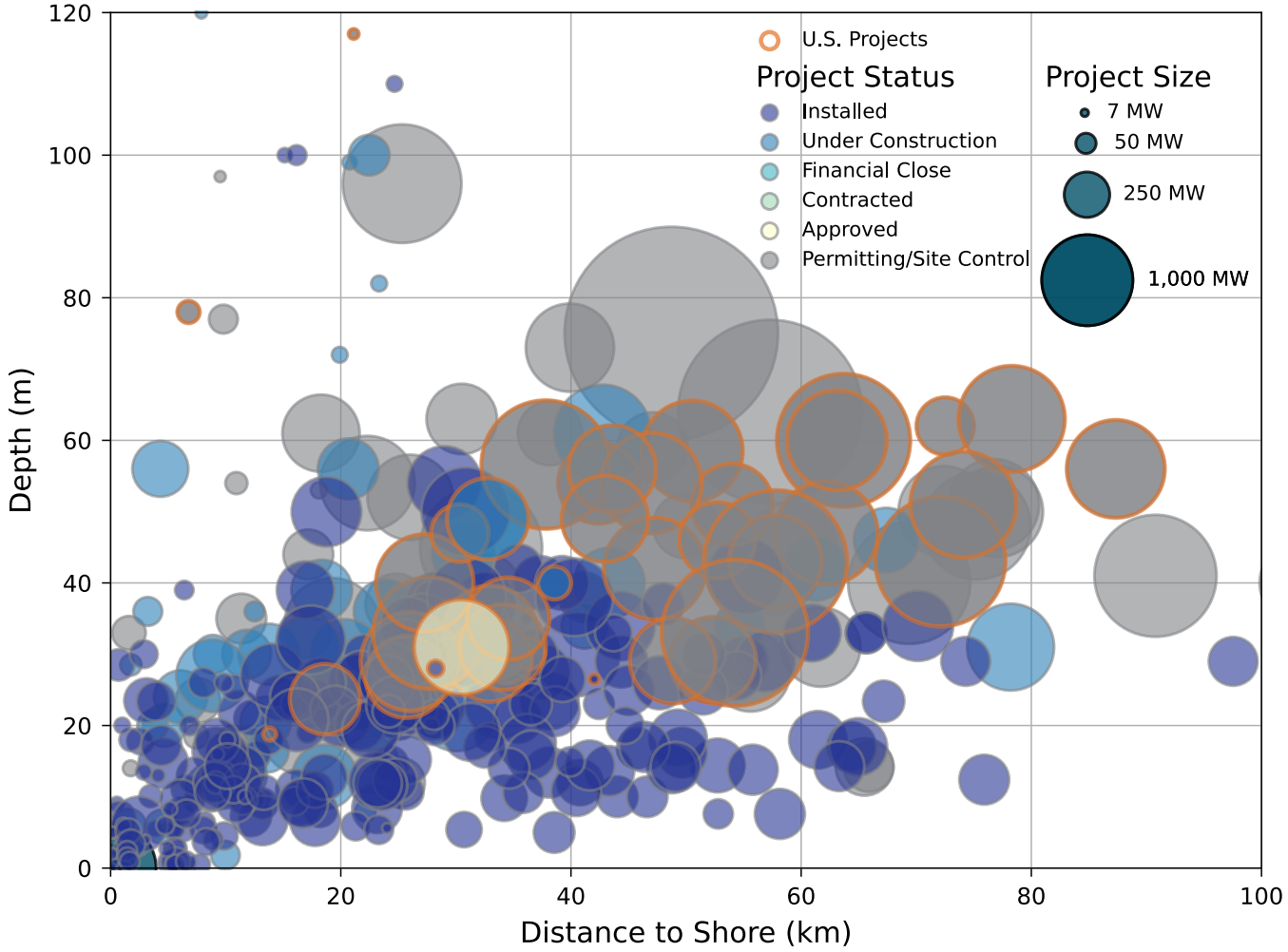


Long-term cumulative floating offshore wind energy deployment projections.

GWEC: Global Wind Energy Council

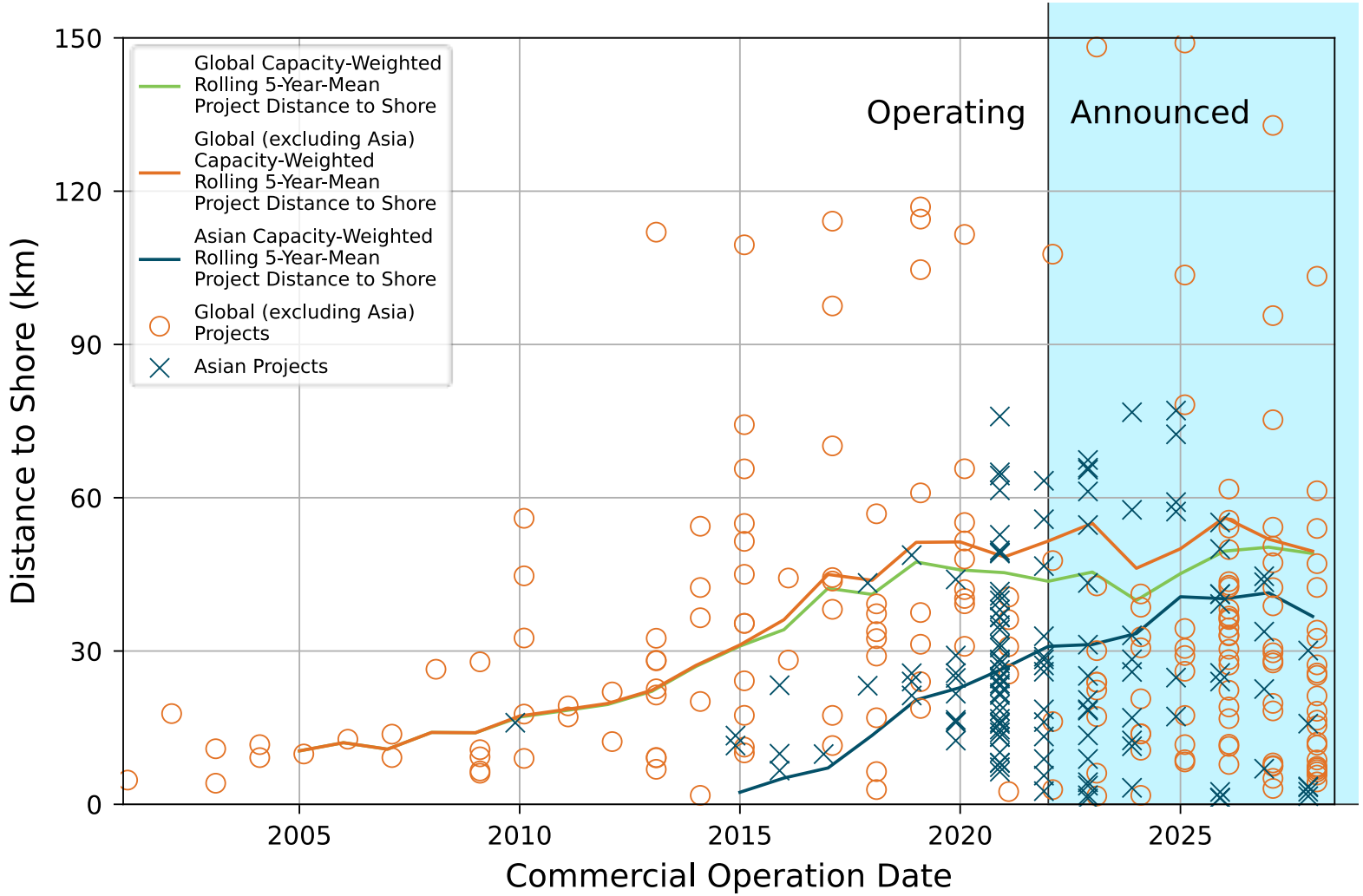
2022 Offshore Wind Energy Technology Trends

Global Offshore Wind Energy Projects Since 2000 Show Increasing Project Size Along With Increasing Water Depth and Distance to Shore



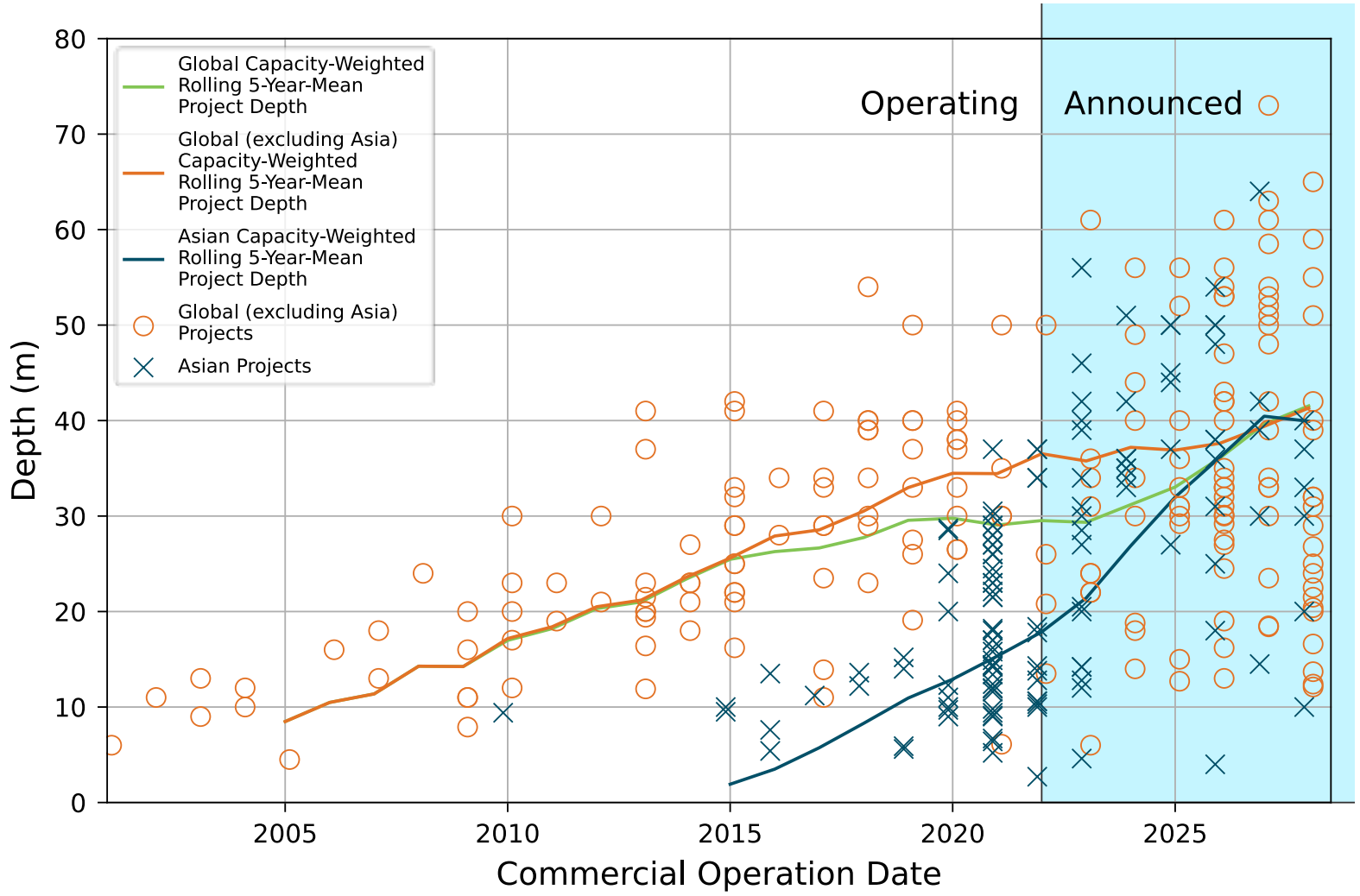
Global offshore wind energy project depths and distances to shore

Global Data Indicate That Average Distance From Shore Is Leveling Off While Asian Projects Are Getting Farther From Shore



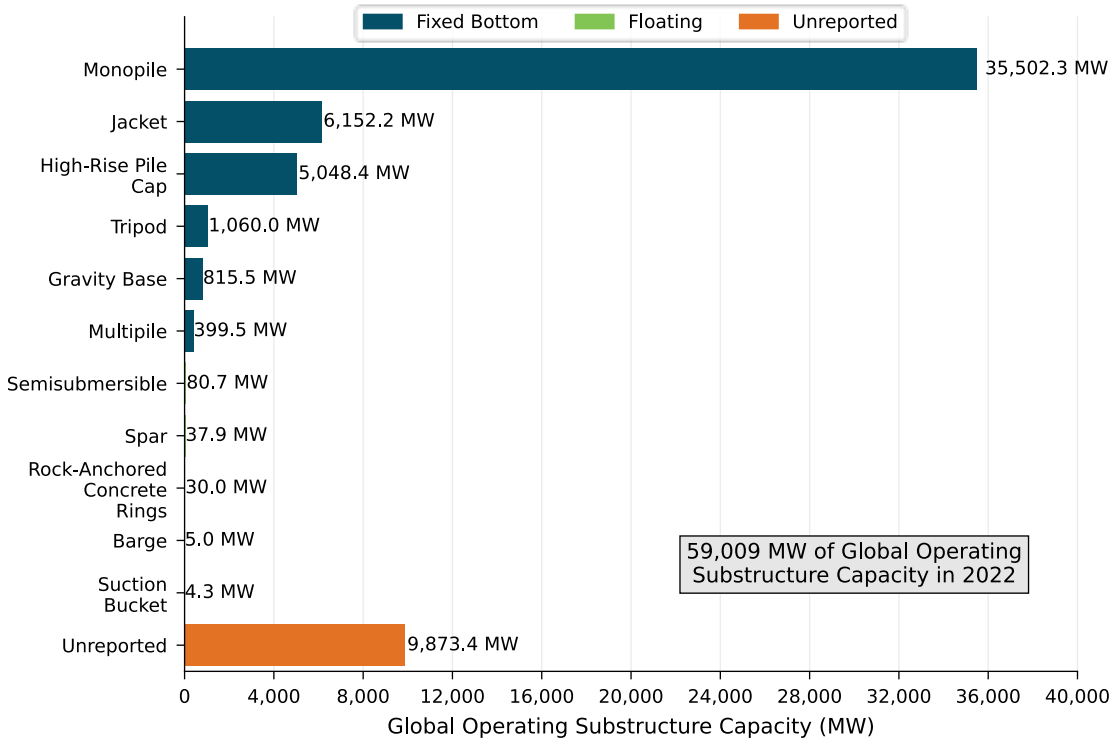
Distance to shore for global offshore wind energy projects (excludes floating)

Global Offshore Wind Energy Project Data Indicate That Average Water Depth Is Leveling Off While Asian Projects Are Still Trending Toward Deeper Water

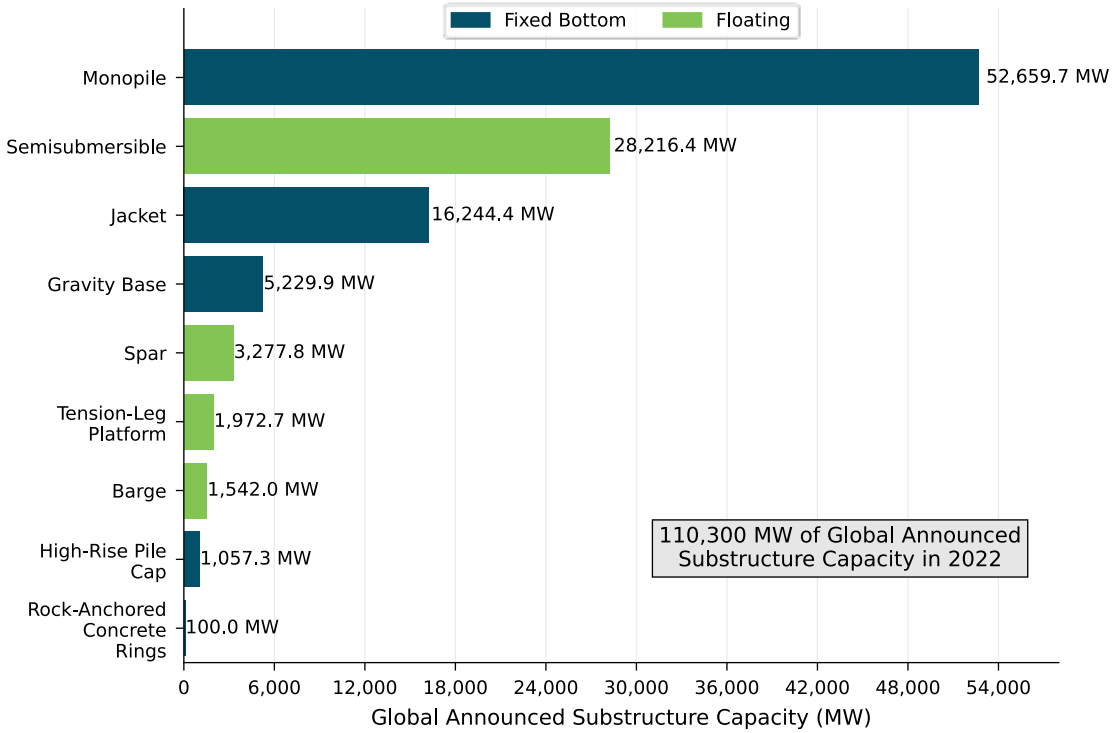


Maximum water depths for global fixed-bottom offshore wind energy projects (excludes floating)

Market Trends Show Increasing Diversity of Substructure Type, With Monopiles Maintaining Largest Market Share



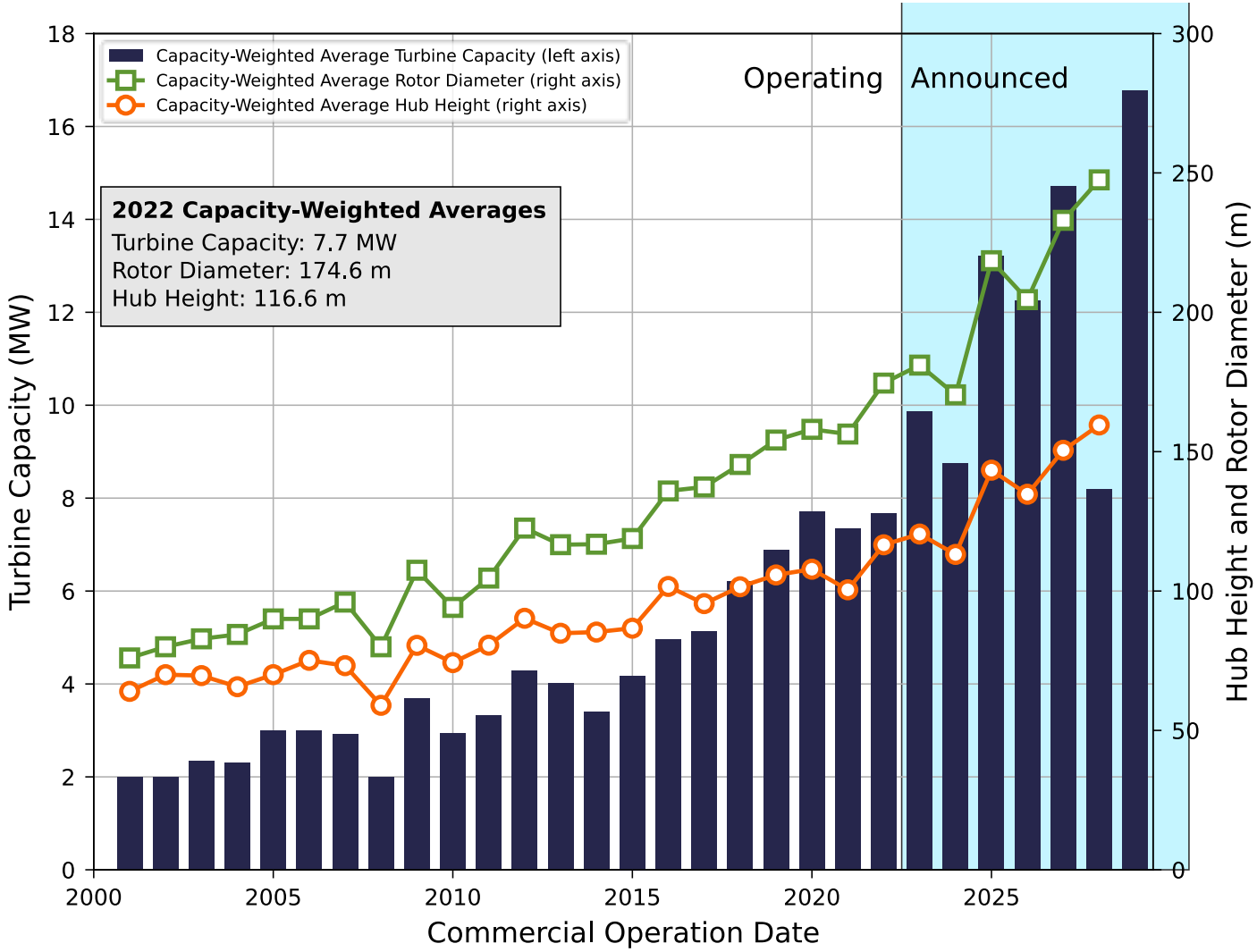
Offshore wind substructure technology types used in operating projects



Announced offshore wind substructure technology for future projects

Average Turbine Nameplate Capacity Remained At About 7.7 MW While Rotor Diameter and Hub Height Showed Increases in 2022

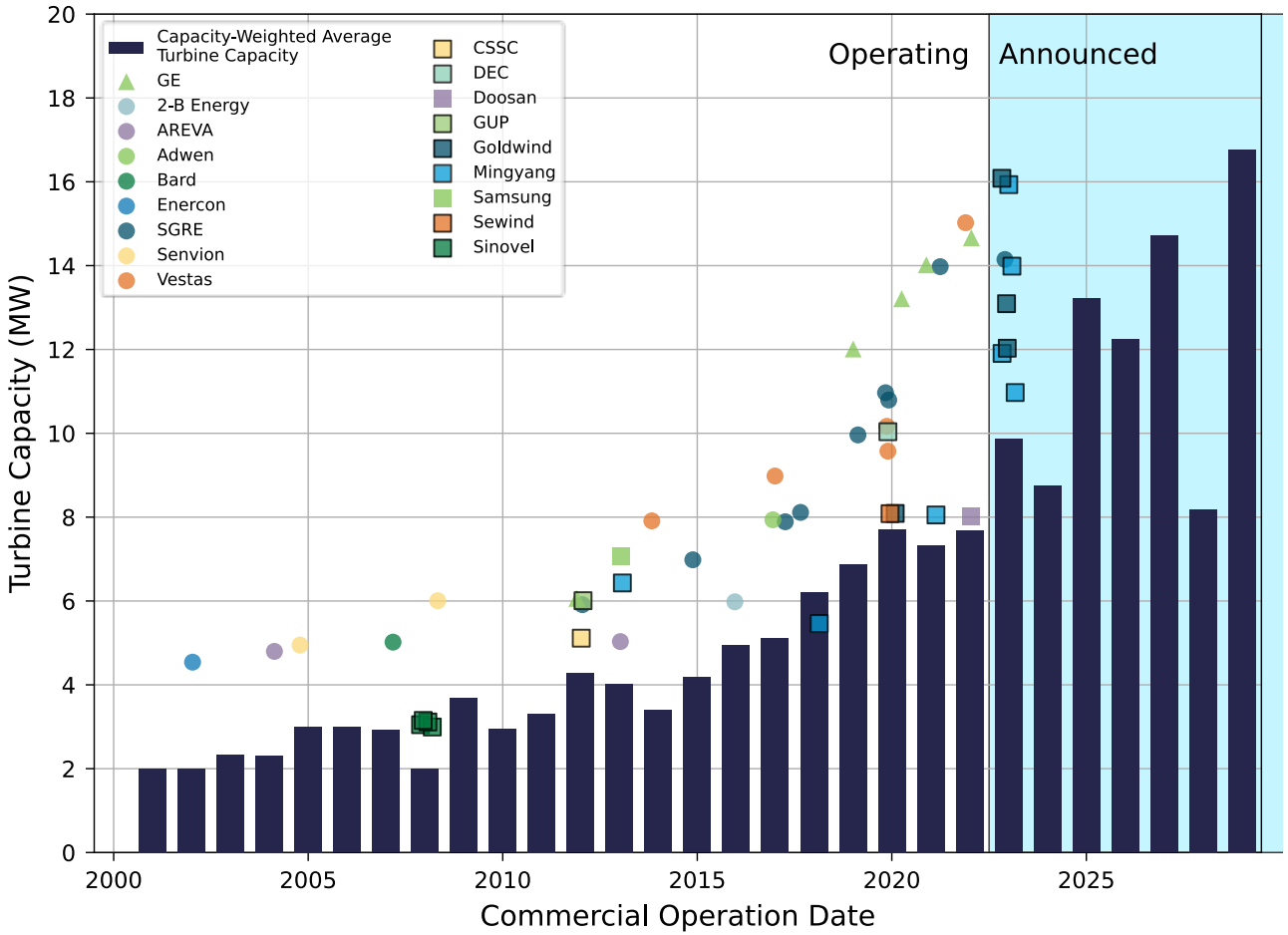
- Installed turbine capacity has leveled at about 7.7 MW but near-term projections suggest growth in the coming years.
- Steady long-term wind turbine size growth is indicated from future project announcements.



Global average offshore wind turbine capacities, hub heights, and rotor diameters

Comparison of Offshore Wind Turbine Operating Prototypes With Average Commercial Offshore Wind Turbine Rating Shows Trend Toward Larger Turbines

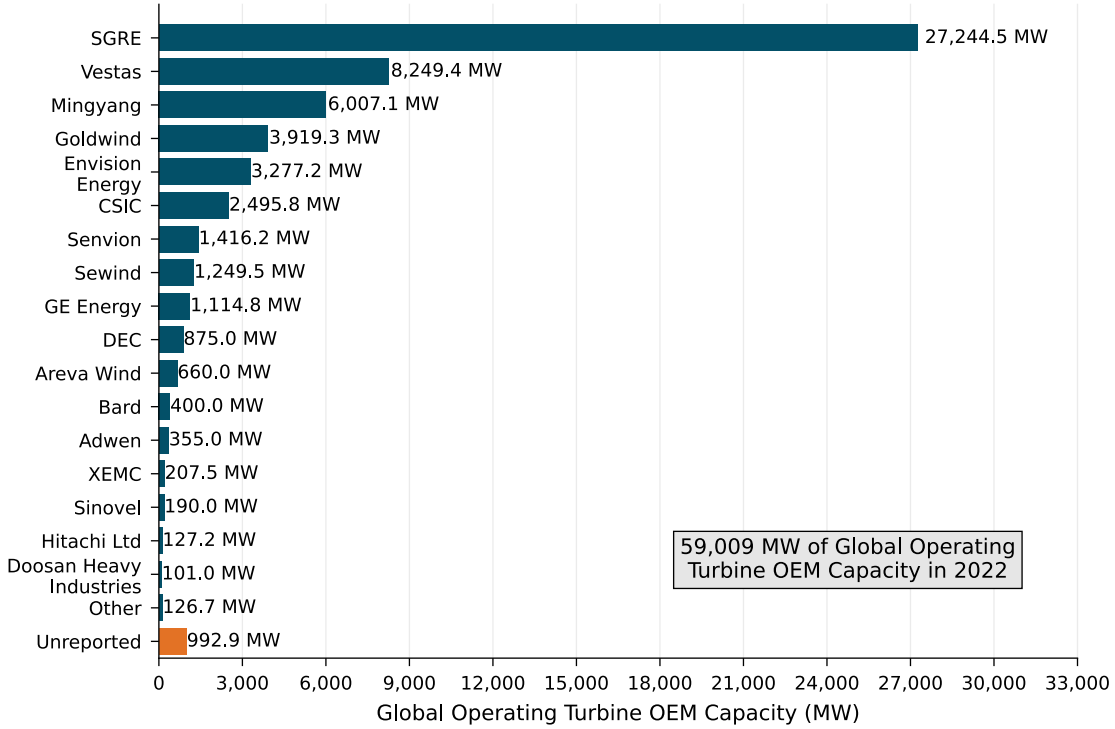
- Market maturity and supply chain adoption of new prototypes may take many years, but an upward trend toward 15-MW-scale wind turbines is likely.
- Most U.S. offshore wind projects are depending on the commercialization of these new prototypes in the 2025 to 2030 timeframe.



Comparison of offshore wind turbine prototypes with commercial offshore wind turbine growth.

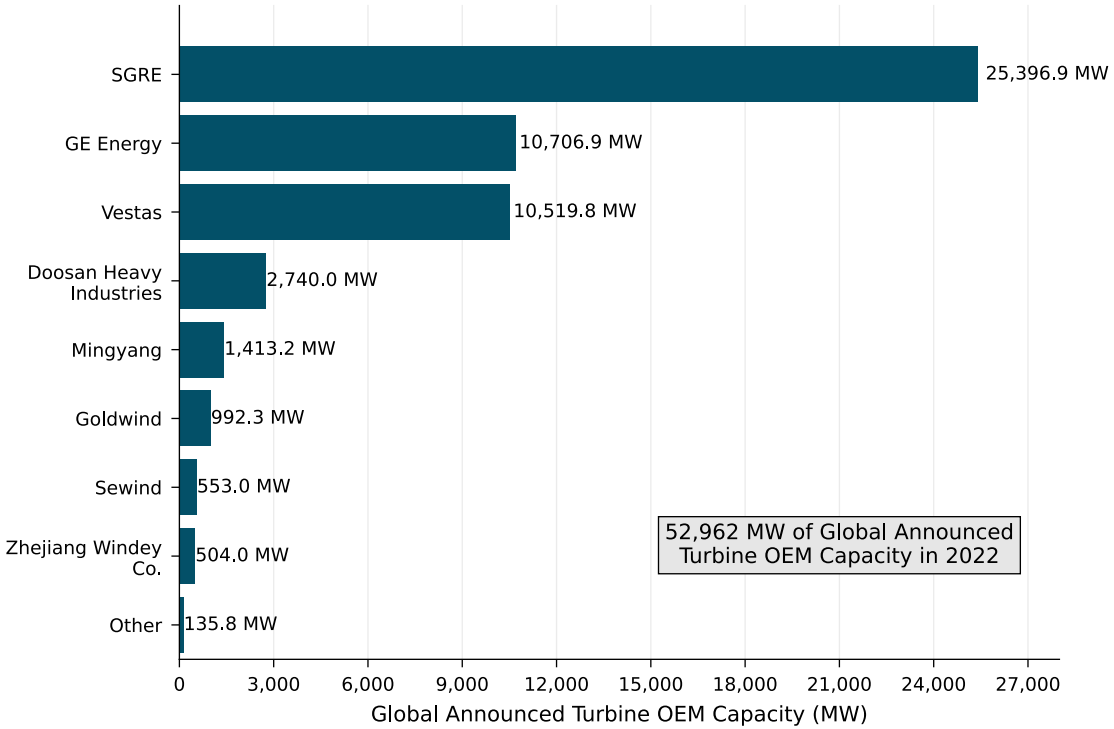
Note: GE is GE Vernova, SGRE is Siemens Gamesa Renewable Energy, CSSC is China State Shipbuilding Corporation, DEC is Dongfang Electric Corp., and GUP is Guodian United Power Technologie Co., Ltd.

Distribution of Market Share Is Trending Toward Greater Balance Among Major Turbine Manufacturers, With Siemens Gamesa (SGRE) Maintaining the Largest Market Share



Offshore wind turbine manufacturer market share for operating projects.

OEM = original equipment manufacturer

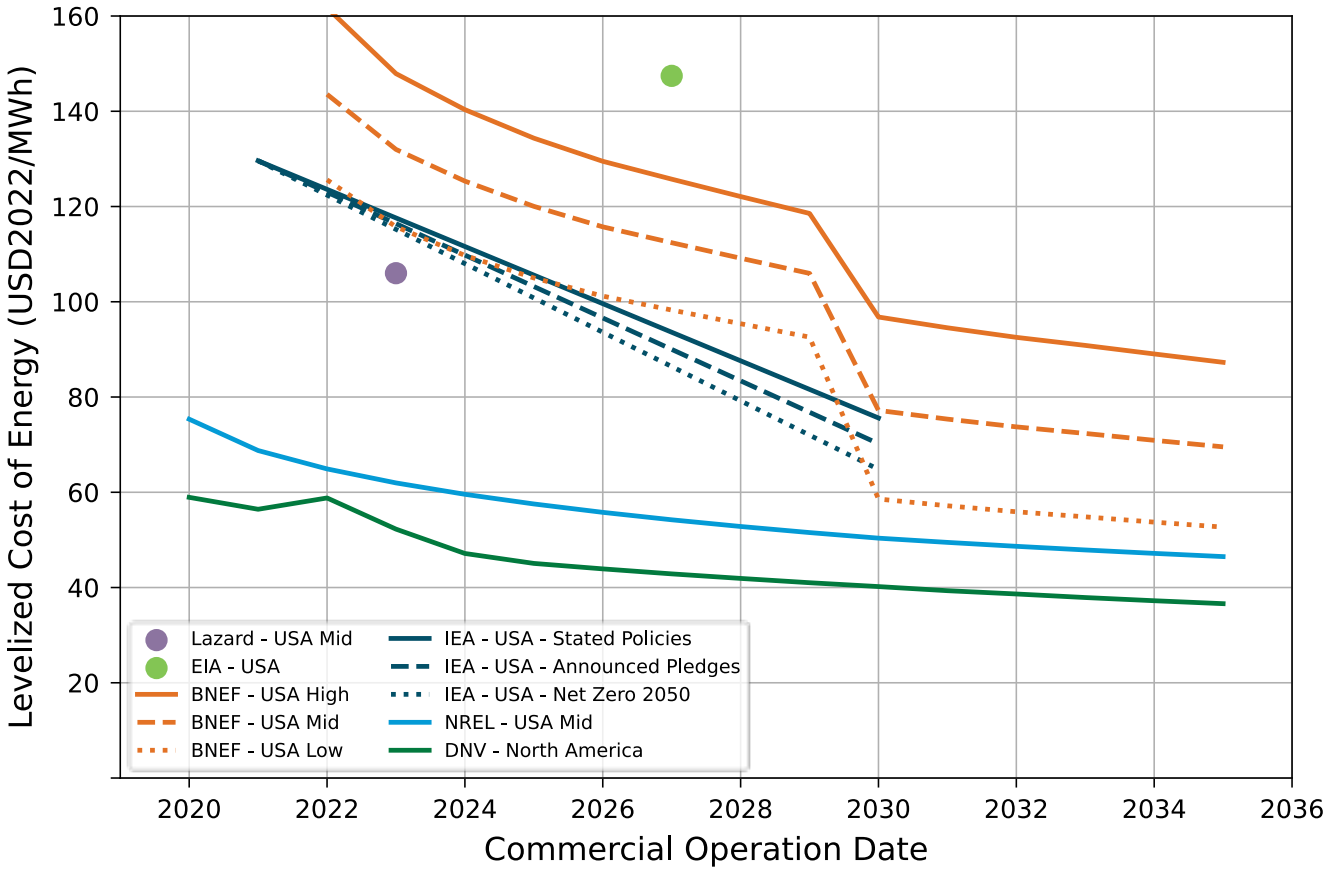


Global offshore wind turbine manufacturer market share for announced projects

2022 Offshore Wind Energy Cost Data

Cost Estimates for U.S. Fixed-Bottom Offshore Wind Projects Show Long-term Cost Declines but Supply Chain Disruptions, Inflation, and Higher Financing Rates Have Created Short-term Price Hikes

- Long-term cost declines are indicated for fixed-bottom wind through 2035.
- The estimated average levelized cost of energy (LCOE) for a hypothetical fixed-bottom project commissioned in 2022 increased 6% since 2021 from $84/megawatt-hour (MWh) to $89/MWh.
- Industry experts estimate greater cost increases for projects with COD between 2025 and 2028 due to recent inflation reported between 11% and 30% since 2021 (Westwood Global Energy Group 2023; Memija 2023).
- Historically, the total cost reduction since 2014 was about 50% (Wiser et al. 2021).

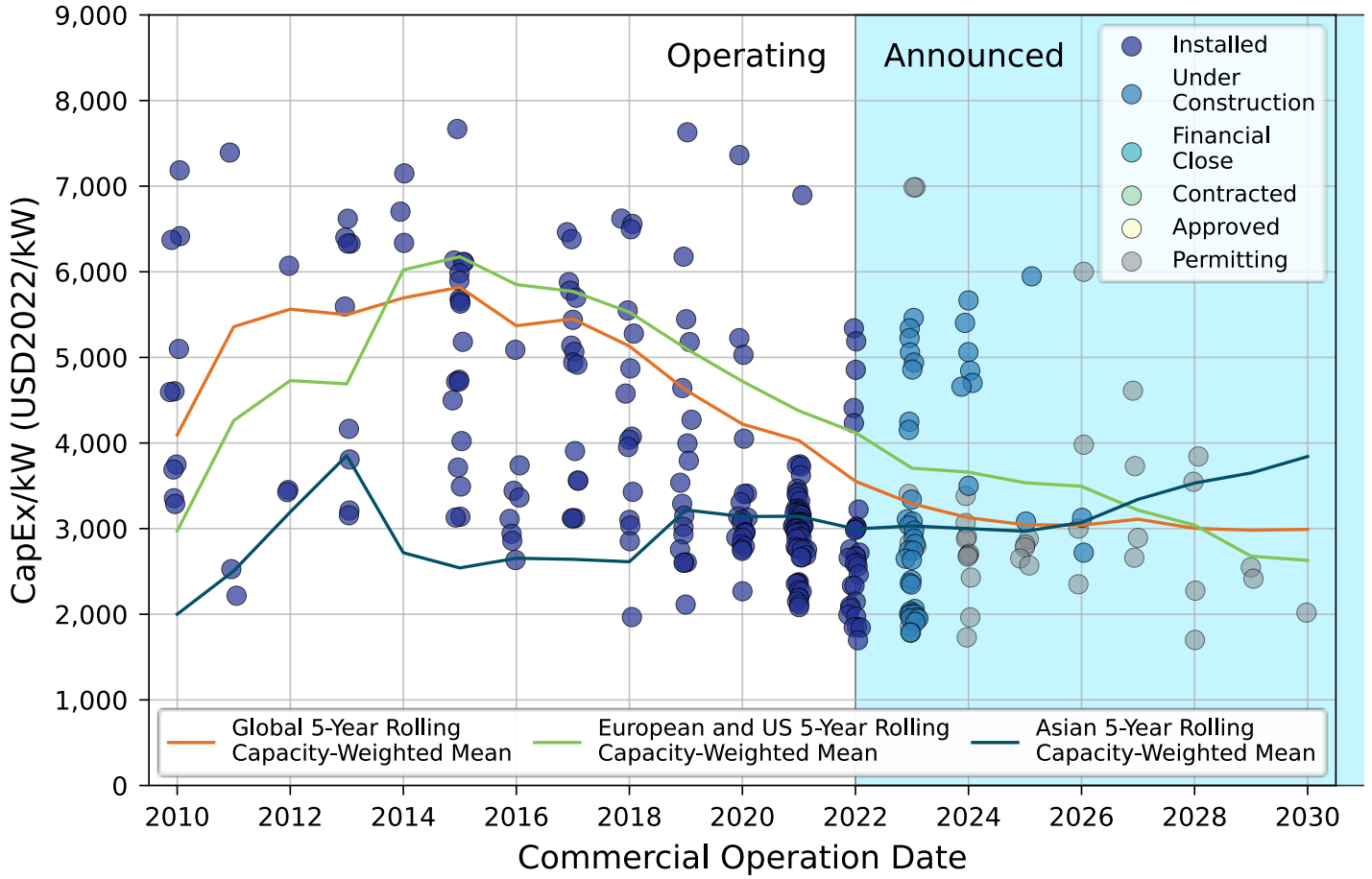


LCOE estimates for fixed-bottom offshore wind energy in the United States.

Sources: Lazard (2023); U.S. Energy Information Administration (EIA; 2022); BNEF (2022b); International Energy Agency (2022); NREL (2022); DNV (2022).

Capital Expenditures for Global Offshore Wind Energy Projects

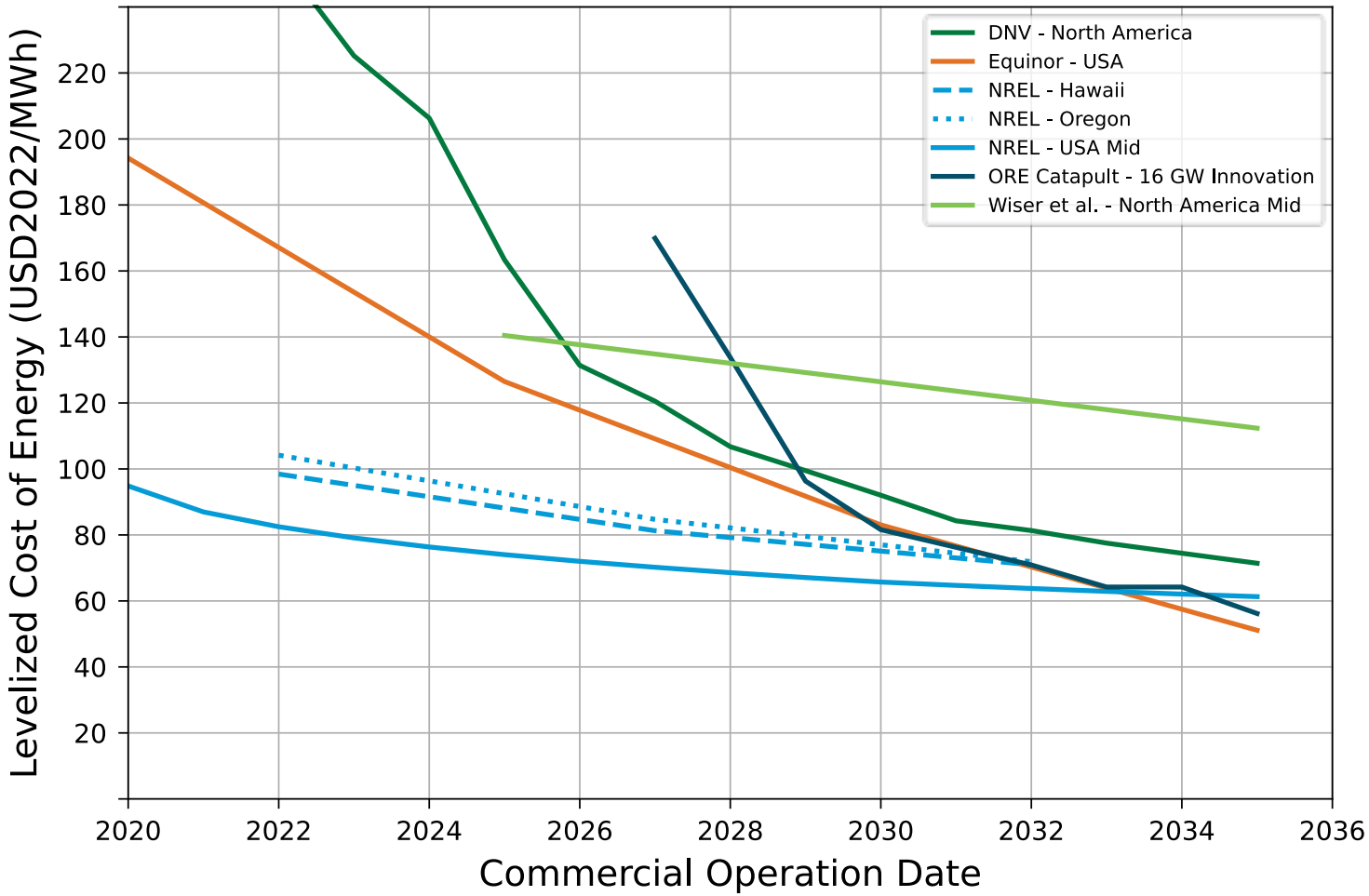
- The 5-year rolling average for offshore wind energy project capital expenditures (CapEx) has reached about $3,550/kilowatt (kW) in 2022 (COD) globally.
- The 5-year rolling average of CapEx for European and U.S. projects is reported to be just above $4,000/kW, whereas Asian projects are about $3,000/kW.
- Data indicate a decline of the 5-year rolling capacity-weighted mean CapEx globally from $3,550/kW in 2022 to about $3,000/kW by the late 2020s, but recent cost increases may not be fully reflected in these estimates.



Capital expenditures for global offshore wind energy projects

U.S. LCOE Estimates for Floating Offshore Wind Indicate Long-Term Cost Reductions

- Floating offshore wind LCOE is estimated to decline from approximately $82–$255/MWh in 2022 to $66–$128/MWh in 2030.
- Estimates assume commercial-scale floating offshore wind power plants and mature industry supply chains.



U.S. LCOE estimates for floating offshore wind technologies.

Financing Conditions for U.S. and European Offshore Wind Energy from 2006 to Present

Year	Coverage	Debt/Sponsor Equity/Tax Equity (%)	Pricing (Basis Points)	Contingency Budget (%)	Source
2006–2007	Europe	60/40/0	150–200	12–15	Guillet (2022)
2009–2013	Europe	65/35/0	300–350	10–12	Guillet (2022)
2014–2015	Europe	70/30/0	200–250	15–20	Guillet (2022)
2016–2017	Europe	75/25/0	150–225	12–15	Guillet (2022)
2018–2019	Europe	75/25/0	125–175	8–12	Guillet (2022)
	United States	50/20/30	Not applicable (N/A)	N/A	Martin (2019)
2020–2021	Europe	80/20/0	125–175	8–10	Guillet (2022)
	United States	55/45 (combined)	N/A	N/A	Martin (2021)
2022–2023	United States	55/45 (combined)	N/A	N/A	Martin (2022)

During 2021 the London Inter-Bank Offered Rate (LIBOR) and Secured Overnight Financing Rate (SOFR) interest base rates increased by more than 4%, which has significantly increased the cost of financing for offshore wind and all other energy assets.

Offshore Wind Energy Future Trends

Future Trends Summary

- Fallout from recent cost increases may hinder many U.S. offshore wind energy projects in the near term with significant relief possible from the Inflation Reduction Act.
- The first two commercial-scale offshore wind plants in the United States, Vineyard Wind 1 (800 MW) and South Fork Wind (132 MW), are scheduled to deliver power to the grid in 2023, and the 1,100-MW Ocean Wind 1 project will start construction.
- Projects struggling to remain solvent may cancel some offtake agreements, which could delay industry deployment, particularly for projects intending to commence commercial operations between 2025 and 2028.
- Future projects may benefit from added buffers such as inflation indexing and federal support from the Inflation Reduction Act to soften the adverse macroeconomic impacts.
- Long-term growth in the U.S. market may parallel anticipated global market growth. A projected sixfold increase in capacity is expected over the next decade according to BNEF (2022a) and 4C Offshore (2023) global forecasts.
- The U.S. market fraction is forecast to be about 11% to 19% of the global total by 2032.
- State-level procurement targets strengthened by federal policy are likely to remain the predominant U.S. market driver, but ambitious timelines may be challenged.
- Investments of $8.1 billion made in 2022 suggest a robust emerging offshore wind energy industry in the North and mid-Atlantic regions (Business Network for Offshore Wind 2023; American Clean Power 2023a).
- Commercial offshore wind leasing is expected to ramp up in U.S. regions such as the Pacific Coast, Gulf of Mexico, Central Atlantic, and Gulf of Maine.
- Over 112 GW of offshore wind planning goals and procurement mandates from 13 states by 2050 will continue to drive offshore wind energy development.
- Emerging energy technologies such as floating offshore wind may stimulate long-term development opportunities.

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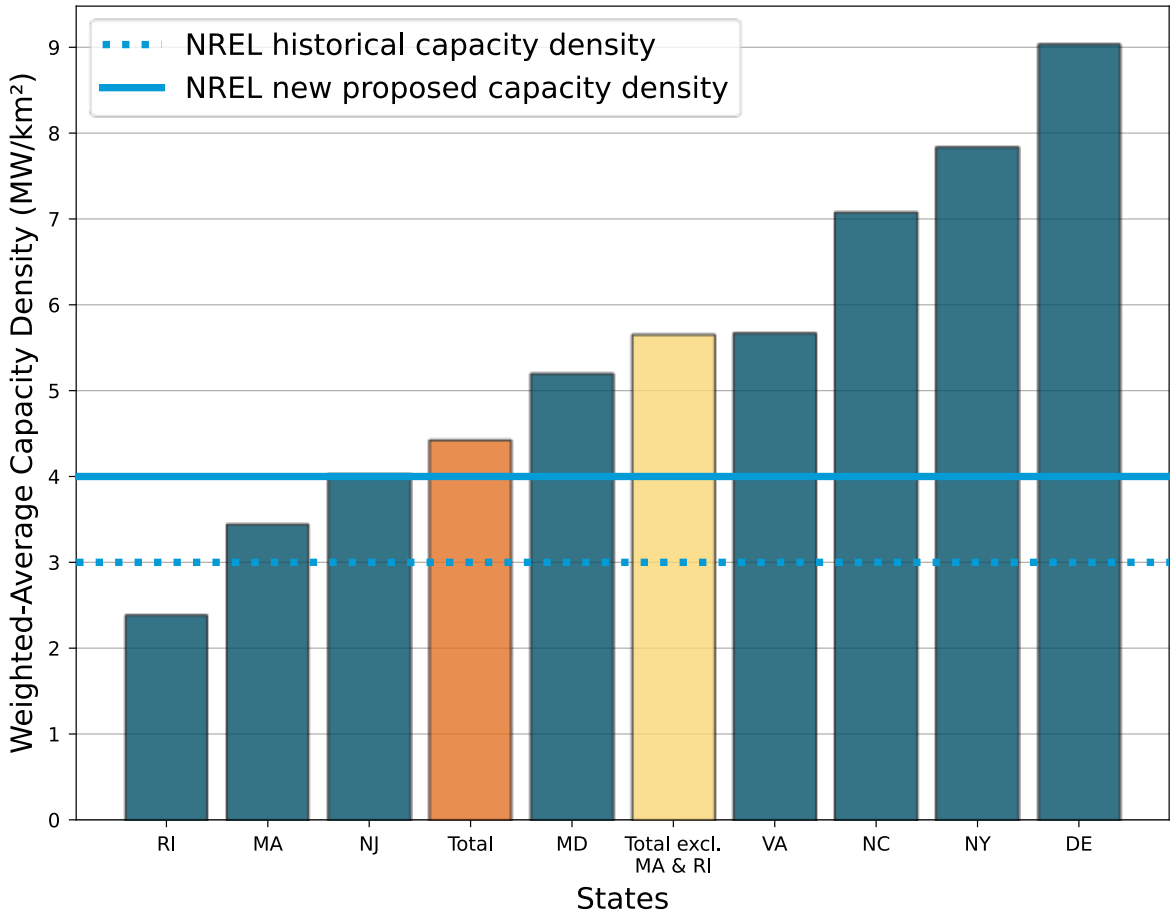
Appendix A
U.S. Offshore Wind Capacity Density Assessment

Based on Available Data From 17 U.S. Fixed-Bottom Projects, the Proposed Capacity Density of U.S. Offshore Wind Energy Projects Varies Widely From 2 MW/km^2 to 9 MW/km^2

Project Name	Lease Area Name	State	Area (acres)	Area (km^2)	Project Capacity (MW)	Capacity Density megawatts (MW)/km^2)
Revolution Wind	OCS-A 0486	Rhode Island (RI)/Massa-chusetts (MA)	82,732	335	704	2.10
South Fork Wind Farm	OCS-A 0517	RI/MA	13,700	55	132	2.38
Sunrise Wind 1	OCS-A 0487	RI/MA	86,823	351	924	2.63
Bay State Wind	OCS-A 0500	MA	187,523	759	2,000	2.64
Vineyard Wind 1	OCS-A 0501	MA	65,296	264	800	3.03
Ocean Wind 2	OCS-A 0532	New Jersey (NJ)	84,955	344	1,148	3.34
Ocean Wind 1	OCS-A 0498	NJ	75,525	306	1,100	3.60
SouthCoast Wind	OCS-A 0521	MA	127,388	516	2,004	3.89
Beacon Wind	OCS-A 0520	MA	128,811	521	2,430	4.66
New England	OCS-A 0534	MA	101,590	411	2,036	4.95
US Wind	OCS-A 0490	Maryland	79,707	323	1,678	5.20
Atlantic Shores Offshore Wind South 1	OCS-A 0499	NJ	70,272	284	1,510	5.31
Coastal Virginia Offshore Wind (Commercial)	OCS-A 0483	Virginia	112,799	456	2,587	5.67
Kitty Hawk	OCS-A 0508	North Carolina	122,405	495	3,500	7.07
Empire Wind 1	OCS-A 0512	New York (NY)	27,951	112	816	7.44
Empire Wind 2	OCS-A 0512	NY	38,363	155	1,260	8.12
Skipjack	OCS-A 0519	Delaware	26,332	107	966	9.07

Weighted-Average Capacity Densities Calculated From Project Construction and Operating Plans Show Higher Power Density Than Previously Assumed

- The weighted-average capacity density for U.S. projects in aggregate is 4.42 megawatts (MW)/square kilometers (km^2) (orange bar).
- Excluding projects that are constrained by 1 nautical mile spacing in Massachusetts and Rhode Island, the aggregate weighted-average capacity increases to 5.64 MW/km^2 (yellow bar).
- Based on these data, we increased the general capacity density assumption used to assess undeveloped ocean area where project capacities have not been announced from 3 MW/km^2 to 4 MW/km^2.



Weighted-average capacity densities by state calculated from project data.

RI = Rhode Island; MA = Massachusetts; NJ = New Jersey; MD = Maryland; VA = Virginia; NC = North Carolina; NY = New York; DE = Delaware

Thank You

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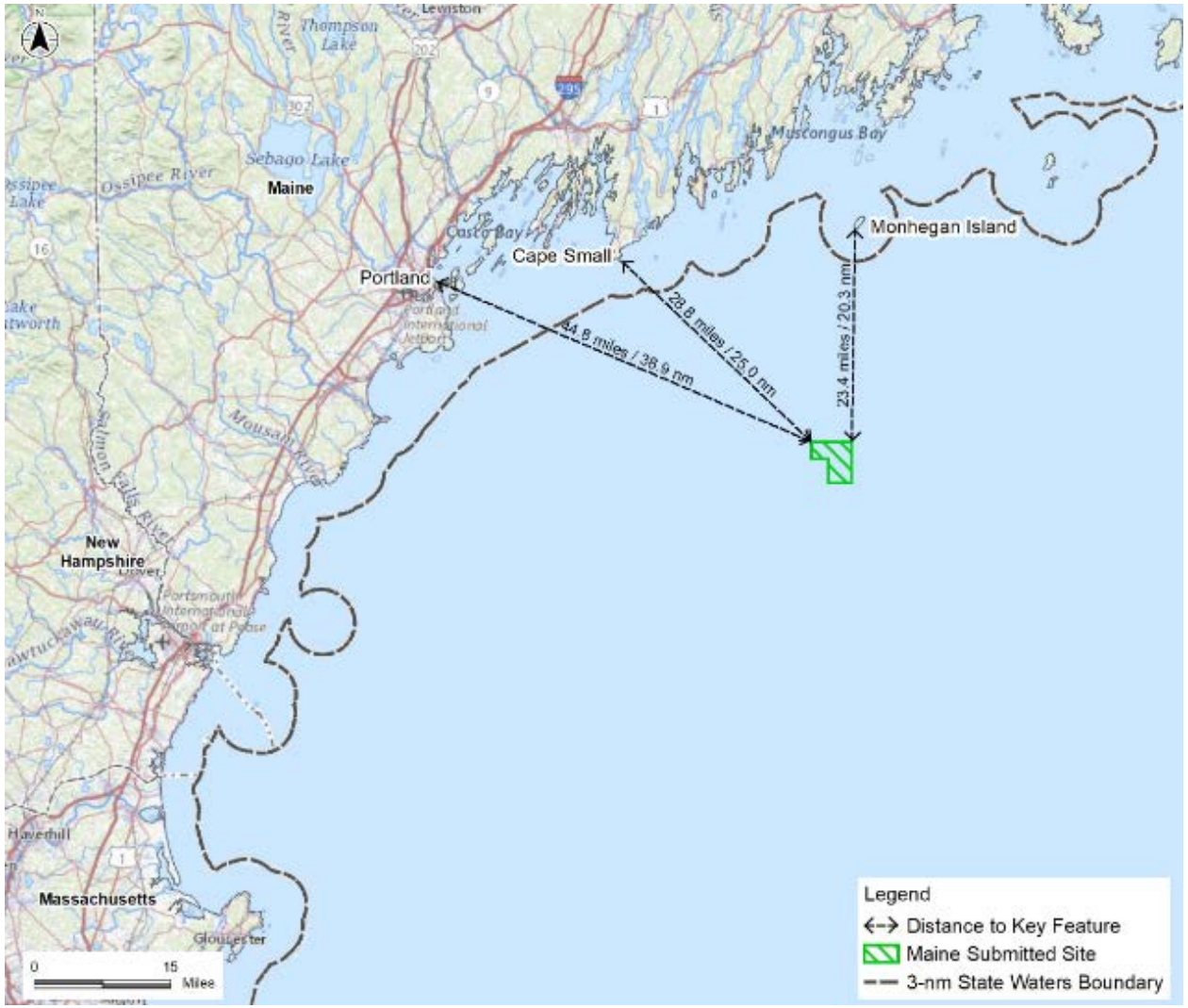
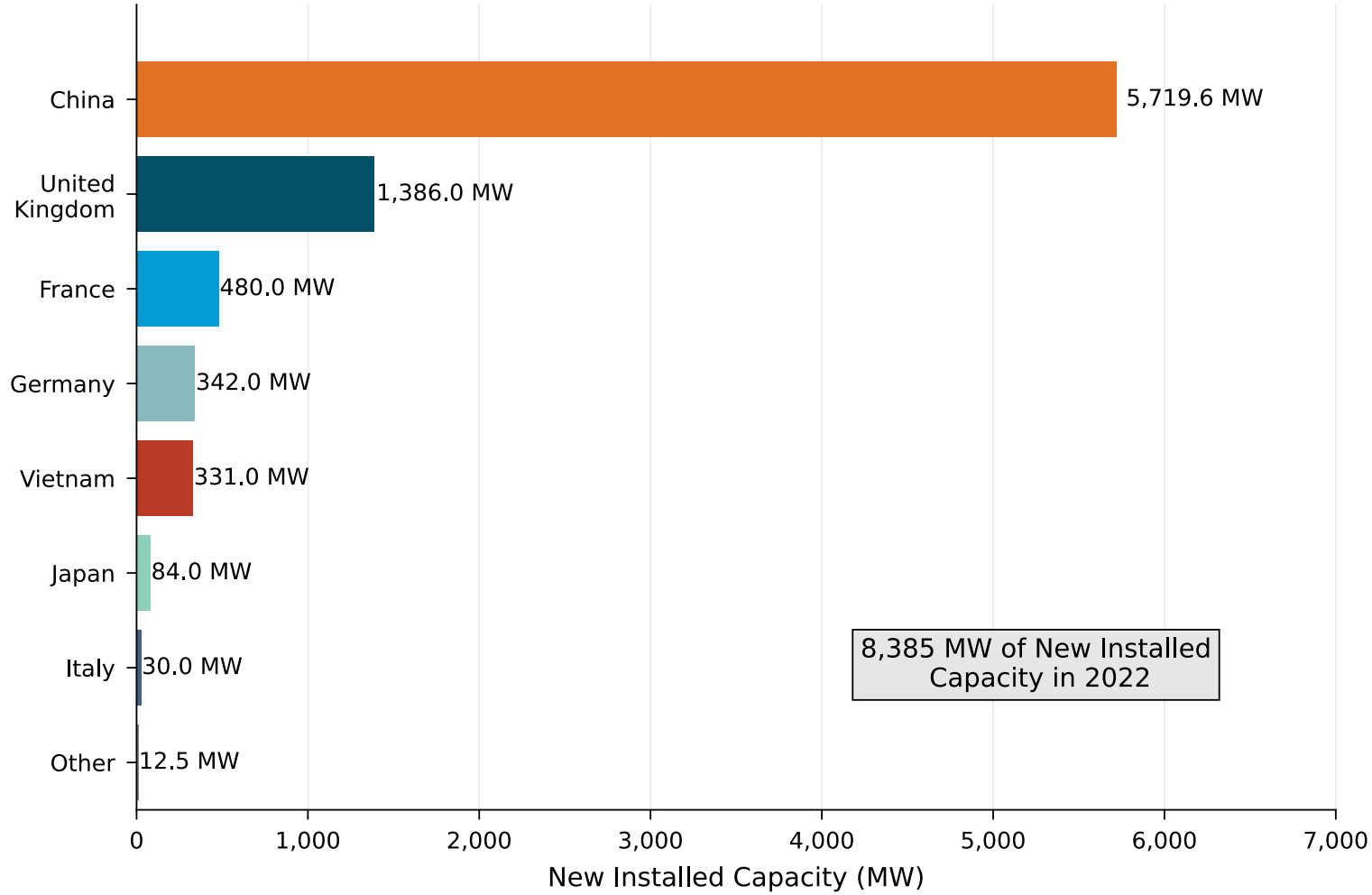
Supplemental Slides

Maine Research Array Requested Lease Area



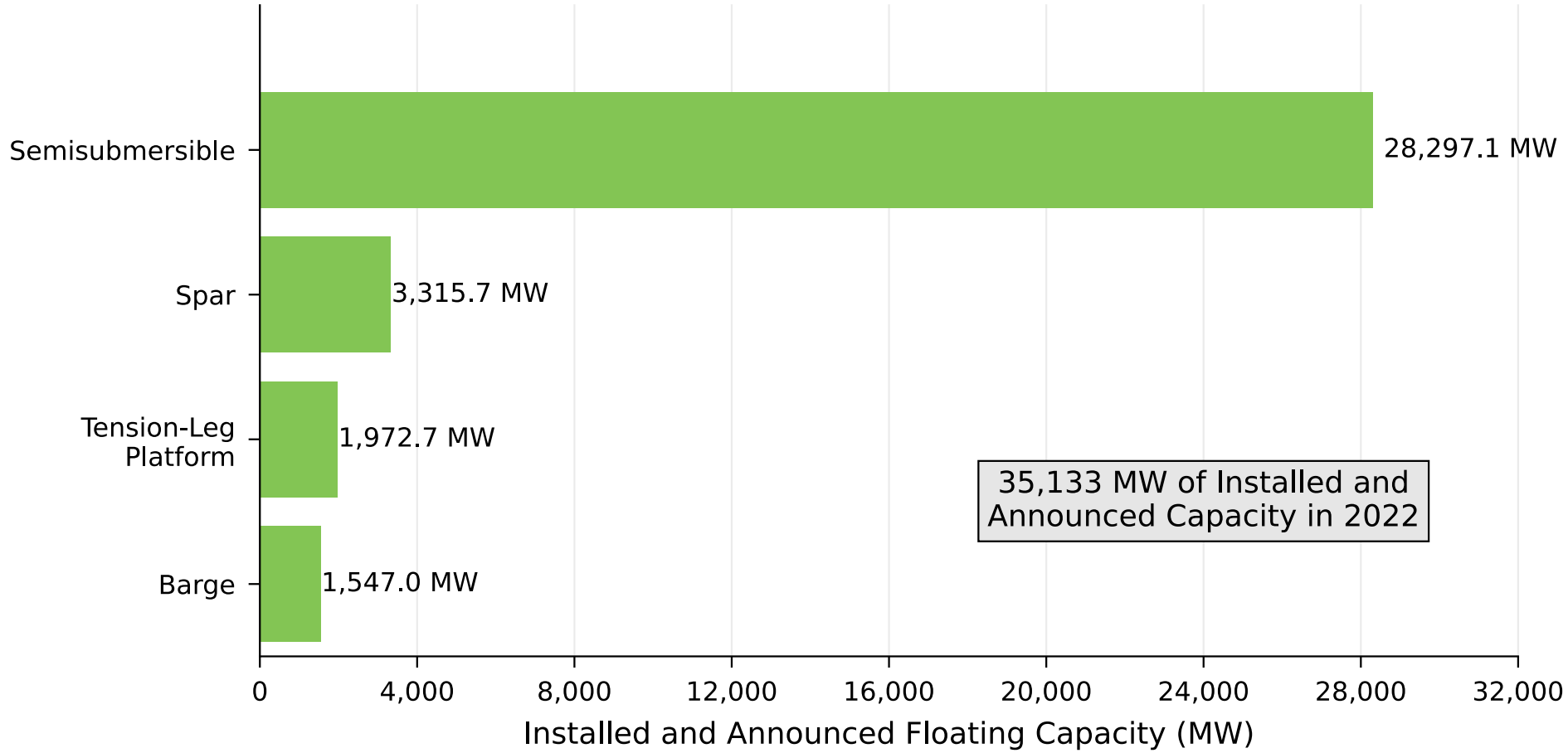
Maine Research Array requested lease area. ***Image from BOEM***

Global Offshore Wind Energy Installations in 2022



Global offshore wind energy installations in 2022

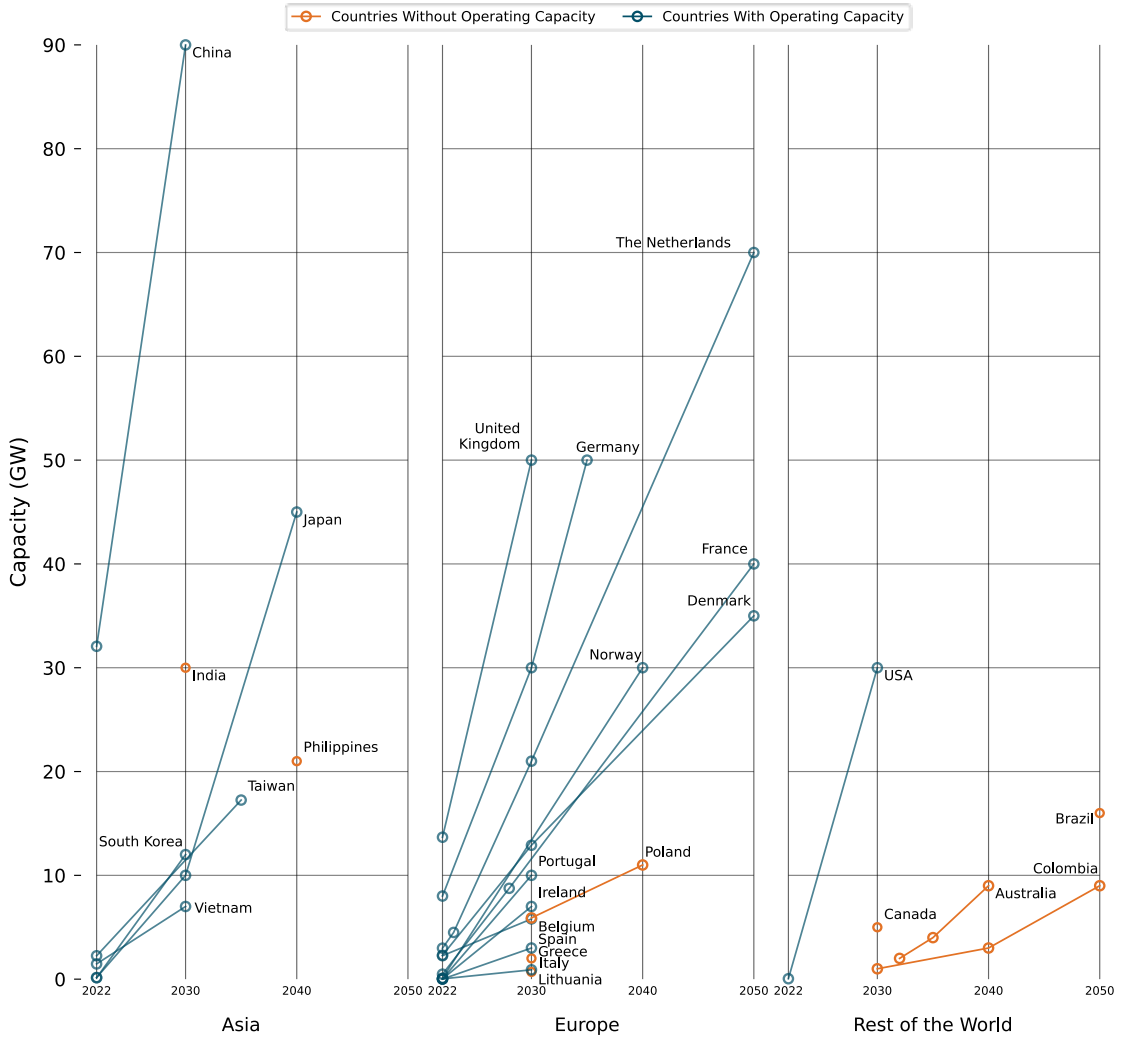
Global Floating Substructure Market Share (Operating and Announced)



Global floating substructure market share (operating and announced)

Country-Specific Offshore Wind Energy Targets Indicate Broad Offshore Wind Energy Engagement Globally

- Governments around the world have established national offshore wind energy deployment targets. This may encourage investment by creating some degree of certainty in regional project pipelines.
- Offshore wind energy targets range from those enshrined in law (e.g., Greek target) to the U.S. 30-gigawatts (GW)-by-2030 target, which is not legally binding at the federal level.
- Countries that are aiming to exceed 40 GW of deployment by 2050 include China, Japan, the United Kingdom, Germany, The Netherlands, and France.



Country-specific offshore wind energy targets

European National Offshore Wind Energy Targets

Country	Installed Capacity in 2022 (GW)	Target(s)	Key Developments or Procurements	Source(s)
Belgium	2.26	5.4–5.8 GW by 2030	The objective is to realize an additional production of 3.15–3.5 GW in the Princess Elisabeth Zone. The Minister of Energy set a future potential target of 8 GW by 2030 for Belgium.	FPS Economy (2023); Wind Europe (2022a)
Denmark	2.31	12.9 GW by 2030; 35 GW by 2050	The Danish government signed a joint declaration to make the North Sea a green powerhouse in Europe.	Fine (2022)
Finland	0.04	-	To become carbon-neutral by 2035, the national climate and energy strategy intends to have the first large-scale offshore wind energy projects operational by 2030, and several more in production by 2035.	Ministry of Economic Affairs and Employment of Finland (2022)
France	0.48	6–8.75 GW by 2028; 40 GW by 2050	The French government signs an offshore sector deal with the wind energy industry to build over 50 wind plants by 2050.	Durakovic (2020); Wind Europe (2022b)
Germany	8.01	30 GW by 2030; 50 GW by 2035	Plans set in place for 1 GW of wind-powered green hydrogen production at sea by 2030; Berlin will deploy 4 GW of wind energy capacity at sea annually from 2027 on.	Reuters (2023); Ivanova (2022)
Greece	0.00	2 GW by 2030	The parliament approves Greece's first offshore wind law.	Tisheva (2022)
Ireland	0.03	7 GW by 2030	The Irish government increased the 2030 offshore wind target from 5 to 7 GW.	renews.biz (2022)
Italy	0.09	0.9 GW by 2030	Italy's current target is 900 MW, but a target of 3.5 GW of floating wind by 2030 is being considered.	Wind Europe (2019); OWC (2022)
Lithuania	0.00	0.7 GW by 2030	The Baltic country submitted a National Energy and Climate Plan to the European Commission.	Radowitz (2019)
Norway	0.09	30 GW by 2040	Norway's prime minister announced the country's goal of 30 GW of offshore wind capacity by 2040.	Wind Europe (2022c)
Poland	0.00	5.9 GW by 2030; 11 GW by 2040	Government pledges to launch a new auction system and to set aside € 22.5 billion for offshore wind development over the coming two decades to reach these targets.	Wind Europe (2021a)
Portugal	0.03	10 GW by 2030	Portugal has increased the target for its debut offshore wind power auction to 10 GW.	Reuters (2022)
Spain	0.01	3 GW by 2030	The Spanish government has approved an offshore wind road map that aims to install up to 3 GW of floating offshore wind energy in Spanish waters by 2030.	Wind Europe (2021b)
Sweden	0.19	-	The Swedish government has launched a search for areas to support the plan to generate 120 terawatt-hours annually.	Durakovic (2022b)
The Netherlands	2.99	4.5 GW by 2023; 21 GW by 2030; 70 GW by 2050	The Climate Agreement (2019) and the coalition agreement (2021) include a commitment to maintain the offshore wind energy policy. The government has presented its offshore wind energy road map.	Government of the Netherlands (n.d.); Buljan (2022a)
United Kingdom	13.67	50 GW by 2030	The UK Energy Strategy aims to dedicate 5 GW to floating wind.	Wind Europe (2022d)

Asian National Offshore Wind Energy Targets

Country	Installed Capacity in 2022 (GW)	Target(s)	Key Developments or Procurements	Source(s)
China	32.06	90 GW by 2030	The regional cumulative targets by 2030 increased to 90 GW in China.	Wood Mackenzie (2023)
India	0.00	30 GW by 2030	The Union Ministry of New and Renewable Energy has set a target of installing 30 GW by 2030.	Infrastructure Investor (2018)
Japan	0.15	10 GW by 2030 30–45 GW by 2040	The Japanese government aims to deploy 45 GW by 2040 as part of its 2050 decarbonization target.	Power Technology (2020)
South Korea	0.13	12 GW by 2030	South Korea's president reaffirms goal of 12 GW of offshore wind energy by 2030.; The Framework Act on Low Carbon, Green Growth sets an optimistic scenario of 18–20 GW by 2030.	InfoLink Consulting (2021); Skopljak (2020)
Oman	0.00	-	16 GW of wind by 2040 (offshore wind energy not specified).	McQue (2021)
Philippines	0.00	21 GW by 2040	The Department of Energy of the Philippines published its Offshore Wind Roadmap to aim for that deployment ambition.	Pinsent Masons (2022)
Taiwan	2.25	15 GW over 10 years between 2026 and 2035	The Ministry of Economic Affairs said that 1.5 GW of offshore wind capacity would be added each year from 2026 until 2035, instead of the previously planned 1 GW.	Yihe (2021)
Vietnam	1.47	7 GW by 2030	The Ministry of Industry and Trade of Vietnam published a new Power Development Plan VIII draft with new capacity targets.	Global Wind Energy Council (2022)

Rest-of-the-World National Offshore Wind Energy Targets

Country	Installed Capacity in 2022 (GW)	Target(s)	Key Developments or Procurements	Source(s)
United States	0.04	30 GW by 2030	The current midterm national target is 30 GW by 2030. Achieving this target would unlock a pathway to 110 GW by 2050.	-
Canada	0.00	5 GW by 2030	Nova Scotia has set a target to offer leases for 5 GW of offshore wind energy by 2030.	Nova Scotia (2022)
Australia	0.00	2 GW by 2032; 4 GW by 2035; 9 GW by 2040	The Victorian Offshore Wind Policy Directions Paper sets nation-leading policy targets.	The Victorian Government (2022)
Brazil	0.00	16 GW by 2050	Brazil's government long-term energy expansion plan sees the potential to deploy 16 GW by 2050.	RECHARGE (2020)
Colombia	0.00	0.2–1 GW by 2030; 0.5–3 GW by 2040; 1.5–9 GW by 2050	The Colombian Ministry for Mines and Energy launched the Roadmap for the Deployment of Offshore Wind Energy in Colombia. The road map shows the offshore wind potential from a low-case to a high-case scenario.	Argus (2022)