

U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Offshore Wind Market Report: 2022 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 Dec. 31, 2021, and recent U.S. developments and events through May 31, 2022.
- 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 project announcements.

NREL has verified and sourced data from the following publications:

- The 4C Offshore Wind Database (4C Offshore 2021a)
 - Bloomberg New Energy Finance (BNEF) Renewable Energy Project Database (BNEF 2021a)
 - 4C Offshore Vessel Database (4C Offshore 2021a)
 - Wood Mackenzie Wind Turbine Trends (Wood Mackenzie 2021).
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- All dollar amounts are reported in 2021 U.S. dollars, unless indicated otherwise.

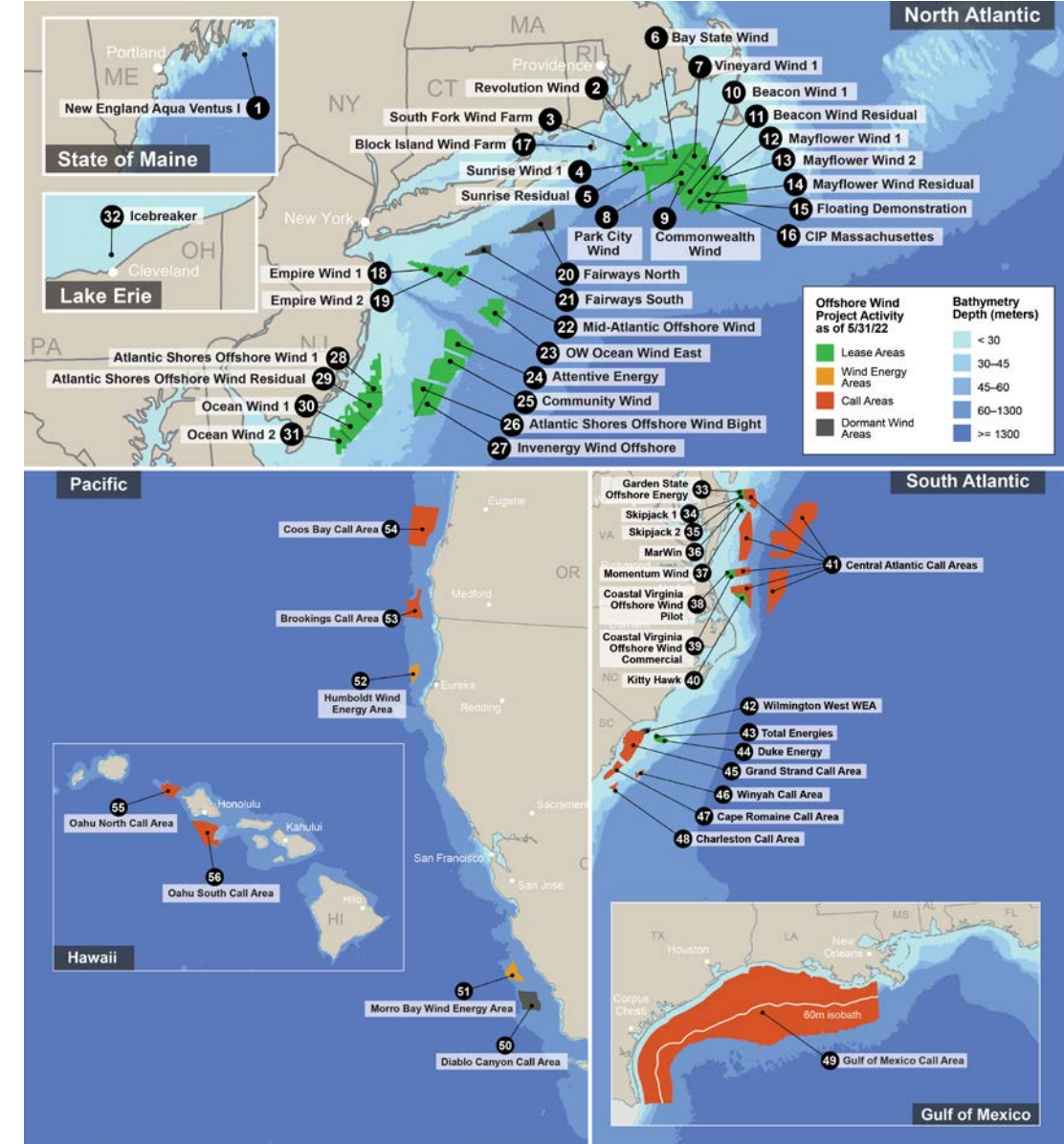
Project Pipeline Classification System Uses the Public U.S. Regulatory Framework to Assess Project Status

Step	Phase Name	Start Criteria	End Criteria
1	Planning	Starts when a developer or regulatory agency initiates the formal site control process	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 and an offtake agreement for electricity production)	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 its offtake agreement	Ends when sponsor announces a “financial investment decision” and has signed contracts for construction work packages
5	Financial Close	Starts when 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 to and generating power to a land-based electrical grid
7	Operating	Starts when all wind turbines are installed and transmitting power to the grid; the commercial operation date (COD) 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
9	On Hold/Canceled	Starts if a sponsor stops development activities, discontinues lease payments, or abandons a prospective site	Ends when a sponsor restarts project development activity

U.S. Offshore Wind Data

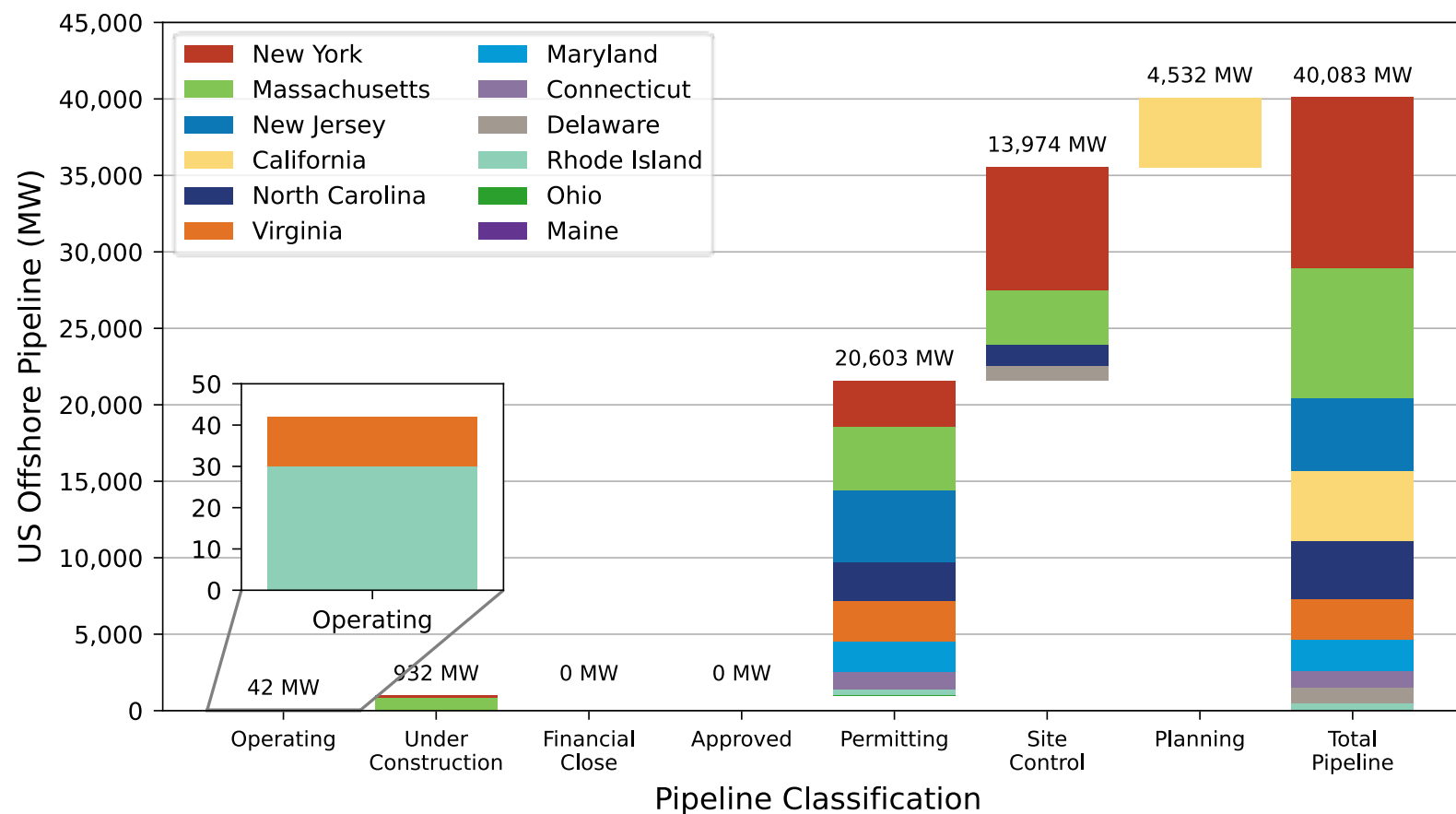
U.S. Offshore Wind Industry Market as of May 31, 2022, Shows Strength in Essential Economic and Policy Areas, Indicating Accelerated Growth

- U.S. Offshore Wind Target set in March 2021 for 30 gigawatts (GW) by 2030 with pathway to 110 GW by 2050
- 39,322 megawatts (MW) of policy commitments from eight eastern states
- 40,083 MW estimated in total project pipeline
- 42 MW installed
- 932 MW approved (Vineyard Wind and South Fork)
- 24 offtake agreements with 17,597 MW of offshore wind under contract
- 18,581 MW in advanced permitting where the developer has submitted a COP and has a clear path to a power offtake agreement
- 2 floating projects: Aqua Ventus 1 and Shell/Atkins/Ocergy.



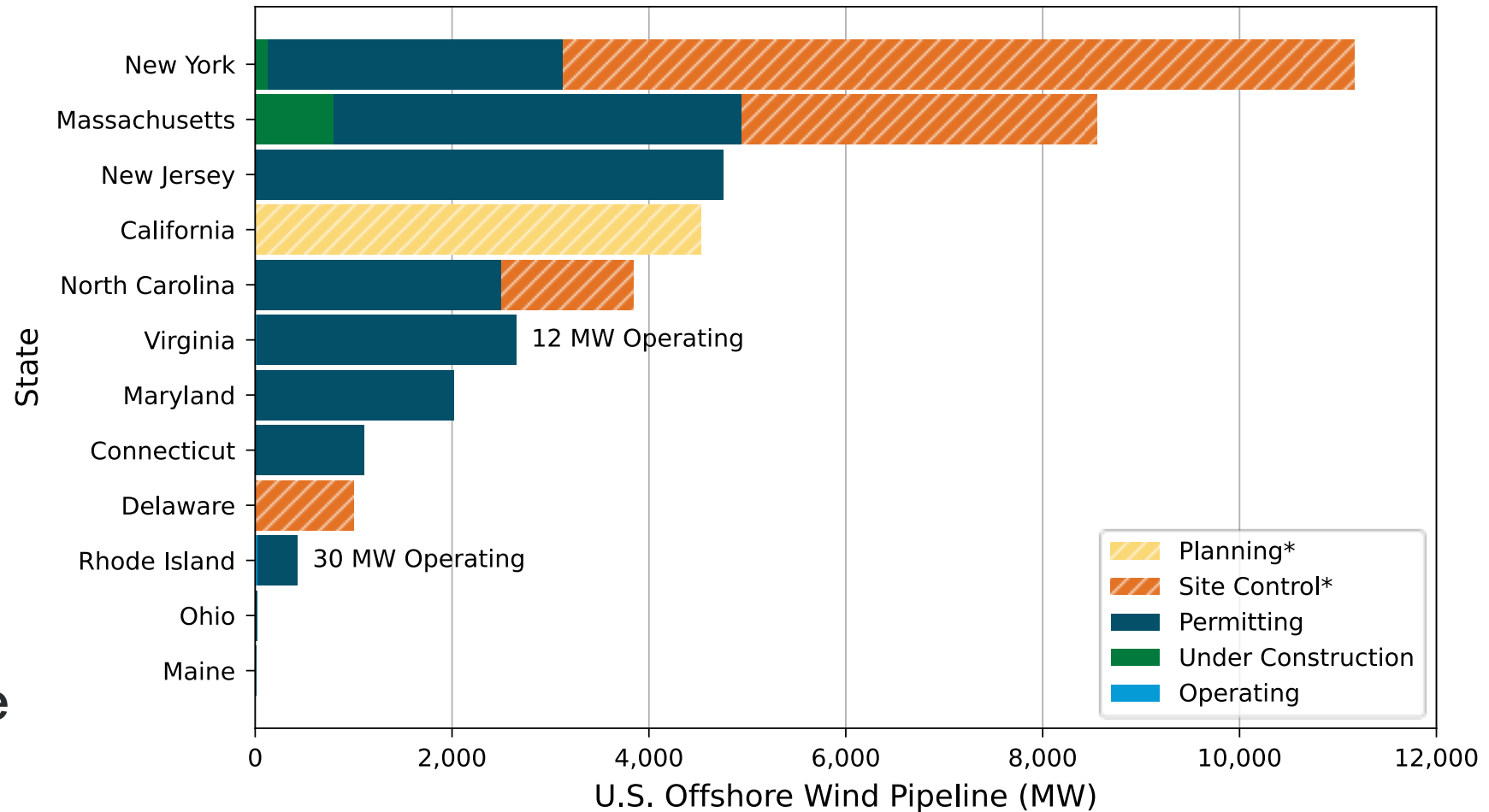
2022 Breakdown of U.S. Project Pipeline Shows More Than 20 GW Are in Permitting and Nearing Approval

- The U.S. offshore wind pipeline grew to a capacity of 40,083 MW.
- The pipeline grew by 13.5% over the 35,324 MW reported in 2021.
- Expansion was driven by the Bureau of Ocean Energy Management's (BOEM's) new leasing activity
 - Eight new lease areas auctioned in the Atlantic
 - Two new wind energy areas (WEAs) in California (DOI 2021)
 - Three existing WEAs were reclassified as “dormant.”



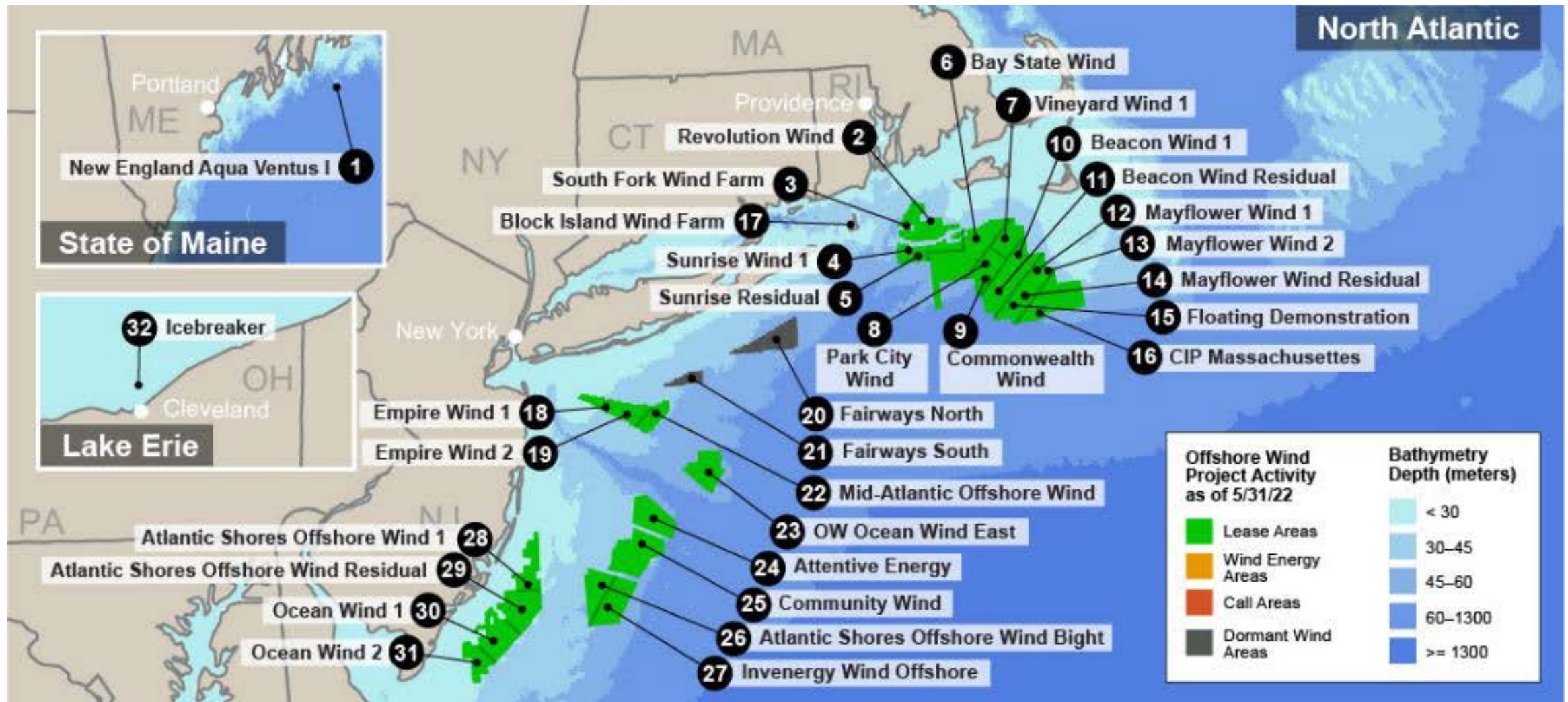
U.S. Project Pipeline by State Indicates That New York, Massachusetts and New Jersey Have the Majority of Capacity

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

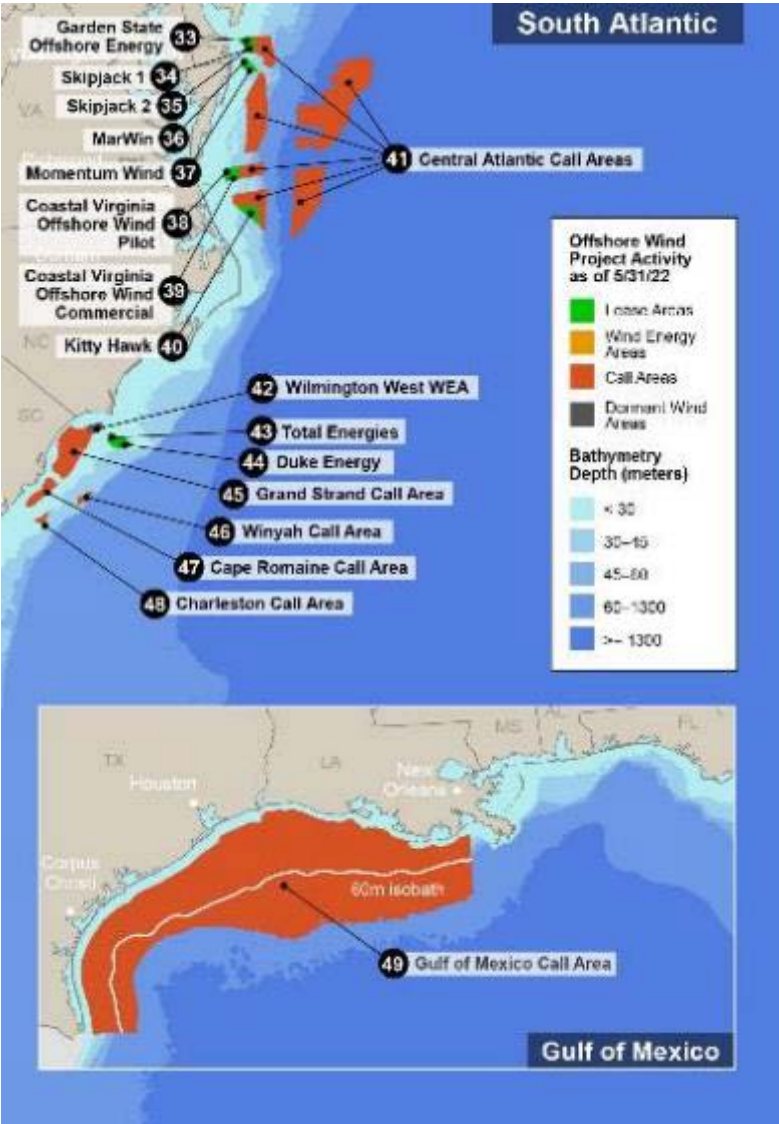


* Capacity for “Permitting” and “Site Control” categories are assigned to the state where the WEA is geographically located. All other categories are assigned to the state where the power will be delivered.

U.S. North Atlantic and Great Lakes Offshore Wind Energy Activity as of May 31, 2022, Illustrates Large-Scale Development Is Underway



South Atlantic, Gulf of Mexico, and Pacific Offshore Wind Activity as of May 31, 2022, Illustrates Strong Development Potential From Early-Stage Leasing



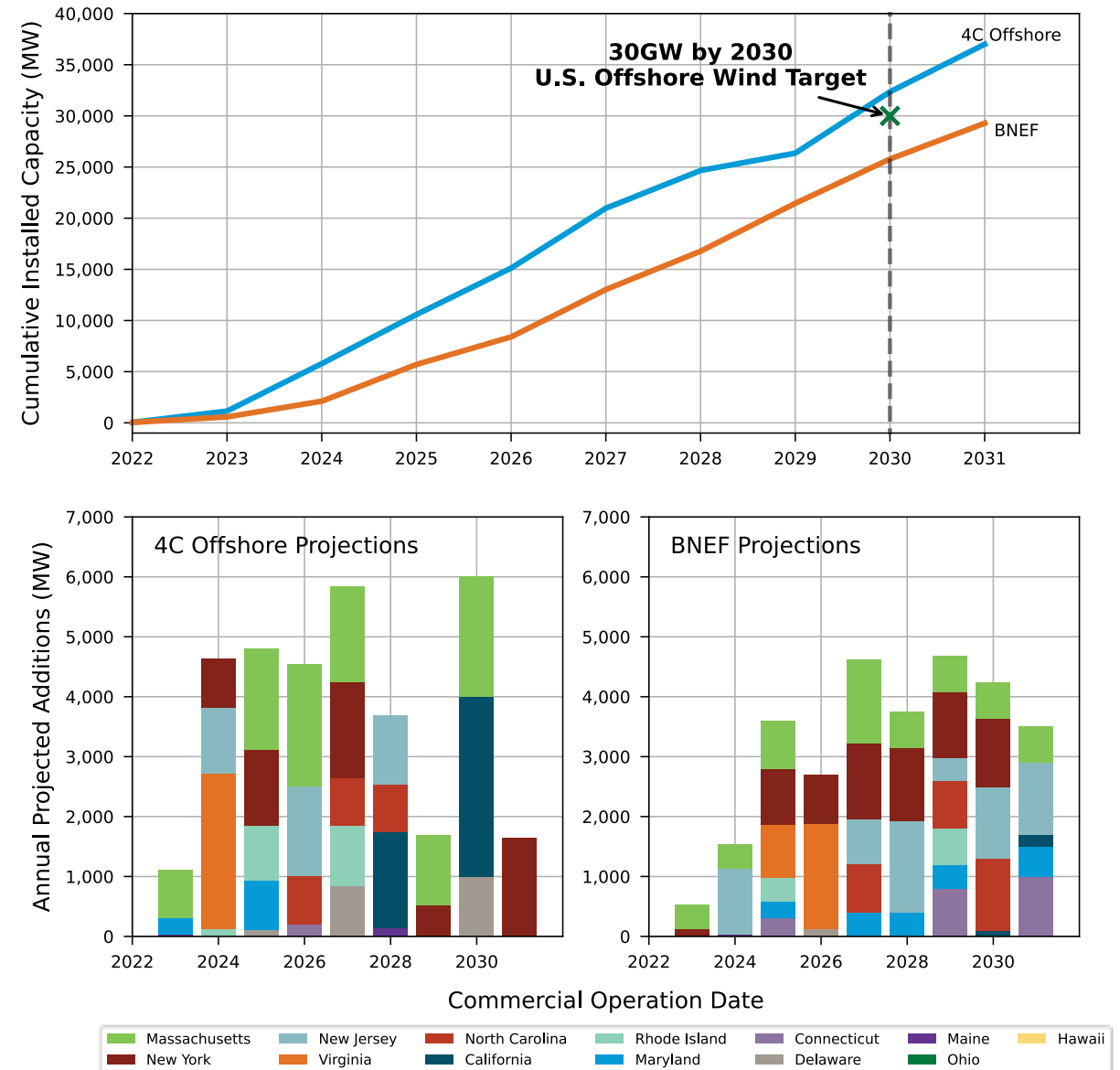
South Atlantic and Gulf of Mexico



Pacific Coast and Hawaii

Industry Forecasts Estimate U.S. Offshore Wind Market Will Deploy Between 26 GW and 32 GW by 2030

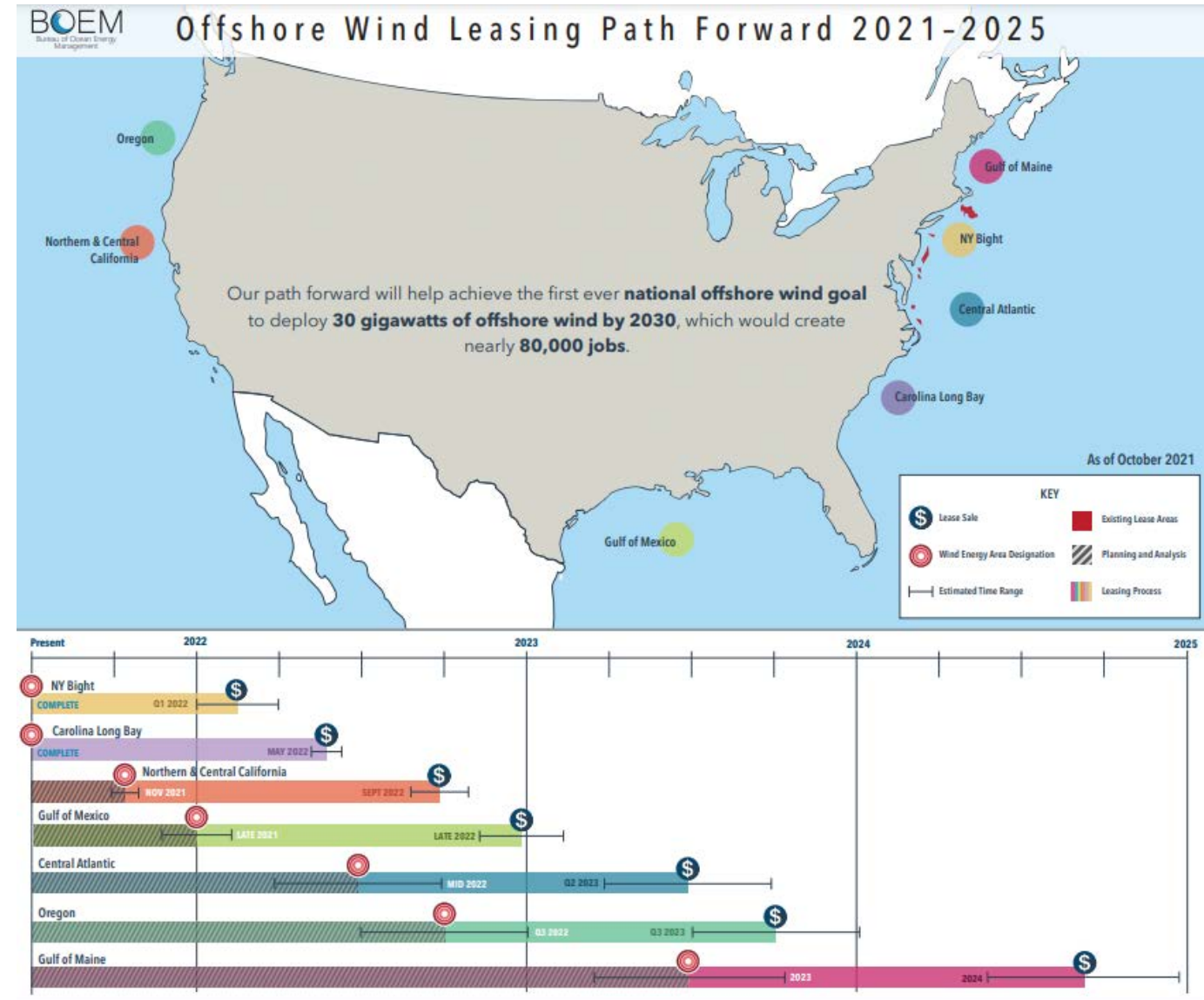
- 2021 4C Offshore and Bloomberg New Energy Finance (BNEF) provide independent forecasts of U.S. offshore wind deployment out to 2031.
- Forecasts estimate that the U.S. offshore wind market will cumulatively reach 26 GW and 32 GW by 2030.
- The U.S. target set by the Biden administration is 30 GW by 2030.
- The administration's target is in line with forecasts.



BOEM Announced the “Offshore Wind Leasing Path Forward 2021–2025” in October 2021, Which Calls for up to Seven New Lease Auctions

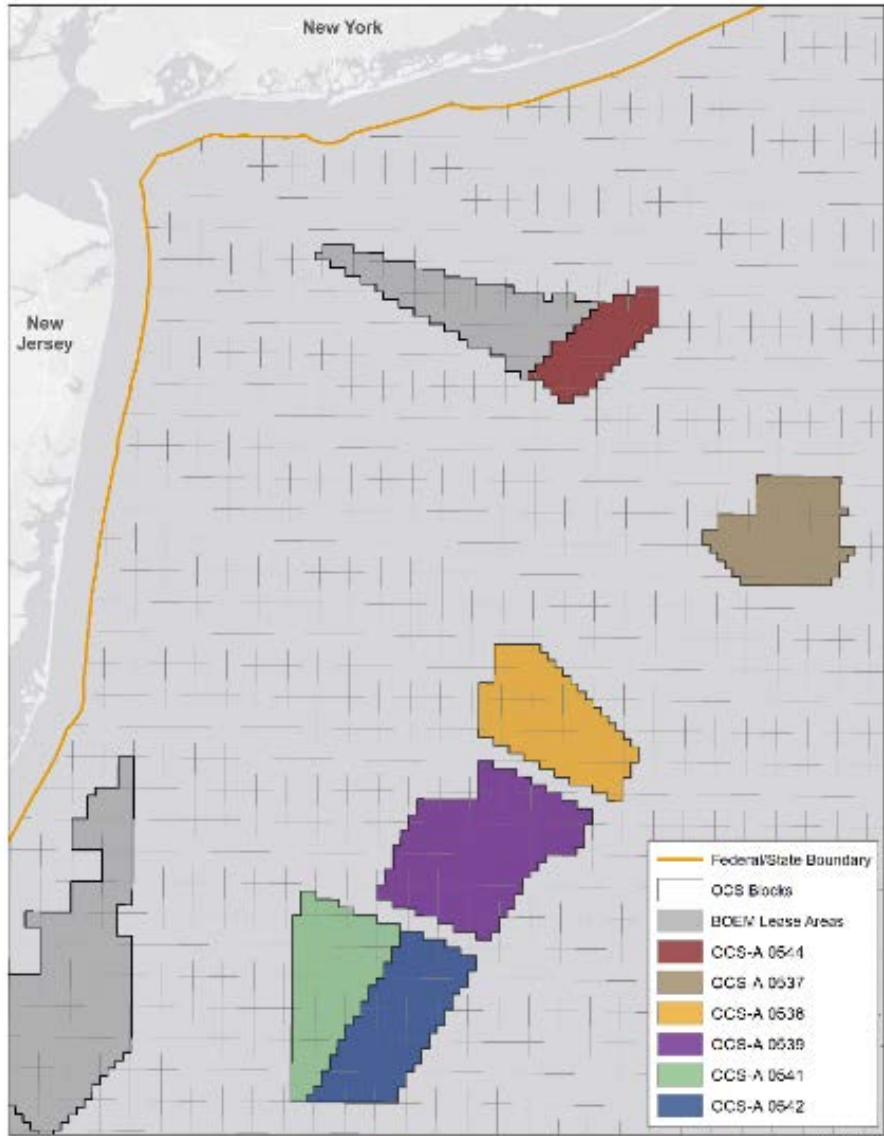
- U.S. Department of the Interior Secretary Deb Harland announced a near-term leasing plan in October 2021.
- BOEM has the authority to carry out up to seven lease auctions by 2025.
- Five of the planned auctions may have floating wind lease areas.
- Planned lease auctions include New York Bight (February 2022), Carolina Long Bay (May 2022), California (late 2022), Gulf of Mexico (early 2023), Central Atlantic (mid 2023), Oregon (late 2023), and Gulf of Maine (mid 2024).

(BOEM 2022)



New York Bight Leasing Auction in February 2022

Yielded \$4.37 Billion in Lease Revenue

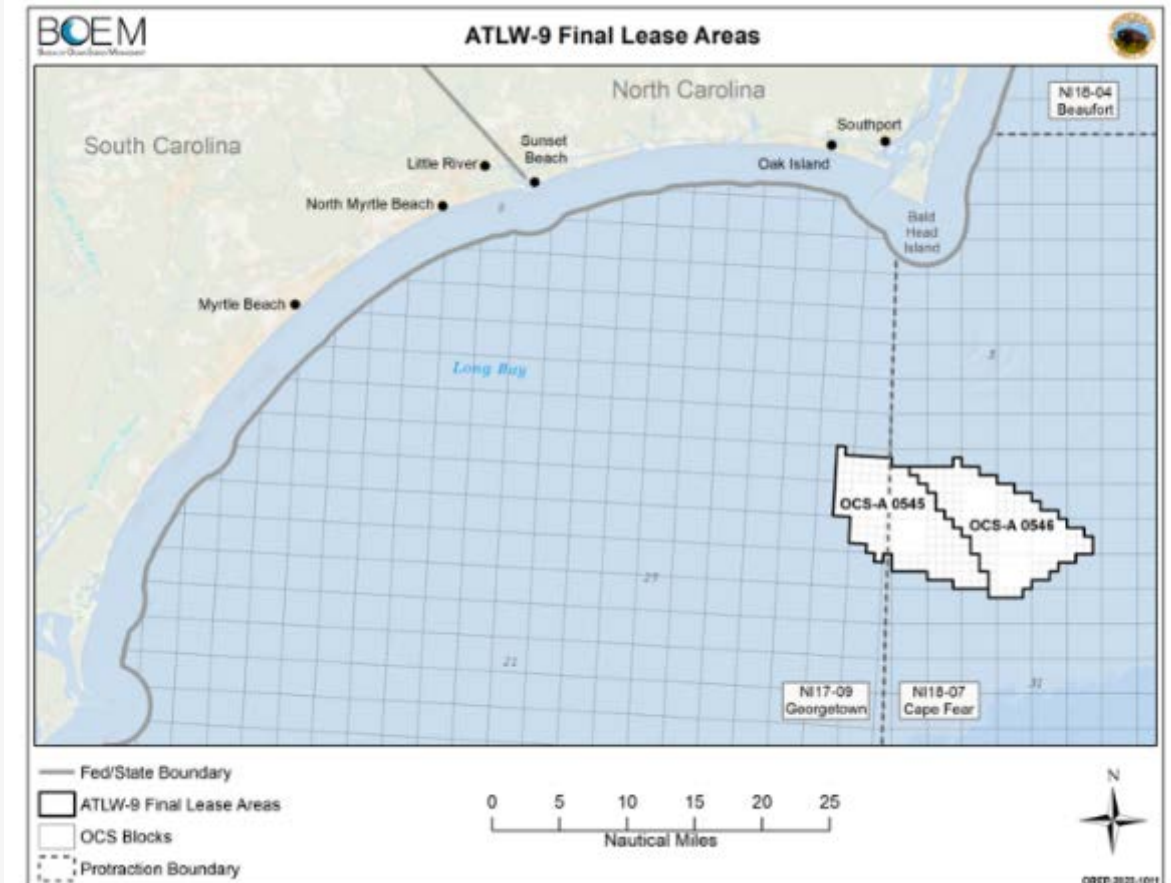


Lease Number	Purchaser	Developer	Area (km ²)	Capacity (MW)	Price
OCS-A 0544	Mid-Atlantic Offshore Wind LLC	CIP	174	523	\$285,000,000
OCS-A 0537	OW Ocean Winds East LLC	EDPR and Engie	289	868	\$765,000,000
OCS-A 0538	Attentive Energy LLC	Total Energies	321	964	\$795,000,000
OCS-A 0539	Bight Wind Holdings LLC	RWE and National Grid	462	1,387	\$1,100,000,000
OCS-A 0541	Atlantic Shores Offshore Wind Bight LLC	Shell and EDF	308	924	\$780,000,000
OCS-A 0542	Invenergy Wind Offshore Wind LCC	Invenergy and EnergyRE	311	934	\$645,000,000

- New York Bight lease auction was held in February 2022
- Lease sales totaled \$4.37 billion—record-setting for BOEM and for U.S. offshore wind
- Sales added more than 5,600 MW in capacity to the pipeline
- Winning bidders added new players to the U.S. market, including Total Energies, RWE, Invenergy, and EnergyRE.

Carolina Long Bay Wind Energy Area Leases Sold for \$315 Million—the First BOEM Offshore Wind Auction With Multi-Factor Bidding

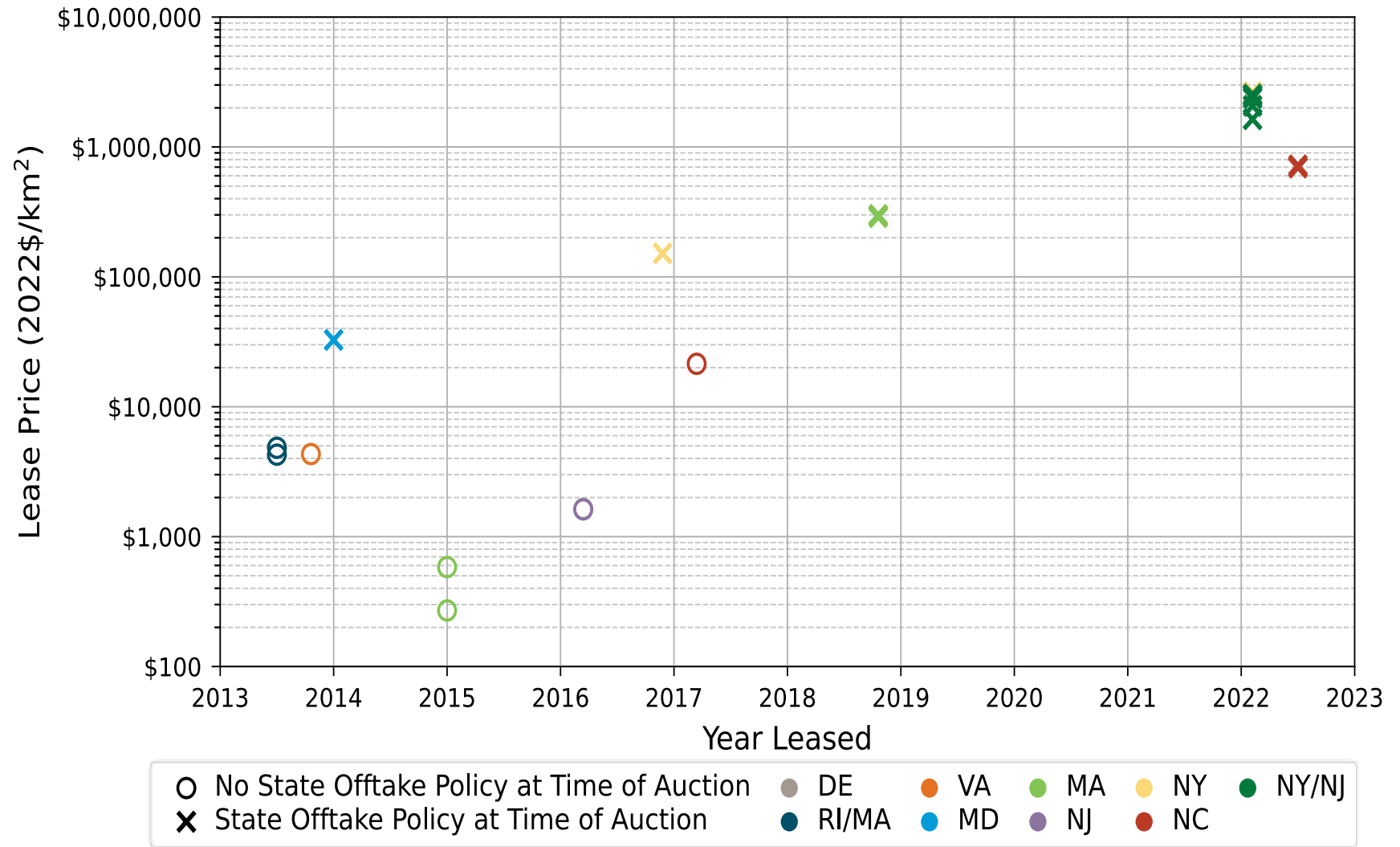
- Carolina Long Bay lease auction was held in May 2022.
- Lease sales totaled \$315 million.
- Leases added more than 1,337 MW in capacity to the pipeline.
- Winning bidders added Duke Energies Renewable Wind LLC to the new developers in the U.S. Market.
- This was the first BOEM offshore wind auction to use multi-factor bidding, which allows some of the lease revenue to benefit the states.



Lease Number	Purchaser	Area (km ²)	Capacity (MW)	Price
OCS-A 0545	Total Energies Renewables USA LLC	222	667	\$160,000,000
OCS-A 0546	Duke Energies Renewable Wind LLC	223	670	\$155,000,000

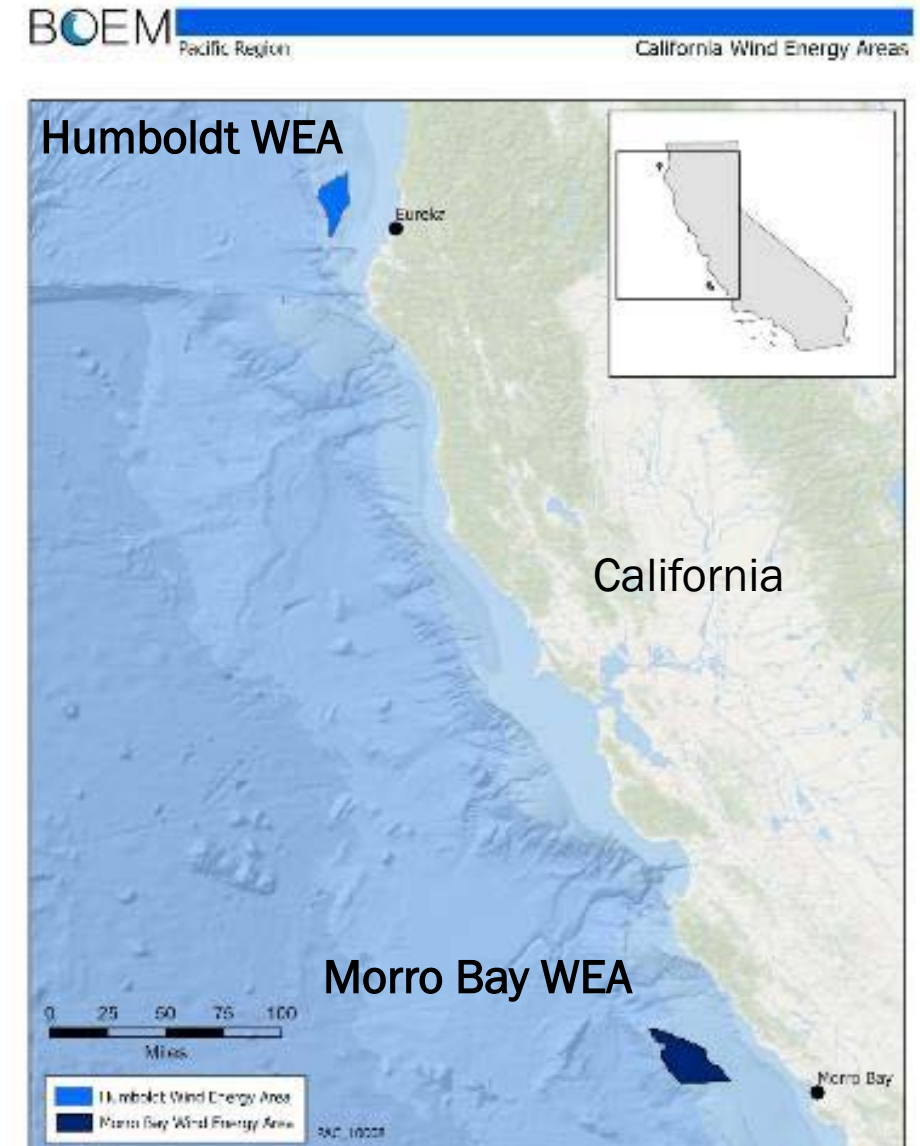
U.S. Offshore Wind Lease Prices Have Grown Logarithmically, With Significantly Higher Lease Prices in States With Strong Procurement Policies

- Plot shows lease prices per square kilometer (km^2) by state over the past 10 years.
- Auction prices have increased logarithmically over time since 2013.
- States with strong procurement policies and deployment mandates show much higher lease prices.



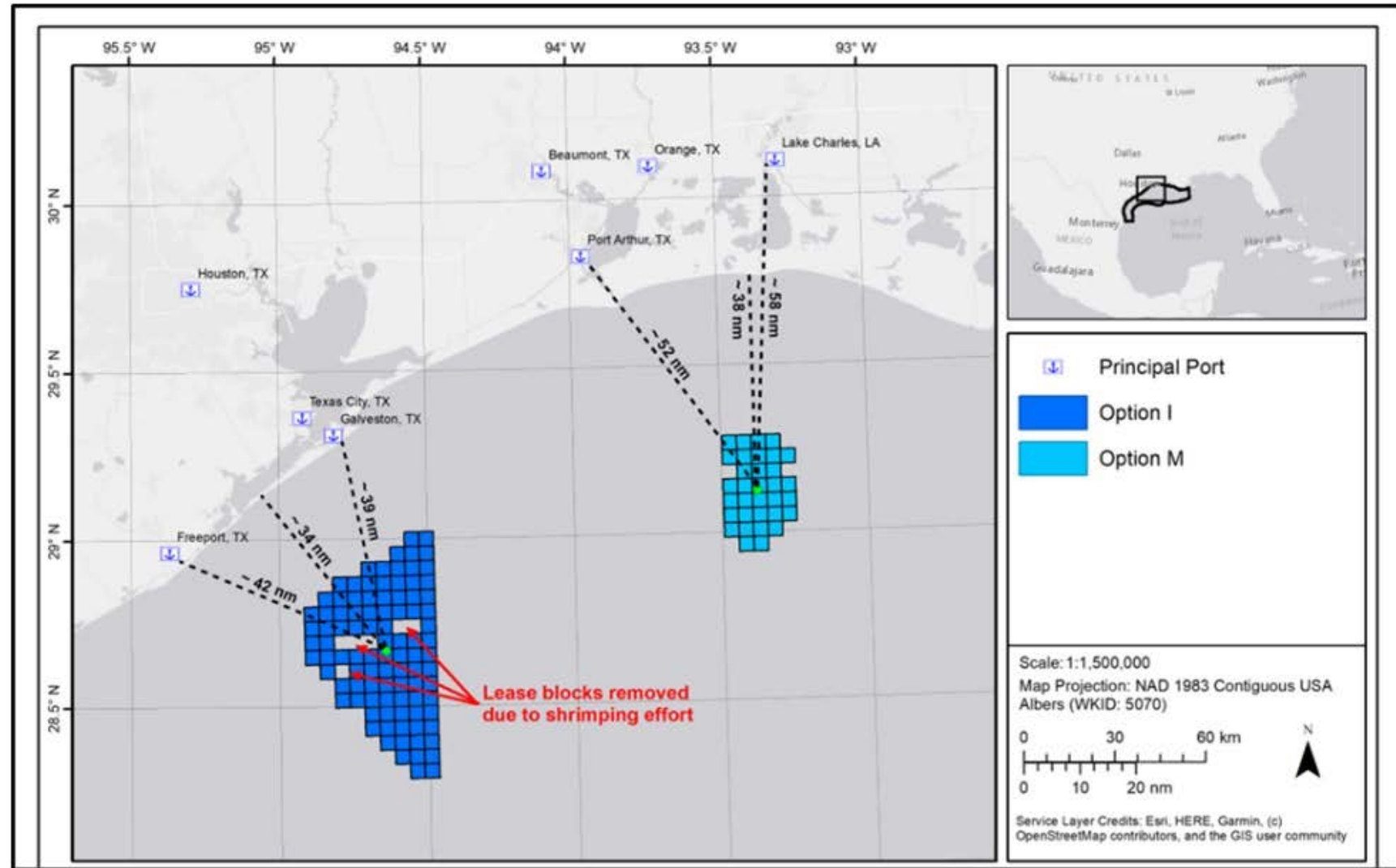
Five Lease Areas in Humboldt and Morro Bay Wind Energy Areas Off California Coast Are Scheduled for Auction in Late 2022

- California lease auctions are planned for late 2022.
- Morro Bay (3 lease areas) and Humboldt (2 lease areas) Wind Energy Areas will be auctioned in a multi-factor auction.
- Proposed sale notice was issued May 2022.
- The five lease areas have a development capacity of more than 4.6 GW.
- Development capacity could be as high as 7.5 GW based on industry norms for array density.



Gulf of Mexico Draft Wind Energy Areas Announced July 20, 2022

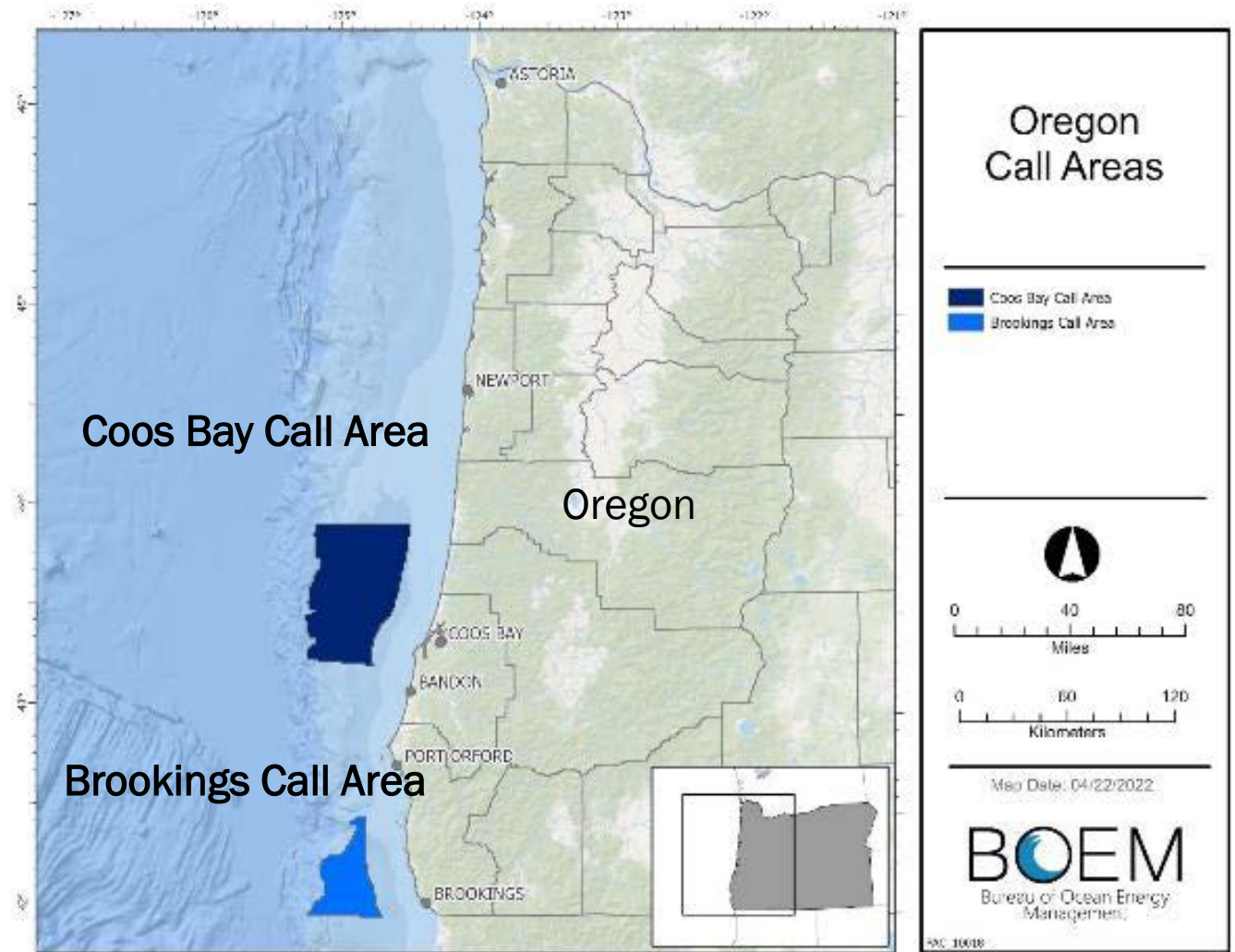
- A regional intergovernmental task force including LA, AL, MS, and TX was formed in 2021.
- A 30-million-acre Call Area was announced in October 2021.
- In February 2022, the Louisiana Climate Action Plan recommended a procurement goal of 5 GW by 2035.
- There are strong synergies with oil and gas infrastructure and hydrogen production.
- On July 20, 2022, the U.S. Department of the Interior announced two draft Gulf of Mexico WEAs.
- Gulf of Mexico lease auction is planned for 2023.



Gulf of Mexico Draft Wind Energy Areas Announced July 20, 2022

Two Call Areas Were Announced Off Oregon Coast in April 2022

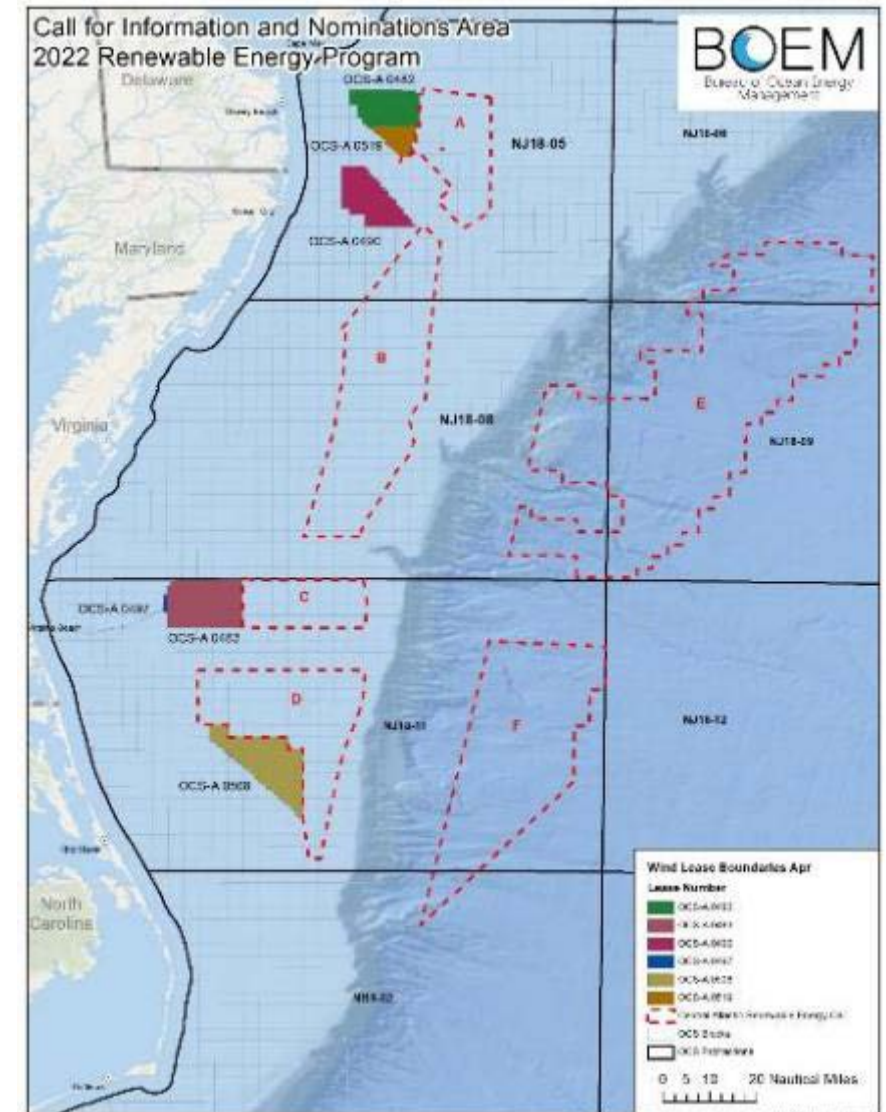
- An Oregon Intergovernmental Task Force was formed in 2011.
- In September 2021, Oregon passed HB 3375, setting a goal for up to 3 GW of offshore wind by 2030.
- Two Call Areas were announced April 27, 2022, in southern Oregon:
 - Coos Bay Call Area (1,364 square miles)
 - Brookings Call Area (448 square miles).
- Oregon lease actions reflect a strong industry push for the development of floating wind technology.



Oregon Call Areas

Six New Call Areas Were Announced in the Central Atlantic on April 27, 2022

- **Four Call Areas are in water depths suited for fixed-bottom technology and two are in ultra-deep water of about 2,600 meters (m).**
- **Less than 60-m depth:**
 - Call Area A: 952 km²
 - Call Area B: 2,639 km²
 - Call Area C: 744 km²
 - Call Area D: 1,791 km².
- **Deep Call Areas:**
 - Call Area E: Depth to 2,500-m and 2,600-m bathymetric contour; 6,556 km²
 - Call Area F: Depth to 2,600-m bathymetric contour; 3,090 km².



Central Atlantic Call Areas

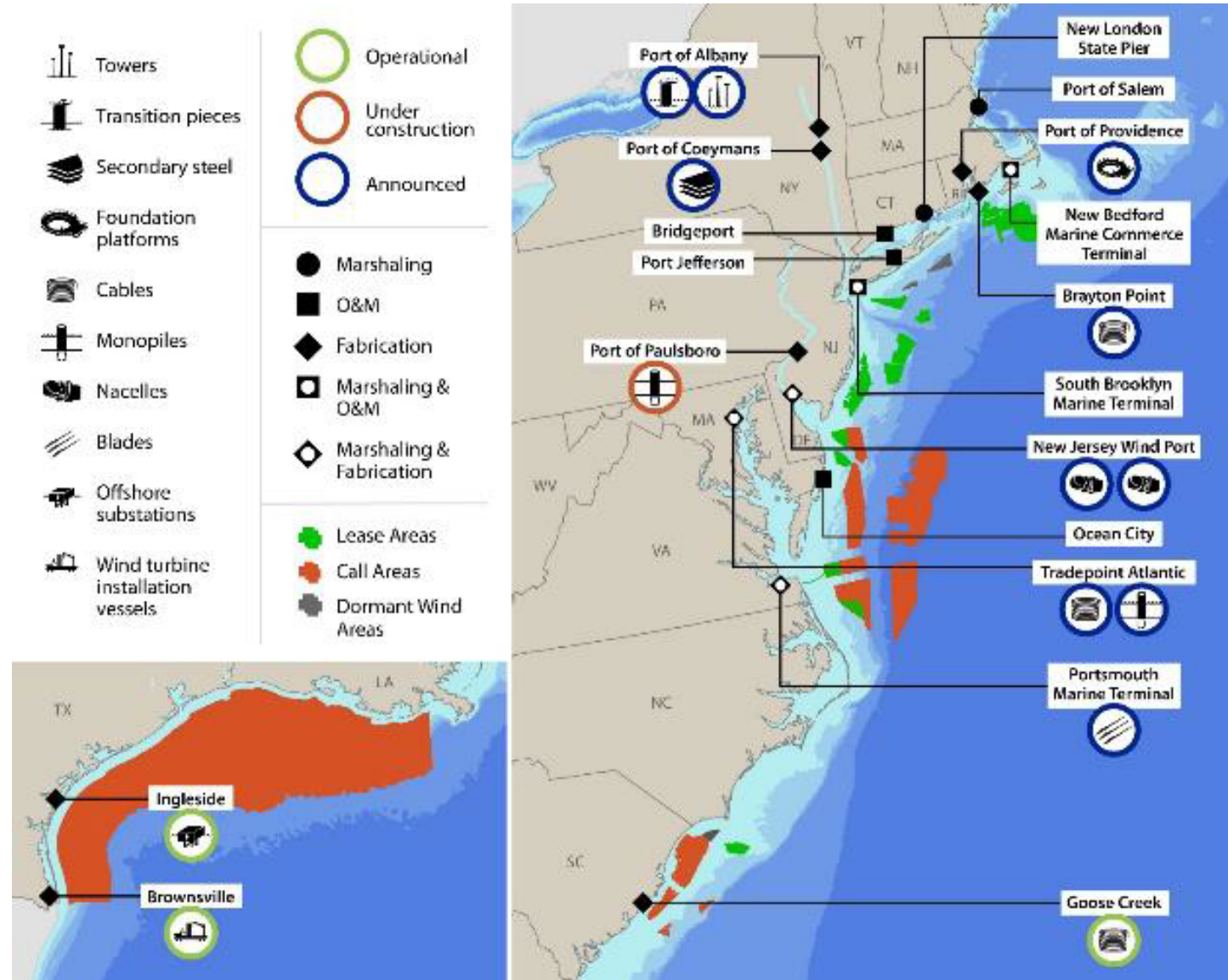
U.S. State Offshore Wind Procurement Policies

Total 17,597 MW as of May 31, 2022

State	Offshore Target (MW)	Goal Year	Amount Procured (MW)	Authorities	Year Implemented
Maine	-	-	12	None	
Ohio	-	-	21	None	
Massachusetts	5,600	2035	3,236	An Act to Promote Energy Diversity An Act to Advance Clean Energy An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy	2016 2018 2021
Rhode Island	-	-	430	None	-
Connecticut	2,000	2030	1,104	Public Act No. 19-71	2019
New York	9,000	2035	4,362	Case 18E-0071 Climate Leadership & Community Protection Act	2018 2019
New Jersey	7,500	2035	3,758	Offshore Economic Development Act Executive Order 8/AB 3723 Executive Order 92	2010 2018 2019
Maryland	2,022	2030	2,022	Maryland Offshore Wind Energy Act Clean Energy Jobs Act	2013 2019
Virginia	5,200	2034	2,652	Virginia Clean Economy Act	2021
North Carolina	8,000	2040	-	Executive Order 218	2021
Total	39,322		17,597		

2021–2022 Port Investments Continue to Grow With Billions Being Invested in Supply Chain and Multiple Marshalling Ports

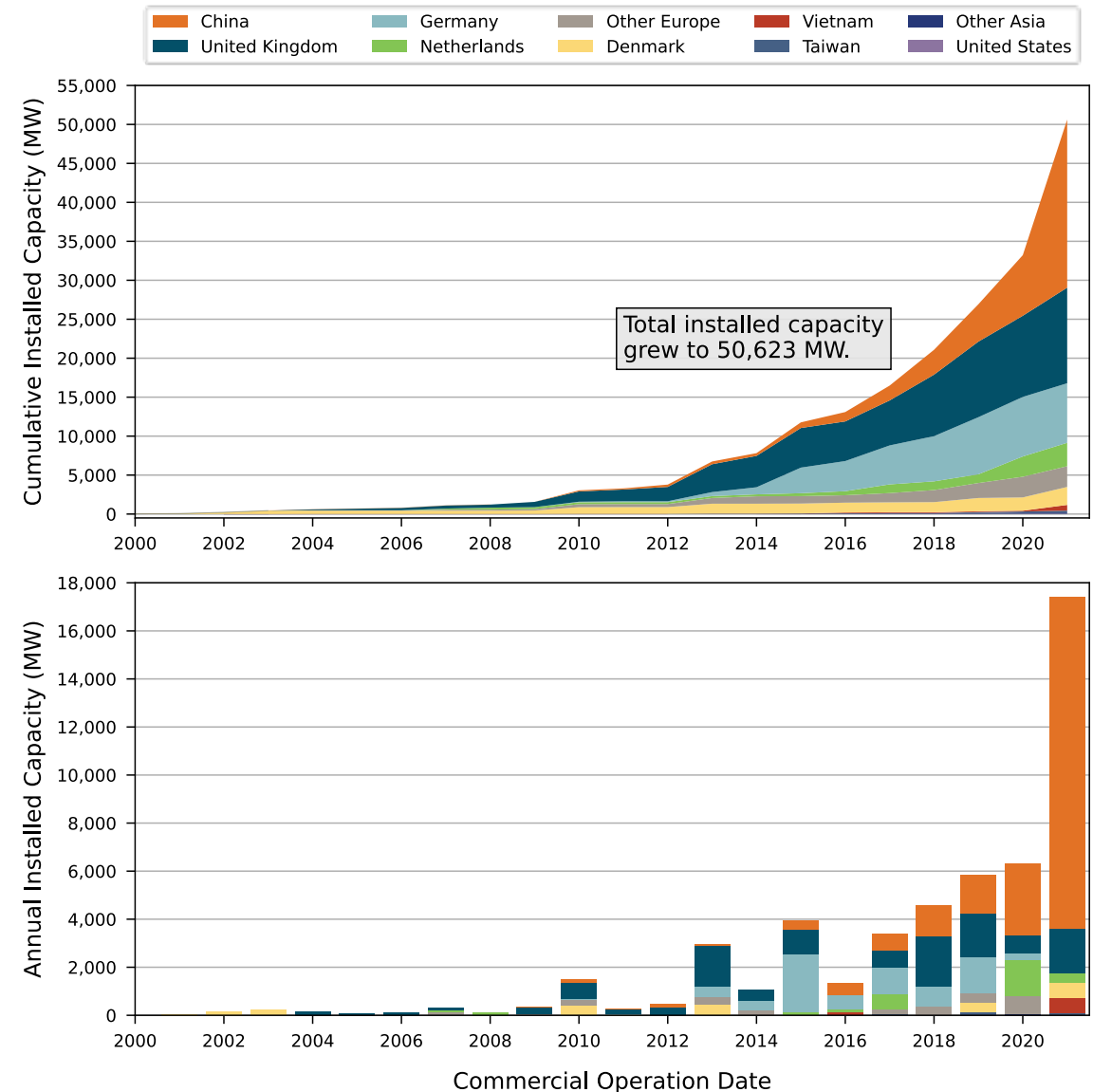
- Most port and supply chain activity is in the North Atlantic.
- 2021–2022 port investments continue to grow with billions being invested; multiple marshalling ports are underway.
- Only one Jones-Act-Compliant wind turbine installation vessel is under construction in Texas.
- Feeder barge concepts are being developed to work with foreign-flagged vessels.



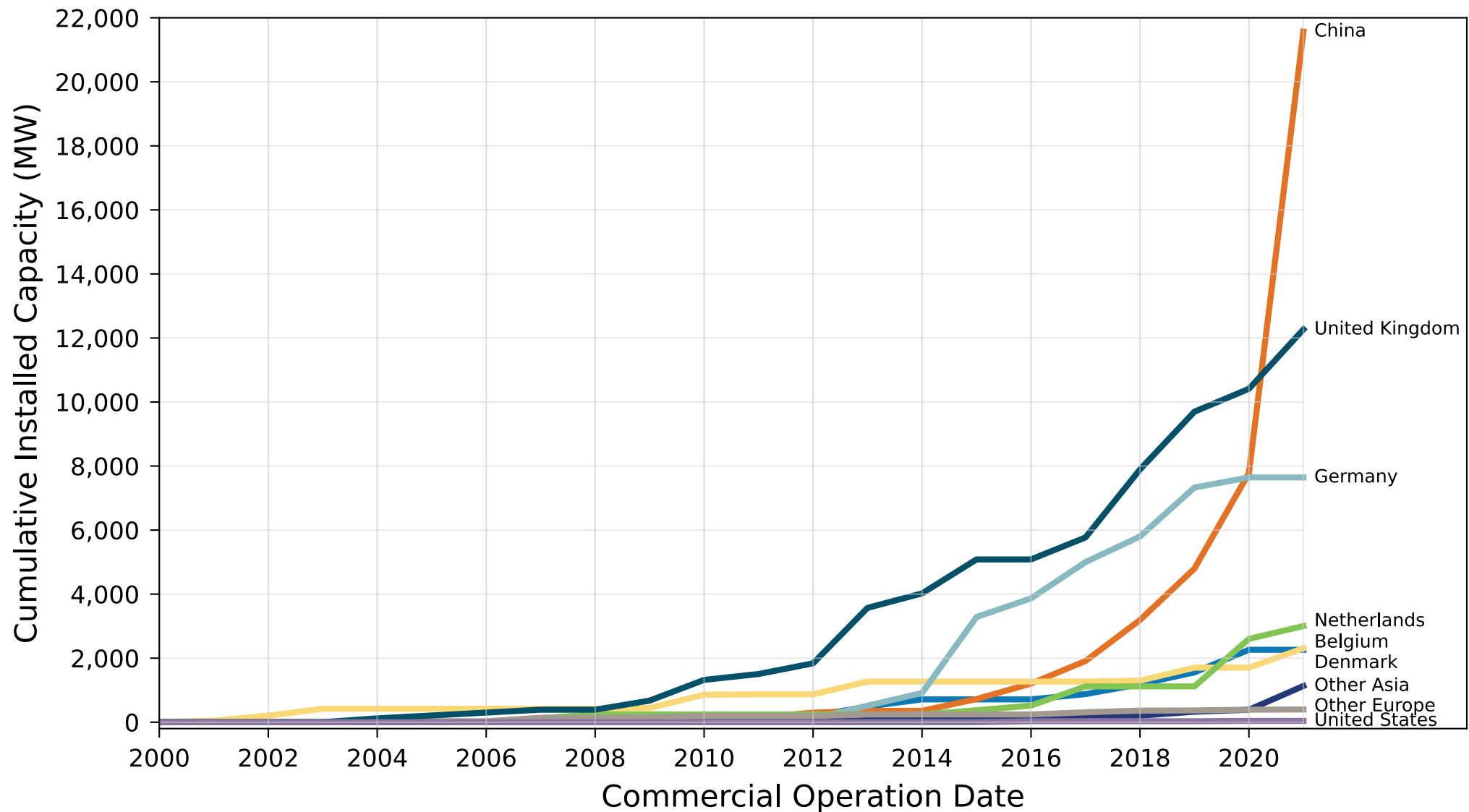
Global Offshore Wind Data

Global Cumulative Offshore Wind Energy Deployment Tops 50 GW in 2021 With Record-Setting Annual Capacity Additions of More Than 17 GW in 2021

- Global offshore wind energy in 2021 had a record year for deployment with about 17,398 MW of new projects commissioned.
- The cumulative global installed capacity reached 50,623 MW from 257 operating projects.
- Most of 2021 new capacity is attributed to China, which commissioned 13,790 MW—more capacity in 1 year than the entire world has installed in any single previous year.
- The United Kingdom deployed 1,855 MW, Vietnam deployed 643 MW, Denmark deployed 604 MW, the Netherlands deployed 402 MW, and Taiwan deployed 109 MW.

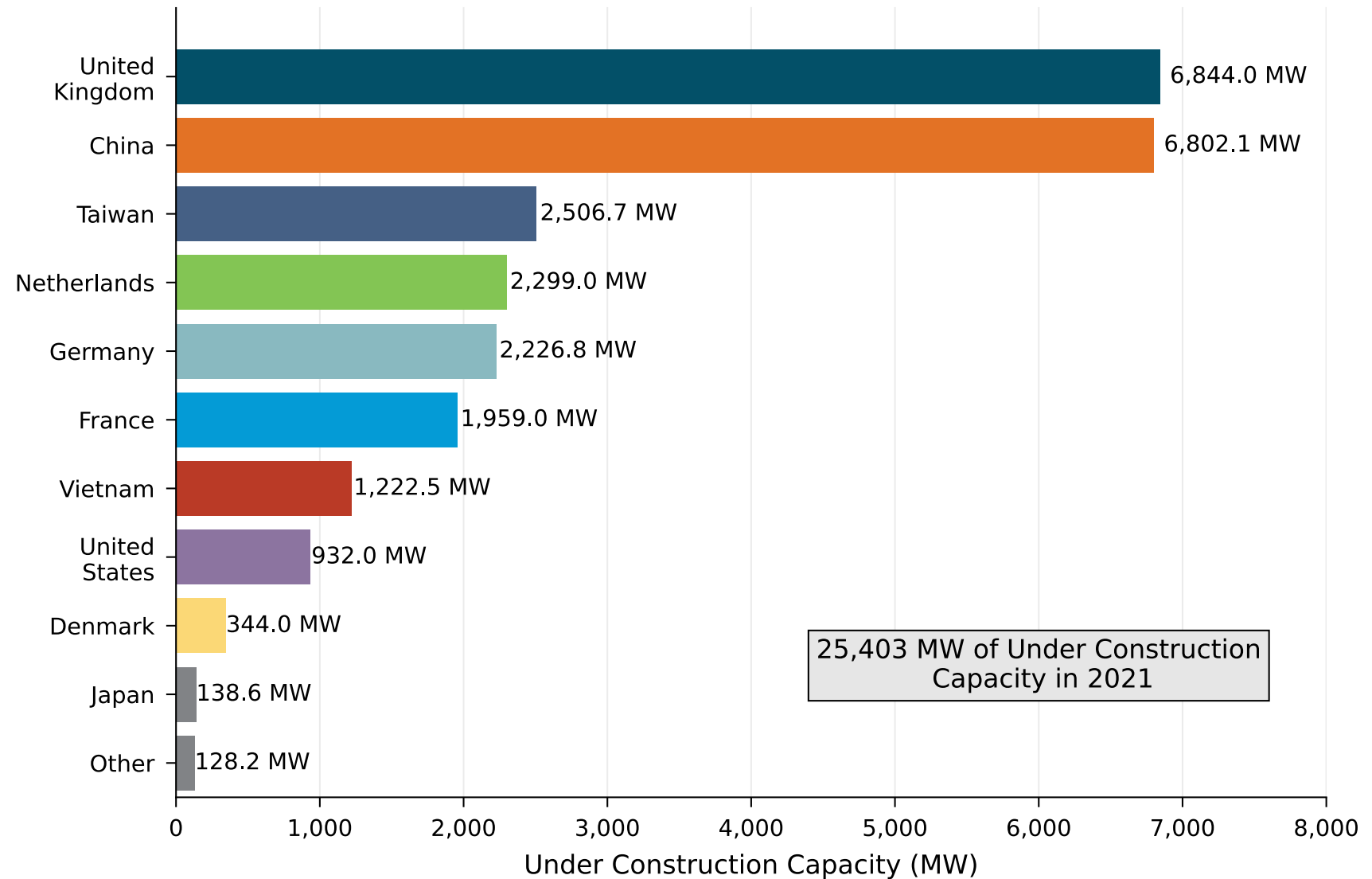


Global Cumulative Offshore Wind Installation by Country Shows China's Sharp Rise to the Global Offshore Wind Leader



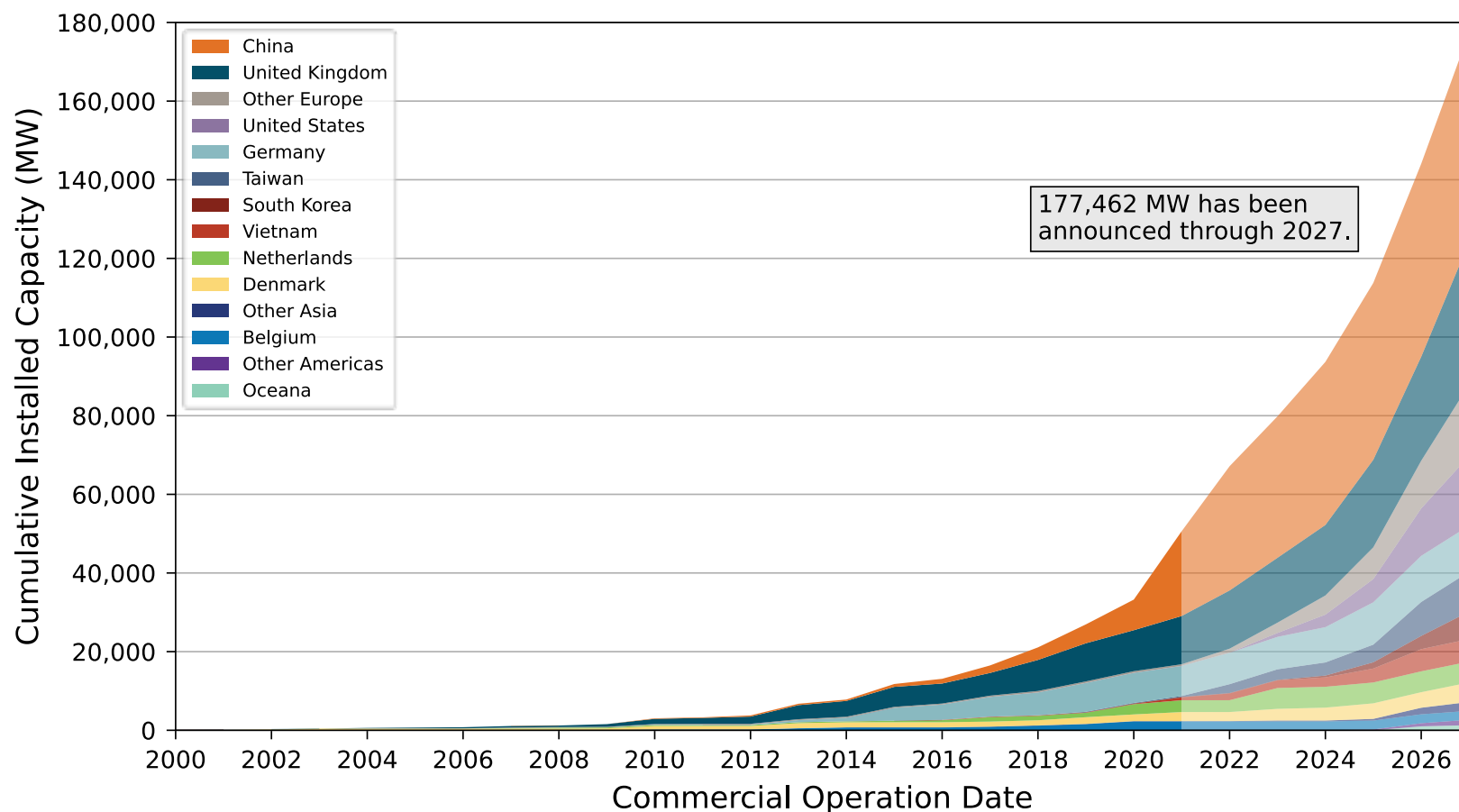
More Than 25 GW of Offshore Wind Capacity Was Under Construction Globally as of December 31, 2021

- Projects under construction are a good indicator of near-term deployment.
- Projects under construction have already received financing and are most likely to begin operations on a specified date.



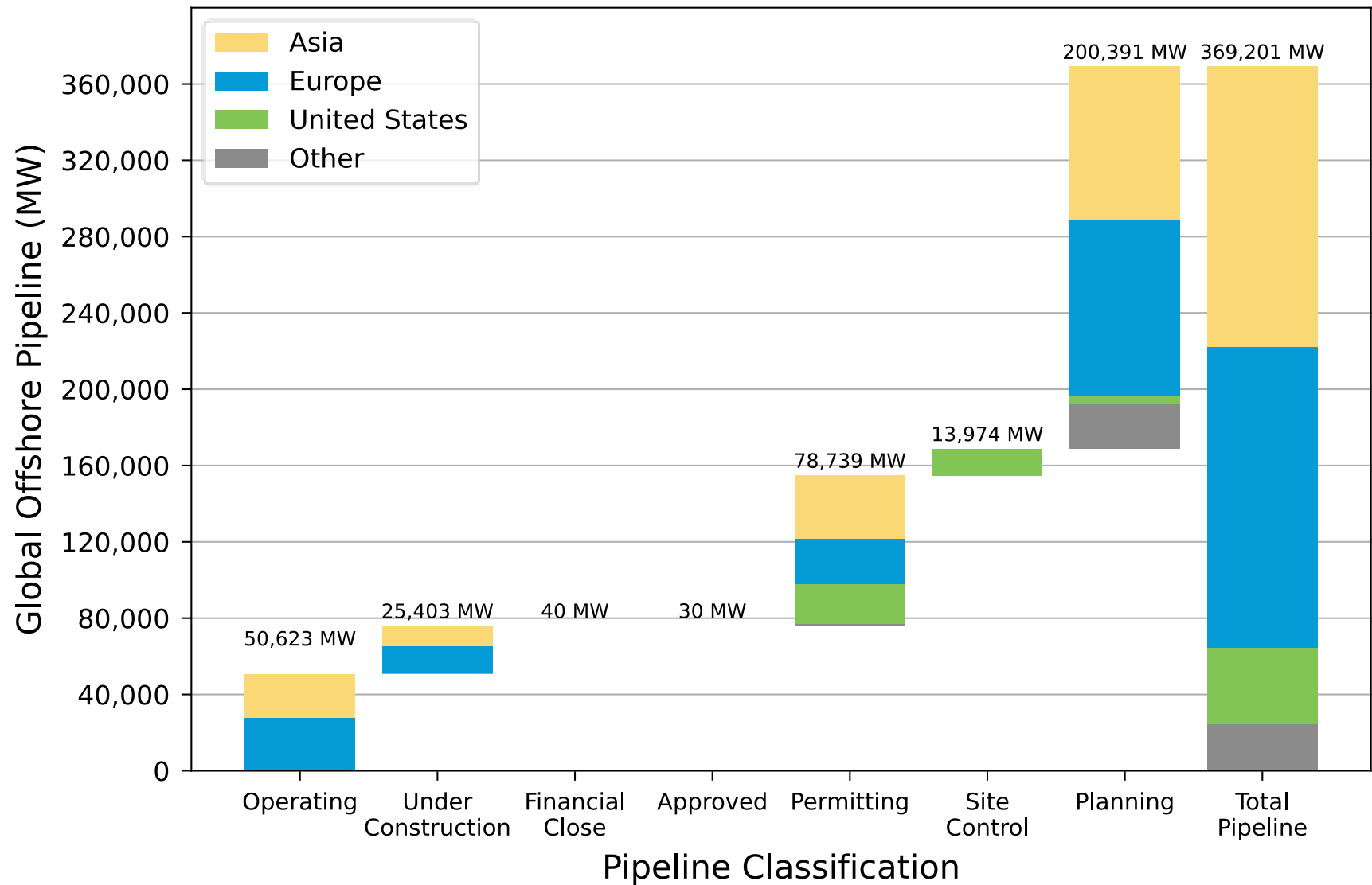
Developer-Announced Offshore Wind Capacity Indicates Cumulative Offshore Deployment Could Reach 177 GW by 2027

- Market data to 2027 show strong growth in Asia, Europe, and the United States.
- In 2022, many European countries have increased their deployment targets for offshore wind to reduce dependence on Russian fossil fuels.
- Commercialization of floating wind adds to future market diversity and growth.
- The cumulative offshore wind energy deployment by 2027 could reach approximately 177 GW.



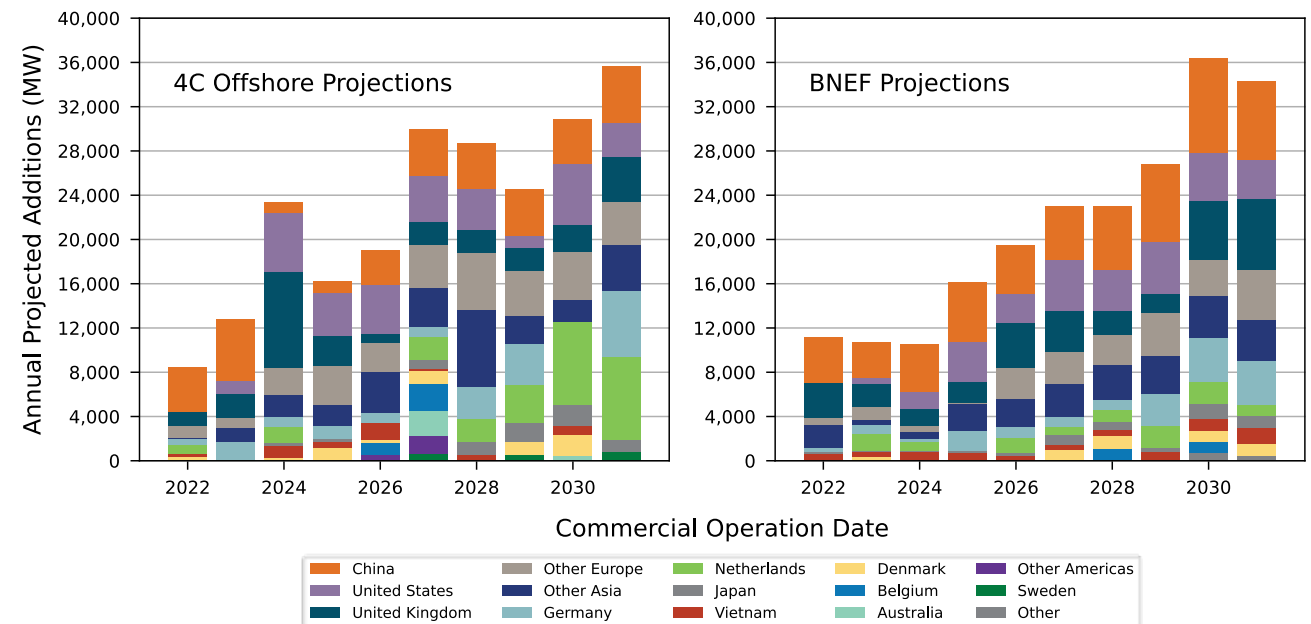
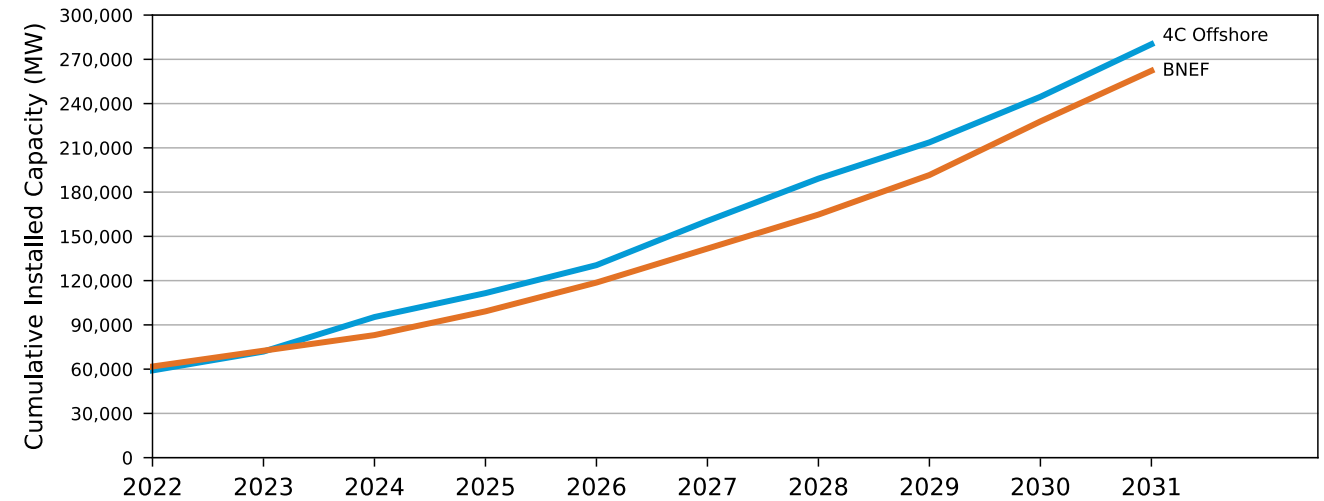
Global Offshore Wind Energy Pipeline Capacity Grew to Over 369 GW in 2021

- As of Dec. 31, 2021, the global pipeline for offshore wind energy development capacity was assessed to be more than 369 GW.
- Capacity grew nearly 20% over the 308 GW reported in 2020.
- The uptick in global pipeline capacity is primarily attributed to multiple new Asian projects entering the planning phase.



Industry Forecasts for Global Offshore Wind Energy Deployment Predict Total Capacity Between 261 GW and 286 GW by 2031

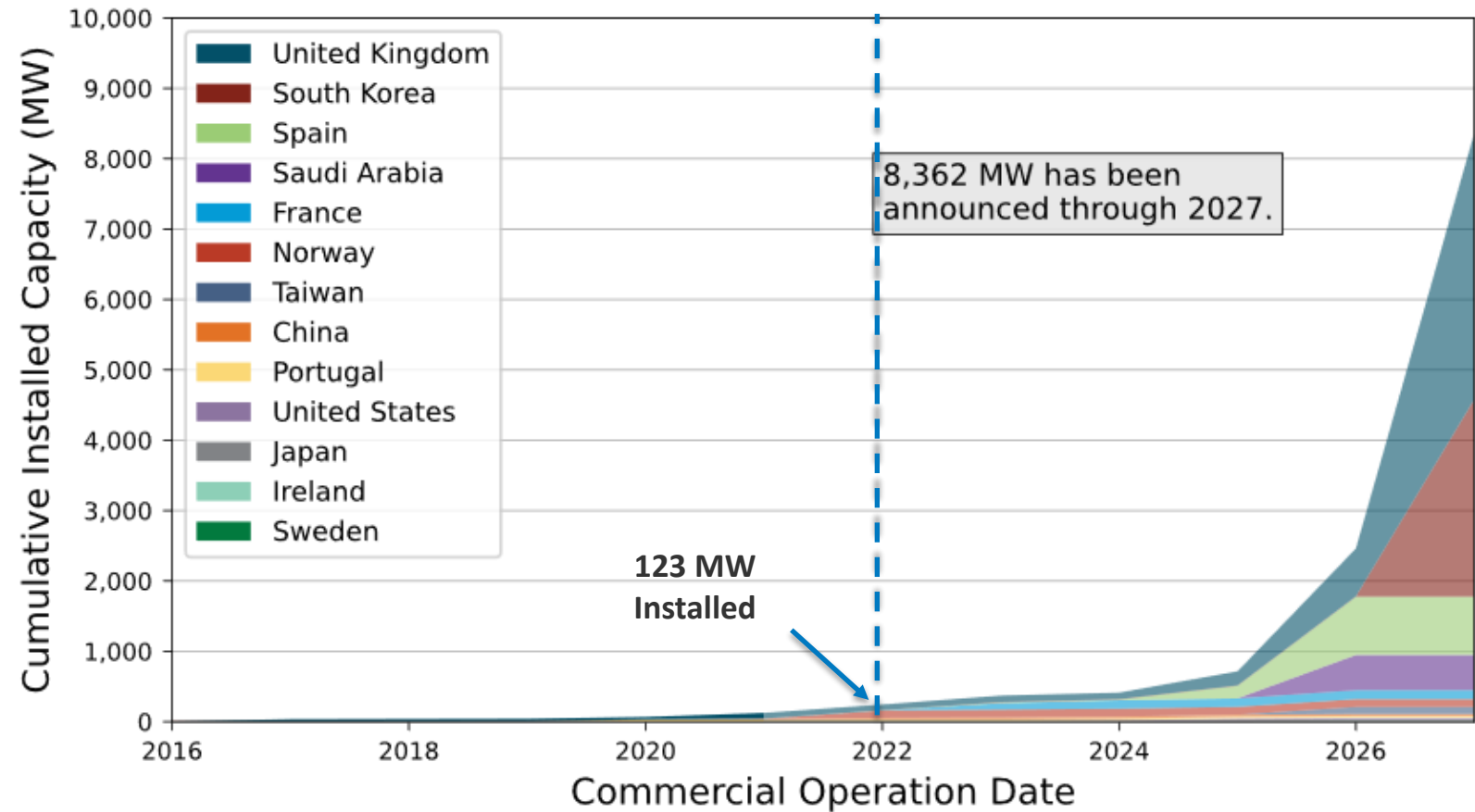
- Two forecasts by BNEF (2021a) and 4C Offshore (2022a) show offshore wind energy projections to 2031.
- BNEF predicts installed offshore wind to reach 261 GW by 2031; 4C Offshore estimates 286 GW by 2031.
- Differences indicate some uncertainty, but both forecasts indicate a fivefold increase in global market growth by 2031.
- Both forecasts predict China will deploy between 65 and 77 GW by 2031.
- Europe is expected to hold 45%–50% of the total installed global offshore wind capacity by 2031.



Global Floating Offshore Wind Data

Cumulative Floating Offshore Wind Capacity by Country Could Exceed 8 GW by 2027 Based On Developer-Announced Commercial Operations Date

- 123 MW of floating offshore wind was operational as of Dec. 31, 2021.
- The near-term floating deployment projections increased to 8,362 MW, more than double the 3,688 MW reported last year.
- Most of the floating offshore wind pipeline is in the planning phase.
- Developer-announced near-term deployment is 3,780 MW for the United Kingdom; 2,806 MW for South Korea, 828 MW for Spain, and 500 MW for Saudi Arabia.



Three Floating Wind Projects Were Commissioned in 2021

- Three floating offshore wind projects came online in 2021, totaling 56.6 MW of new floating capacity.
- Kincardine, the largest floating wind farm to date, was completed in 2021 and is located 15 km off Aberdeen, Scotland. It has five 9.5-MW Vestas turbines mounted on steel semisubmersible substructures from Principle Power Inc.
- The 3.6-MW TetraSpar Demonstration Project was installed in Norway at a water depth of 200 m (Stiesdal A/S 2021).
- A 5.5-MW floating project came online in China, developed by China Three Gorges Group (Russell 2021).

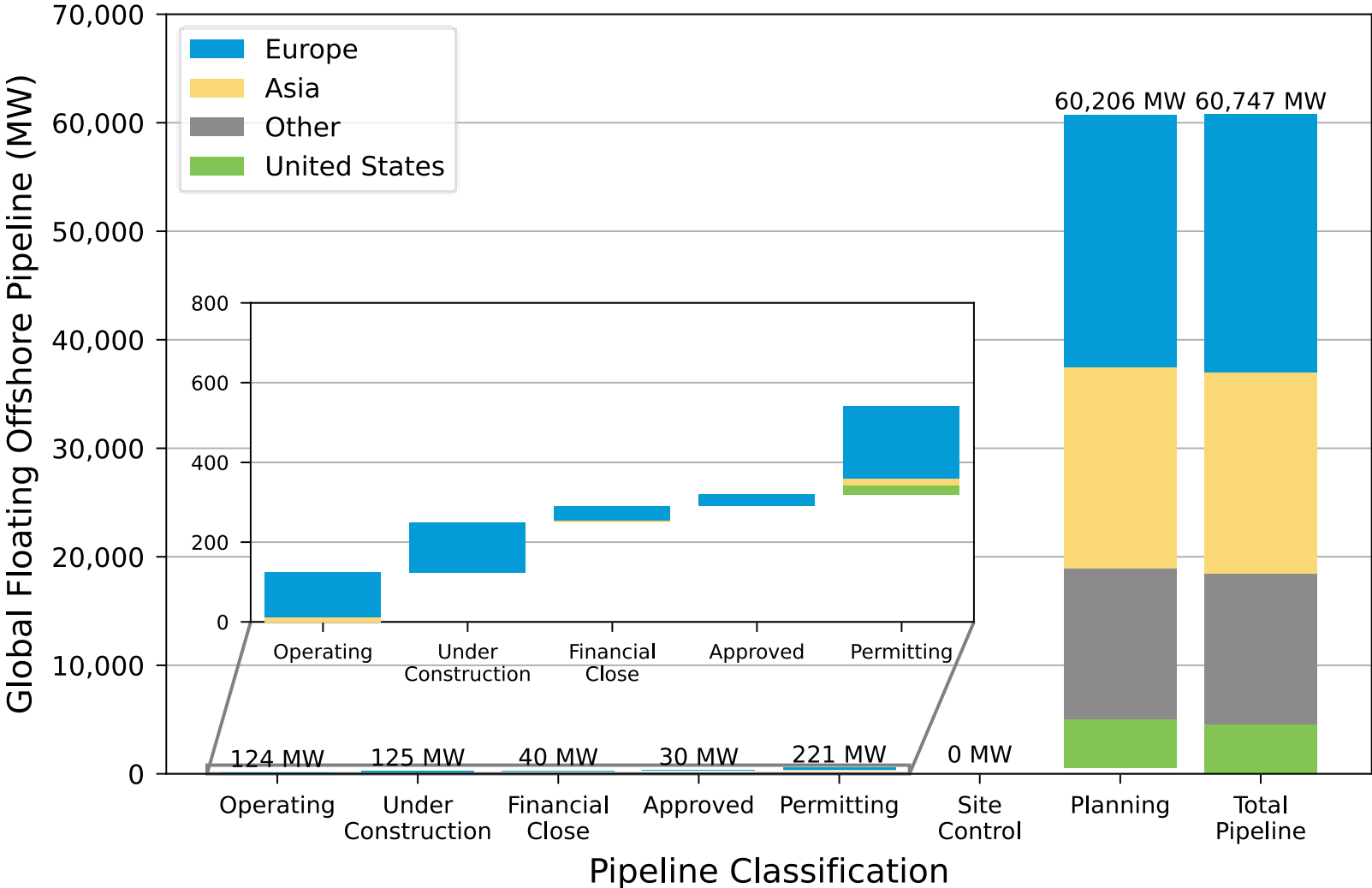


Kincardine 47.5-MW Floating Offshore Wind Plant

Photo courtesy of Principle Power Inc.

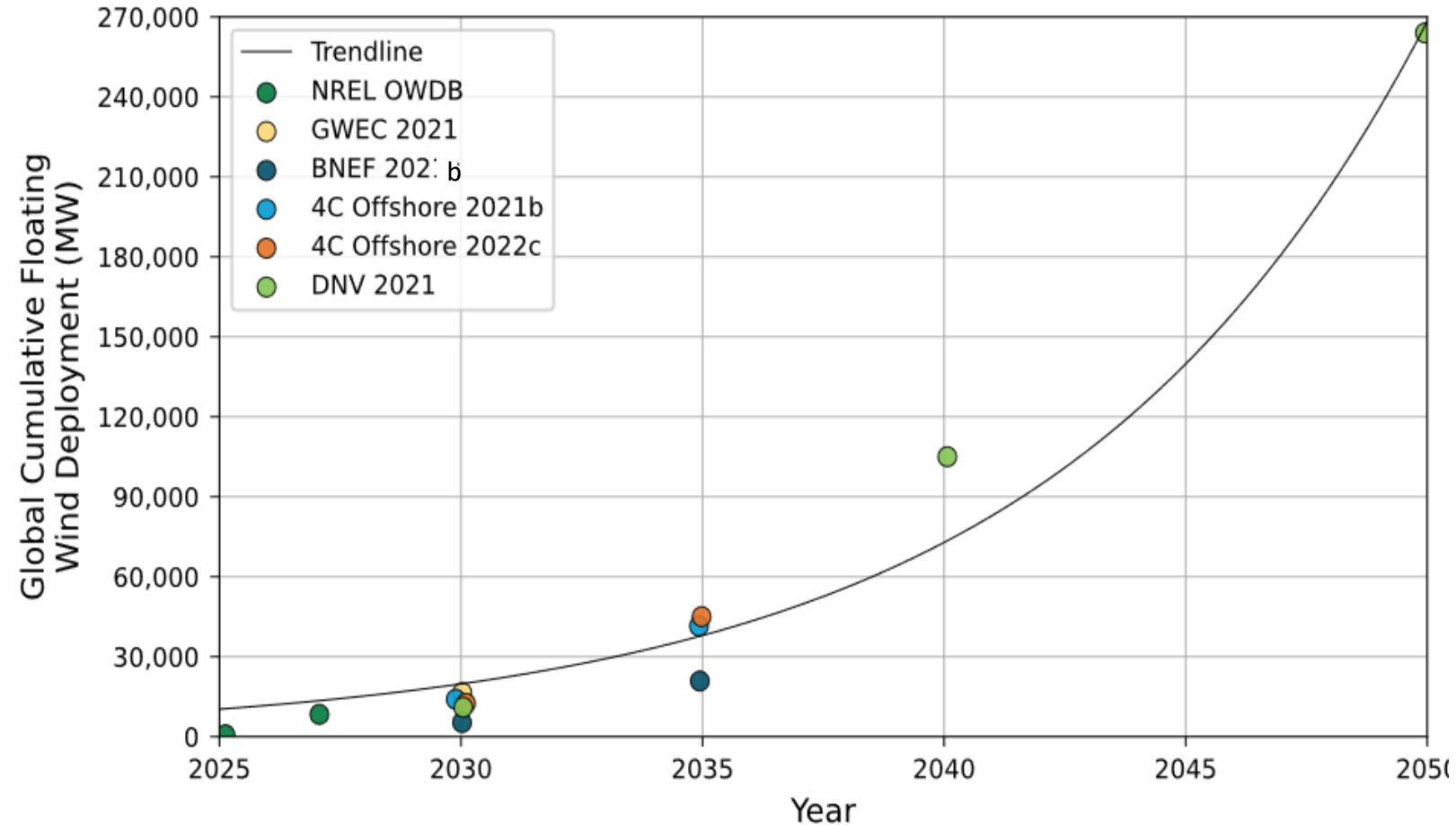
Global Floating Offshore Wind Energy Pipeline More Than Doubled in 2021

- The global pipeline for floating offshore wind energy grew by approximately 125% in 2021, from 26,529 MW to nearly 60,747 MW.
- The growth represents an additional 34,217 MW since the “Offshore Wind Market Report: 2021 Edition.”
- This growth is attributed to several new projects in South Korea, the United Kingdom, Brazil, and Australia beginning their planning phase during 2021.



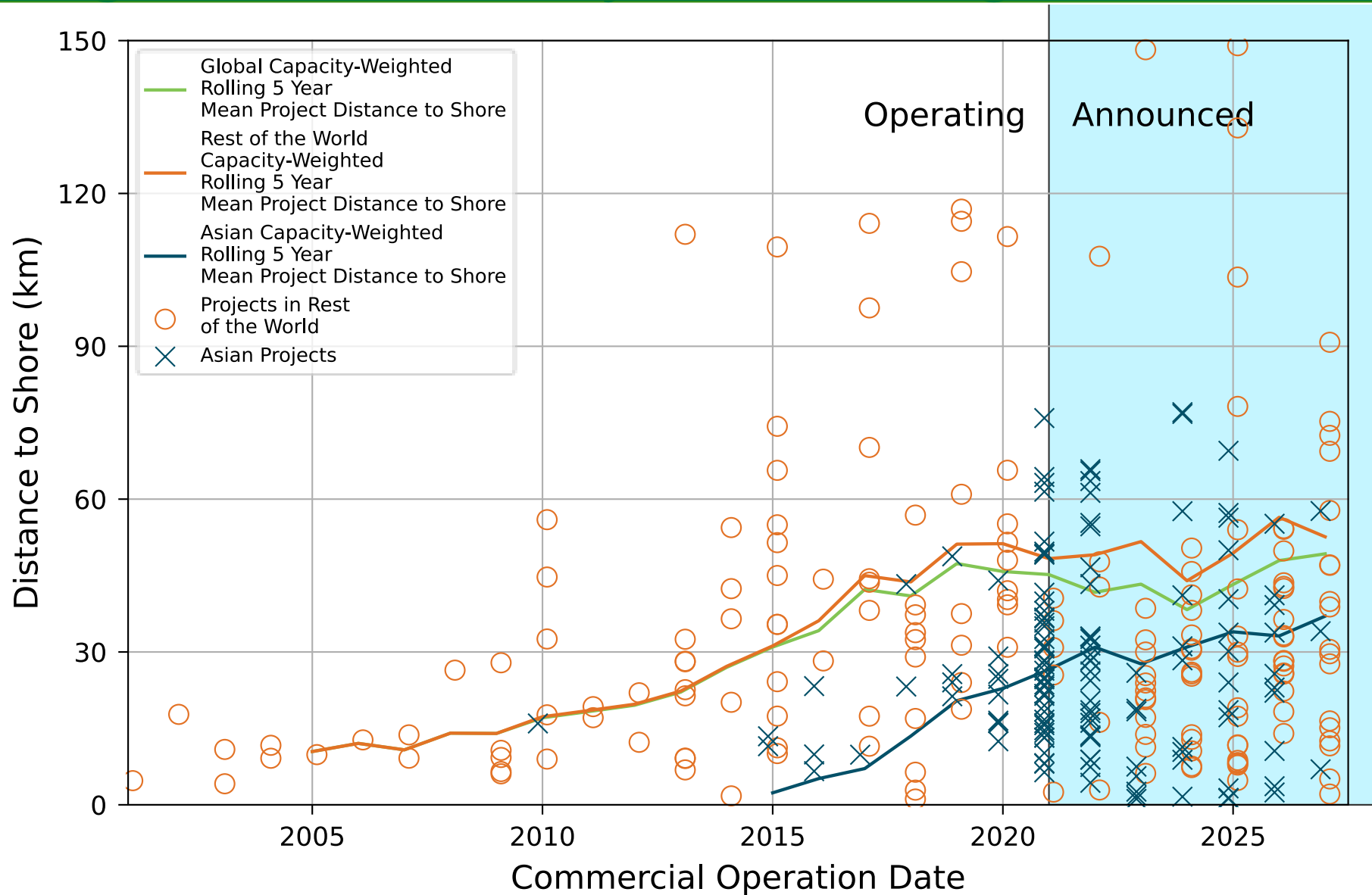
Long-Term Floating Offshore Wind Energy Deployment Forecasts Are Trending Upward With Predicted Deployment of up to 264 GW by 2050

- Five independent forecasts on floating offshore wind deployment from 2025 to 2050 show about 10 GW by 2030 to 264 GW by 2050 (Snieckus 2022).
- Market growth can be attributed to declining costs due to:
 - Industry commercialization and supply chain maturity
 - Growing scarcity of shallow, fixed-bottom sites
 - Floating-specific technical innovation
 - Interest from new markets where only deepwater sites are available, such as the U.S. Pacific.

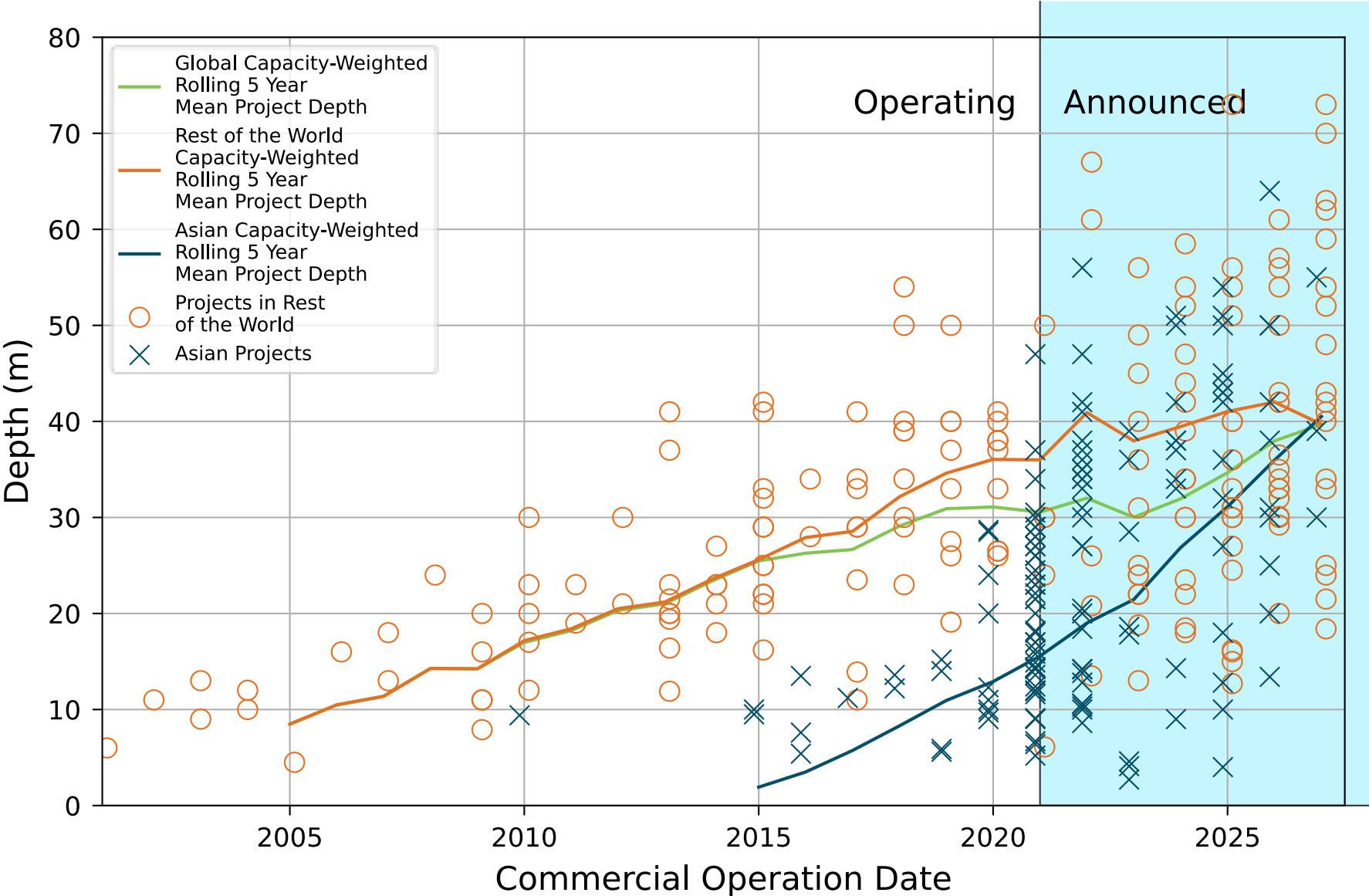


2021 Offshore Wind Technology Trends

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

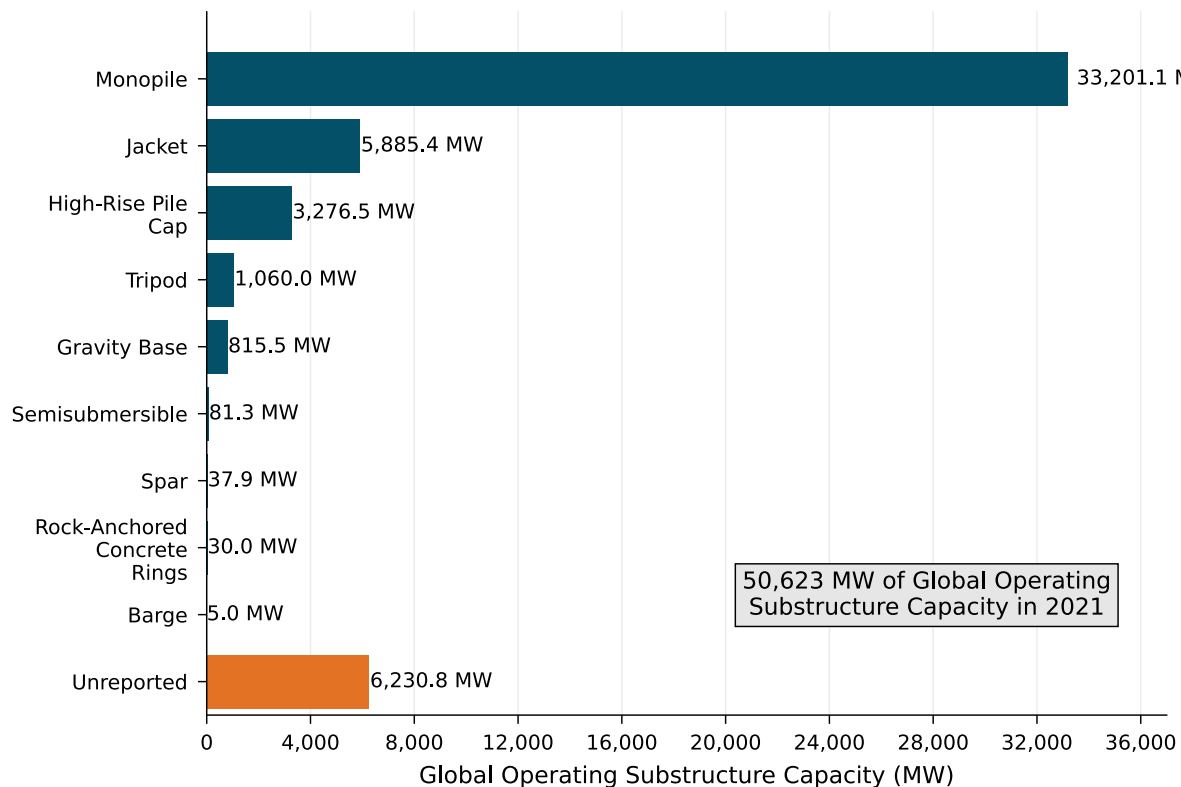


European Offshore Wind Energy Data Indicate That Average Water Depth Is Leveling Off While Asian Projects Are Still Trending Toward Deeper Water

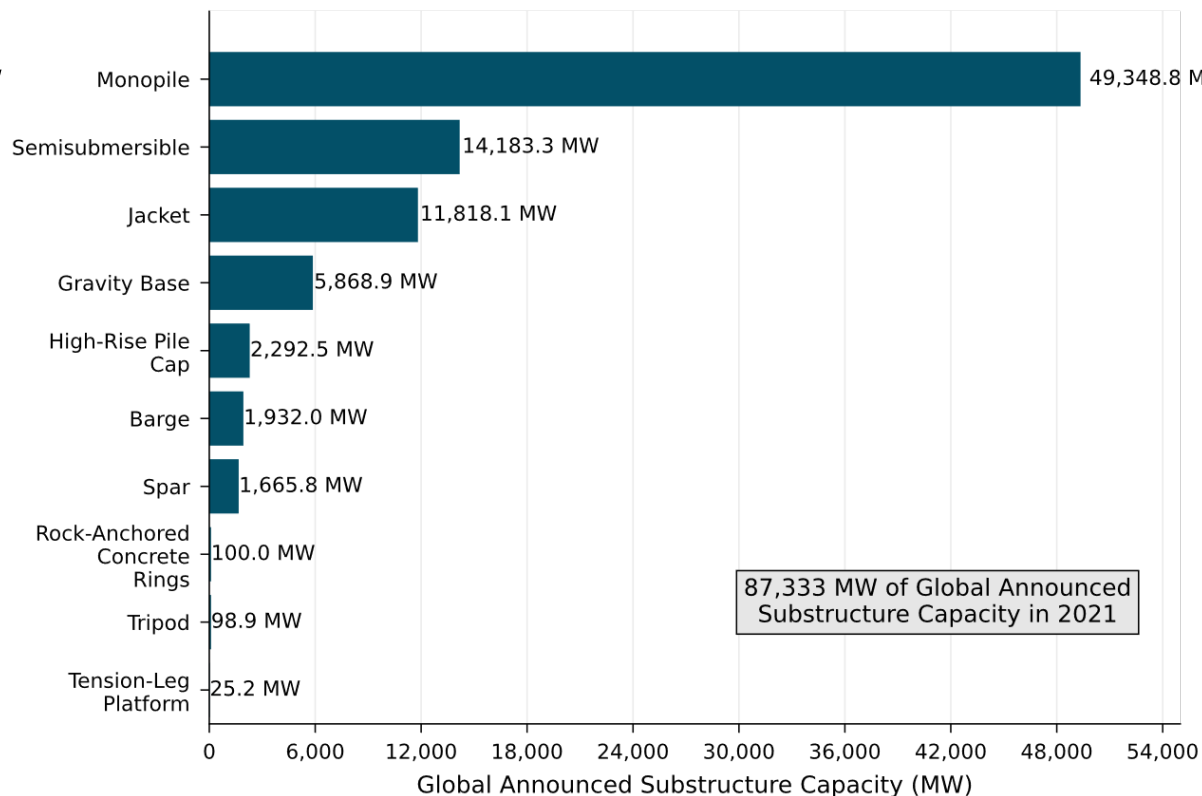


Market Trends Show Increasing Diversity of Substructure Types

With Monopiles Maintaining Dominant Market Share

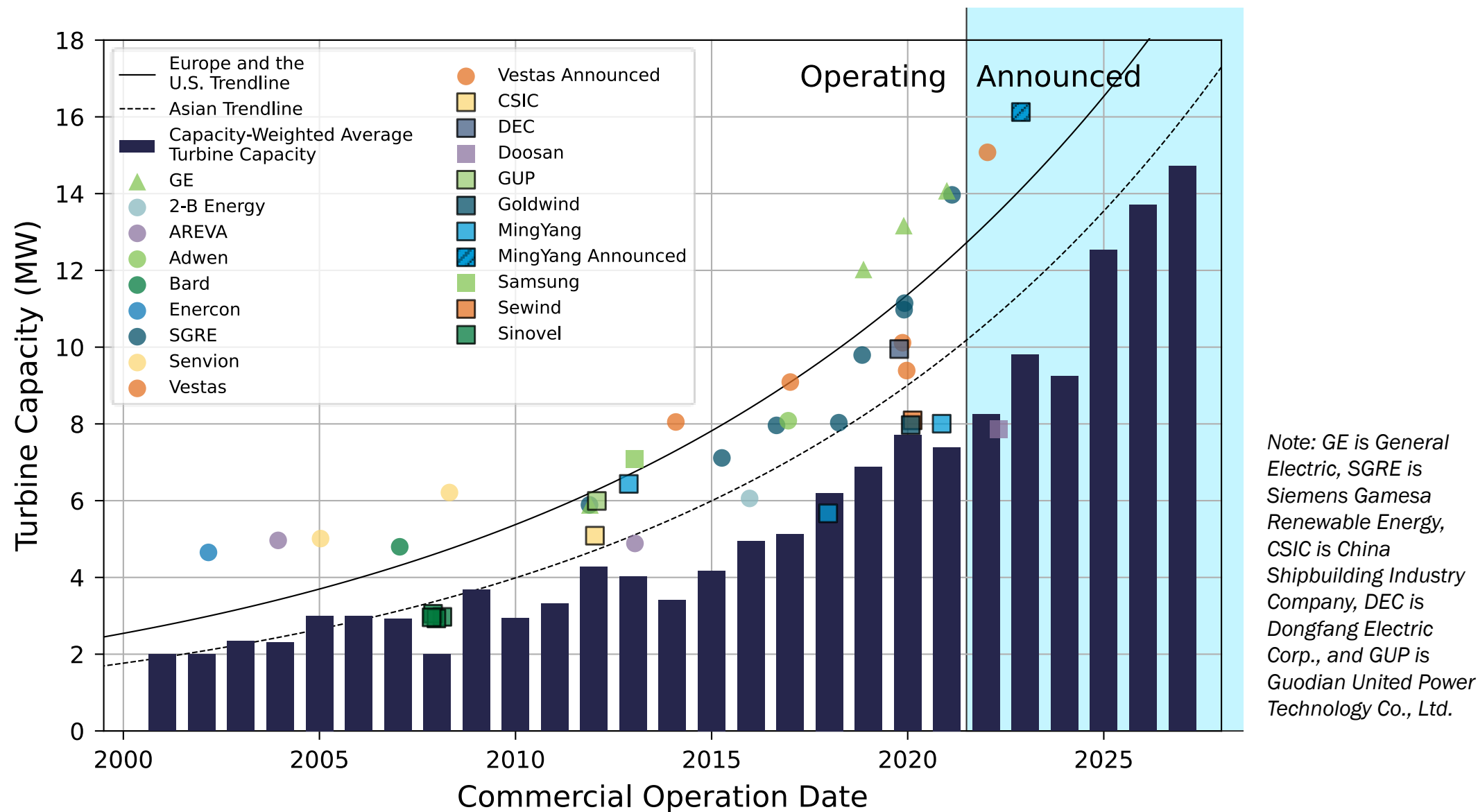


Operating offshore wind substructure technology

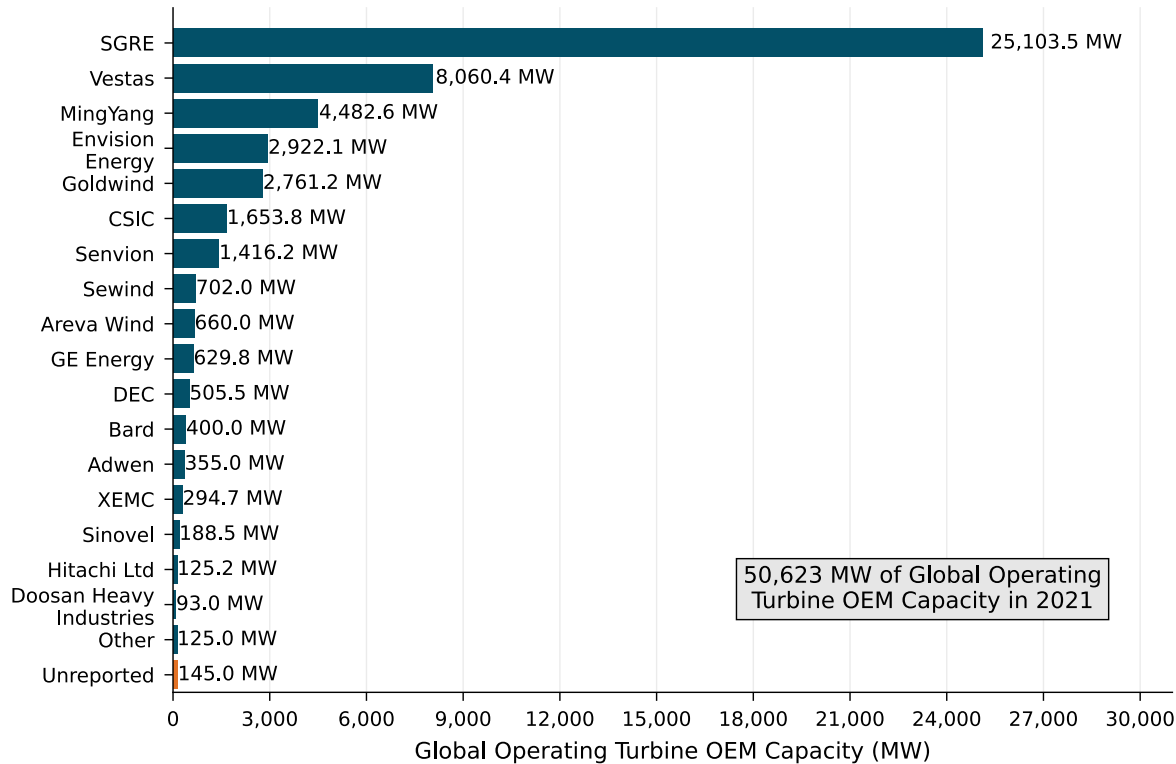


Announced offshore wind substructure technology for future projects

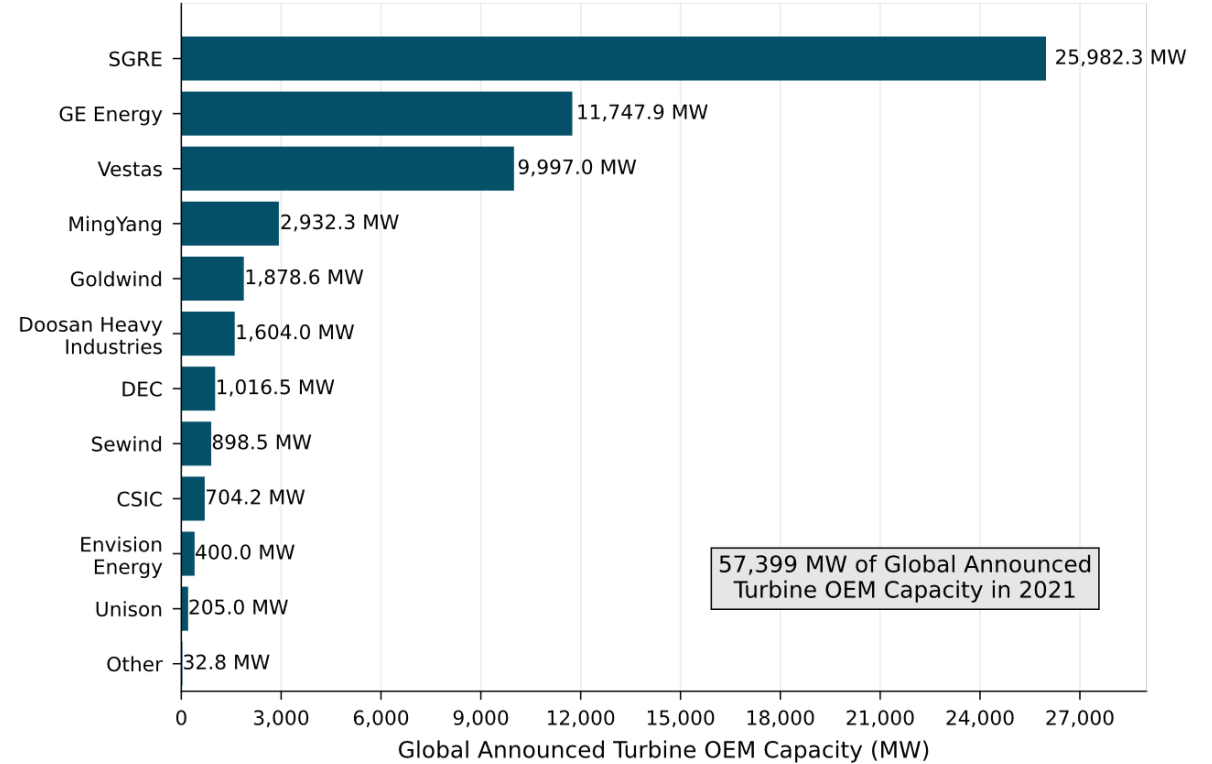
Comparison of New Offshore Wind Turbine Prototypes With Average Commercial Offshore Turbine Size Shows a Trend Toward Larger Machines



Market Trends Show Increasing Diversity of Turbine Manufacturers, With Siemens-Gamesa (SGRE) Maintaining Major Market Share



Offshore wind turbine manufacturer market share for operating projects

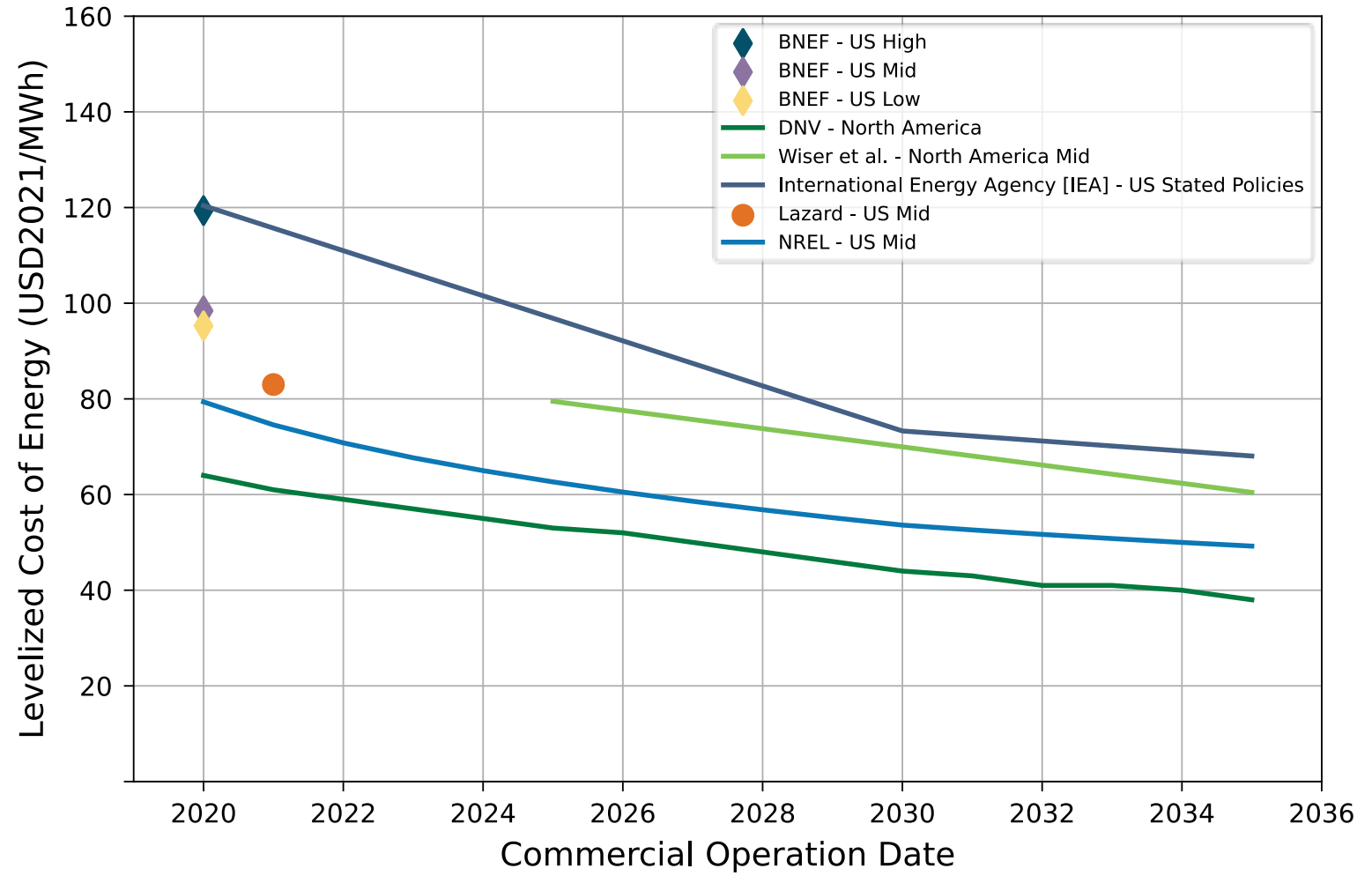


Offshore wind turbine manufacturer market share for announced projects

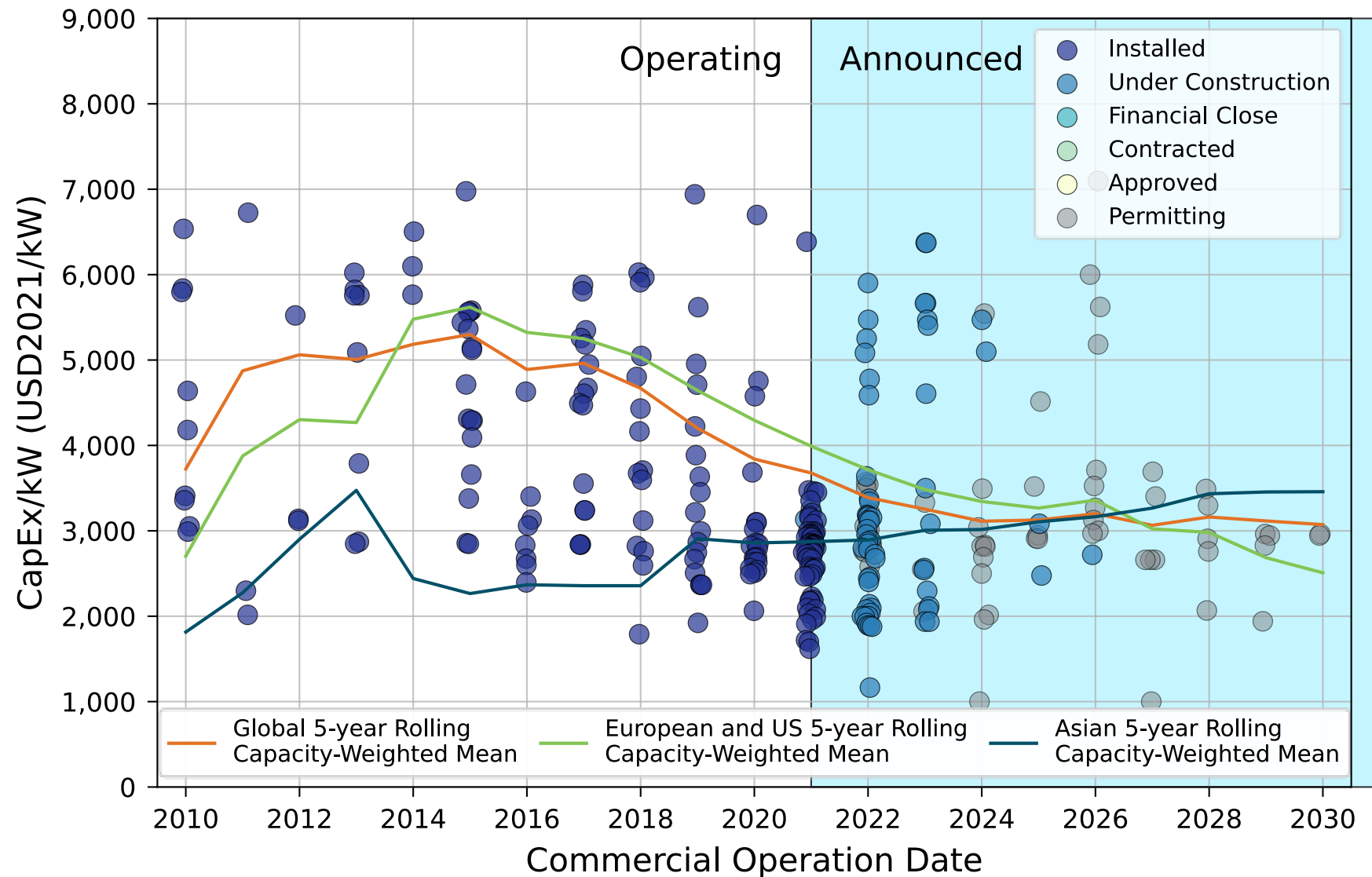
2021 Offshore Wind Cost Data

Cost Estimates for U.S. Fixed-Bottom Offshore Wind Projects Declined 13% Since 2020

- The estimated levelized cost of energy (LCOE) for fixed-bottom projects commissioned in 2021 has declined to \$84/megawatt-hour (MWh) on average, with a range of \$61/MWh to \$116/MWh globally.
- This decline represents a reduction of 13% on average compared to 2020.
- The total cost reduction since 2014 is more than 50% (Wiser et al. 2021).
- Industry experts estimate that levelized cost of energy will be \$60/MWh on average by 2030.

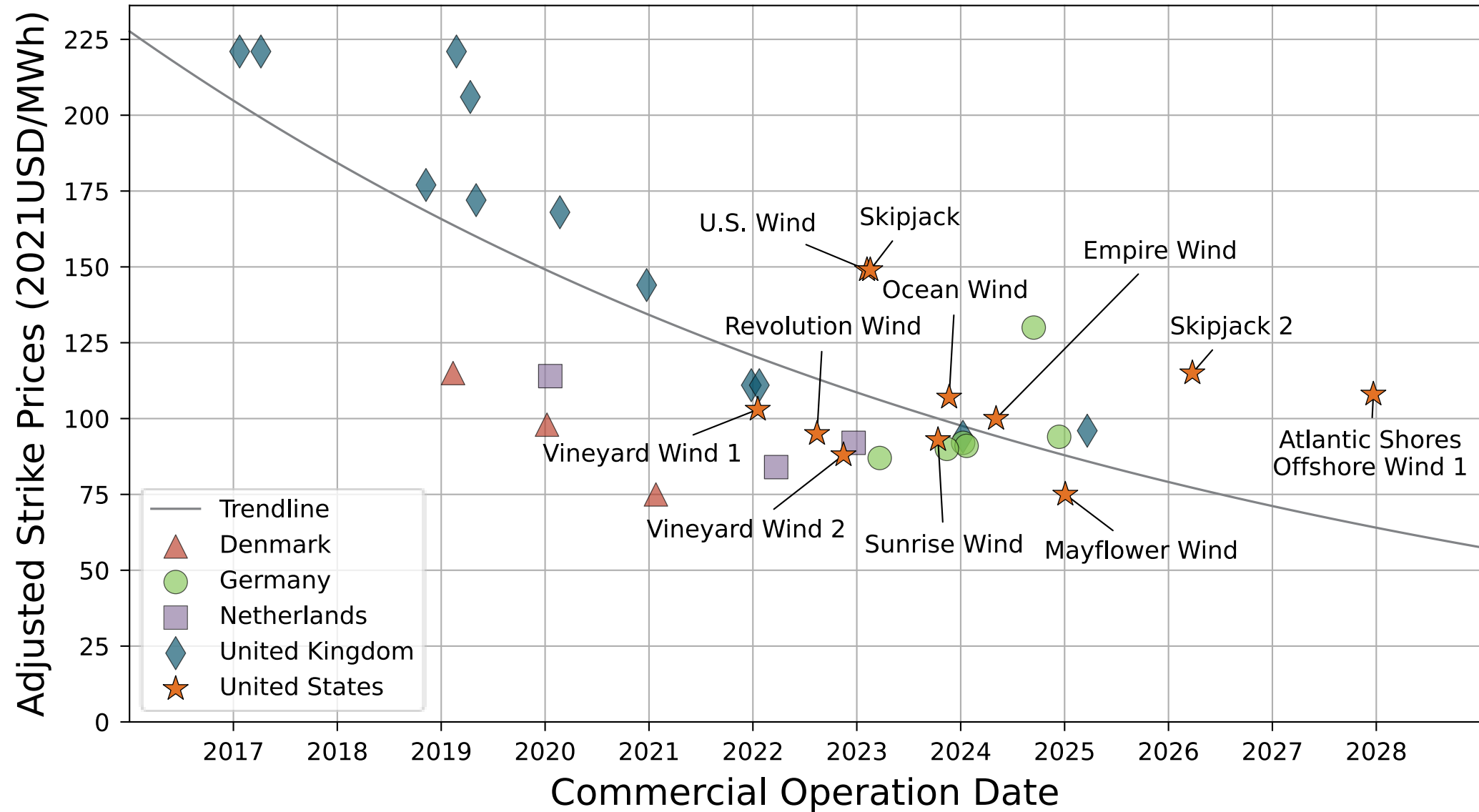


The Capacity-Weighted Average CapEx for Offshore Wind Reached About \$3,700/kW in 2021 Globally, and Just Below \$4,000/kW in Europe and U.S.



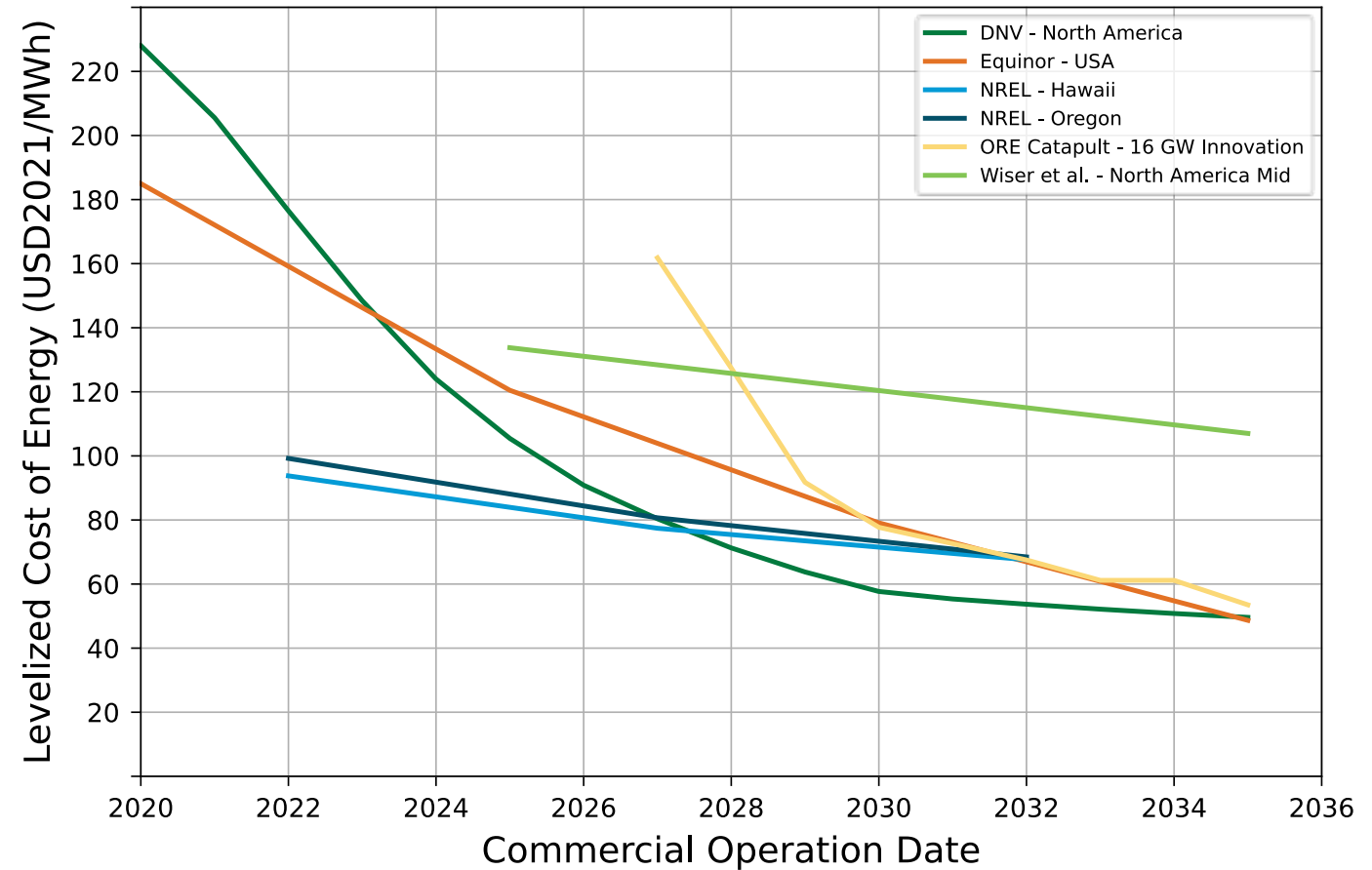
CapEx = capital expenditures

Adjusted Strike Price Comparisons Indicate U.S. Projects Prices Are In Line With European Offshore Wind Procurements



Global LCOE Estimates for Floating Offshore Wind Energy Indicate Cost Could Decline to as Low as \$55/MWh by 2030

- Floating offshore wind LCOE is estimated to decline from approximately \$200/MWh (2021) to \$55–\$100/MWh (2030).
- Estimates assume commercial-scale floating wind power plants and mature industry supply chains.
- Technology-specific cost reduction potential includes:
 - Leveraged cost reductions from fixed-bottom systems
 - Use of existing supply chains
 - Optimization of floating structures
 - Reduced complexity of construction at sea (e.g., quayside assembly)
 - Accessing higher wind speeds.



Notice

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