Economic Review and Outlook for Eastern U.S. Offshore Wind Generation

PRESENTED BY

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Brattle

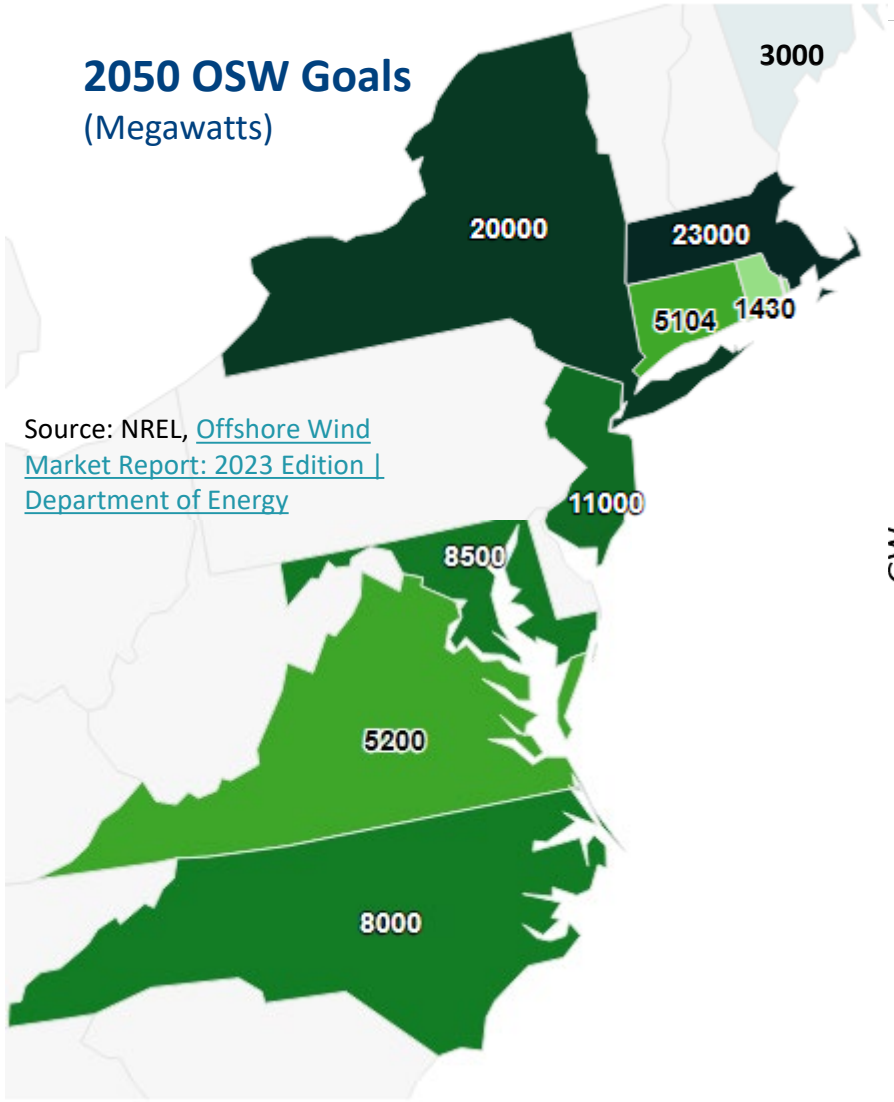
Executive Summary

The last few years have been exceptionally challenging for offshore wind developments due to forces affecting the entire electricity industry:

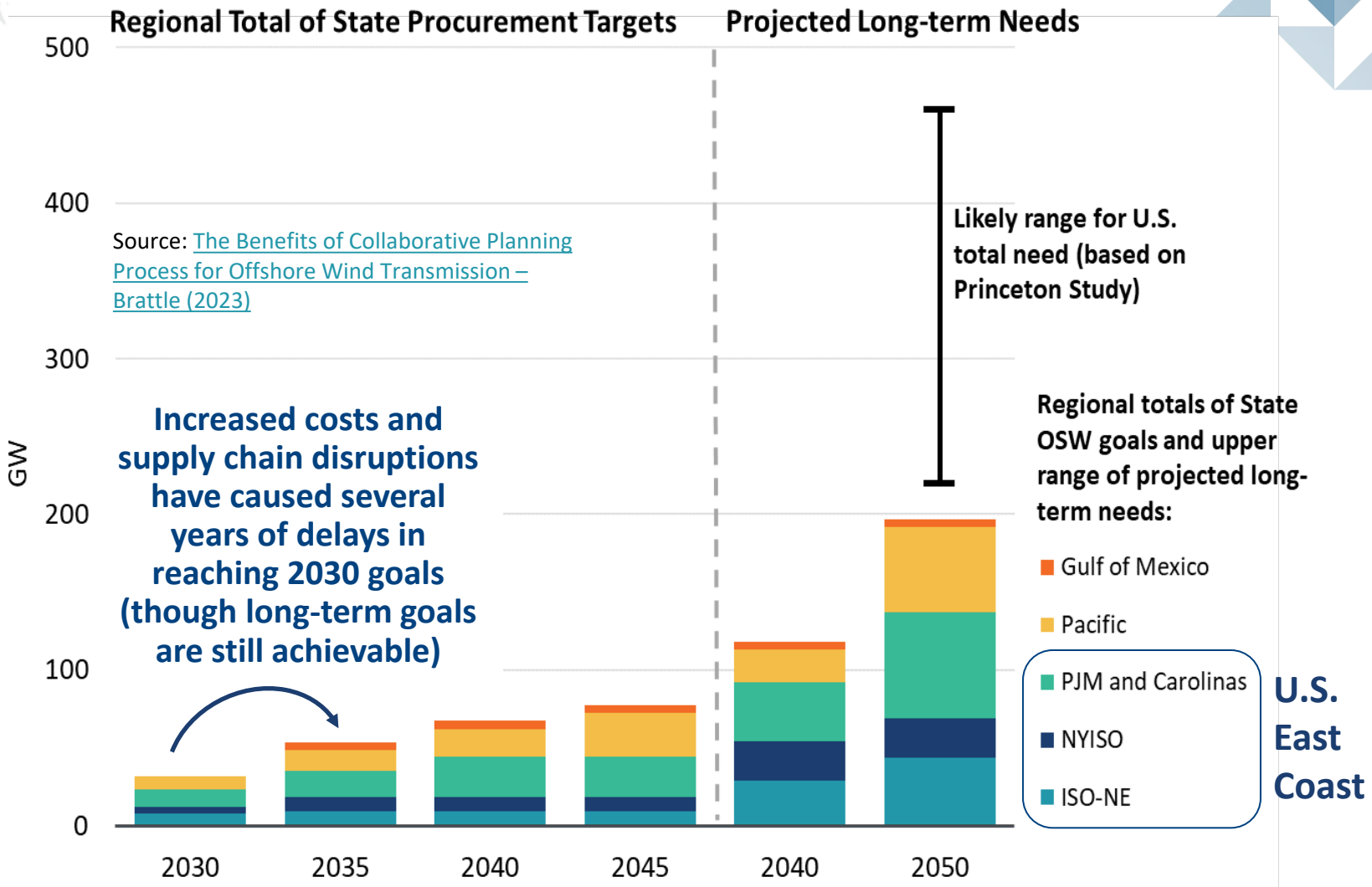
- Global supply chain challenges, cost escalations, and higher interest rates have substantially increased the cost-of developing all new electricity infrastructure
- Supply-chain challenges have been particularly pronounced for U.S. OSW due to the combination of (a) high 2030 procurement targets worldwide and (b) nascent domestic supply of turbines, blades, vessels, and transmission equipment, and (c) highly specialized and rapidly evolving technology
- Impact will delay 2030 OSW goals by several years (so supply and demand can equilibrate)
- These cost escalations and disruptions were unexpected—although we saw similar cost escalation around 2008 for land-based wind generation and transmission
- Contract cancellations (i.e., project development delays) are unfortunate, but will help with supply-chain challenges
- Procurement goals should be maintained for a 4-5 GW/year “pipeline” of OSW projects that can support necessary supply-chain investments (and ease cost and schedule challenges in the years ahead)

Planned Eastern U.S. Offshore Wind Generation Through 2050

2050 OSW Goals
(Megawatts)



Source: NREL, Offshore Wind Market Report: 2023 Edition | Department of Energy



Source: The Benefits of Collaborative Planning Process for Offshore Wind Transmission – Brattle (2023)

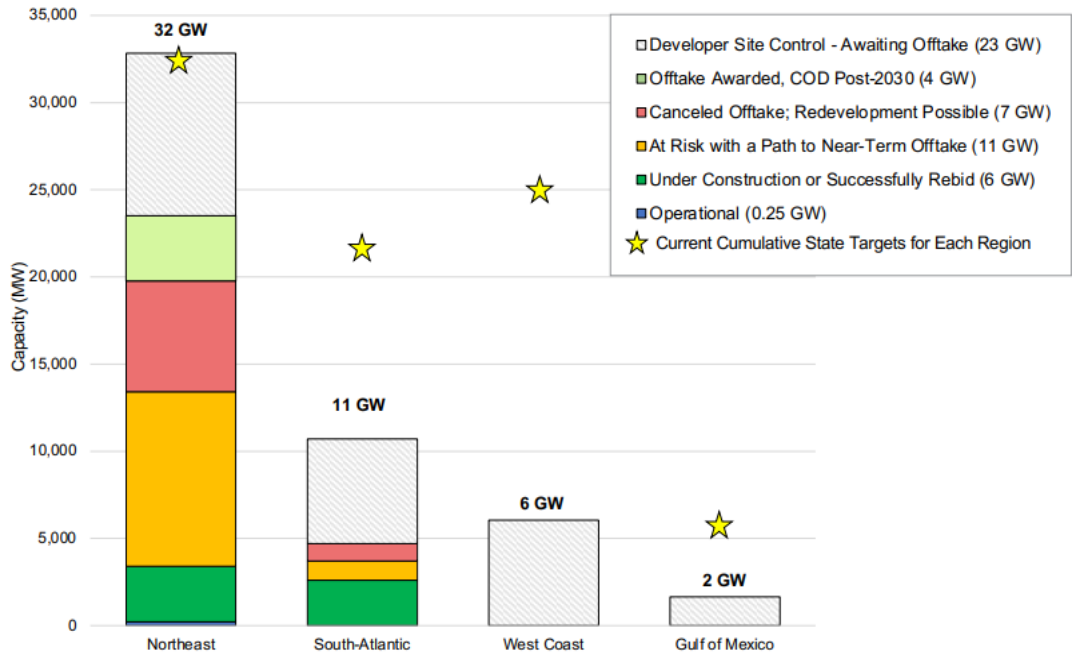
Increased costs and supply chain disruptions have caused several years of delays in reaching 2030 goals (though long-term goals are still achievable)

Note: most of the OSW generation will need to be delivered to shore; some may be used to produce hydrogen

Status of Current Projects and Updated Outlook

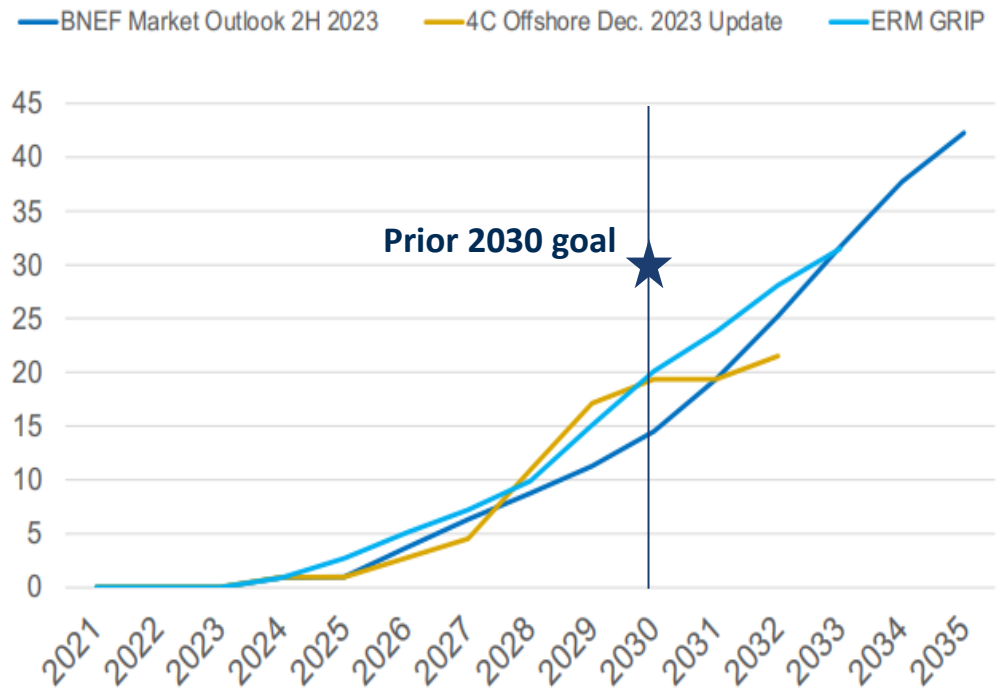
Despite delays in 30 GW goal, the development pipeline for OSW generation remains robust

Figure 7 – U.S. project pipeline: April 2024 snapshot



Note: Northeast refers to Northeast census region (states from ME to NJ), South Atlantic relates to South Atlantic census division (MD to FL)
Source: DOE Analysis

Figure 6 – Near-term U.S. offshore wind deployment: Industry forecasts as of Q1 2024[4]



Note: Forecasts extend only through 2032-35, due to limited visibility into project pipeline beyond ~10 year time horizon

Data Source: BNEF Market Outlook, 4C project pipeline, ERM project pipeline

Source: DOE, April 2024, Offshore Wind Deployment - Pathways to Commercial Liftoff (energy.gov)

Impact of Equipment Cost Escalation and Supply Chain Disruptions

Cost of Electrical Equipment: Increased 40% since 2021

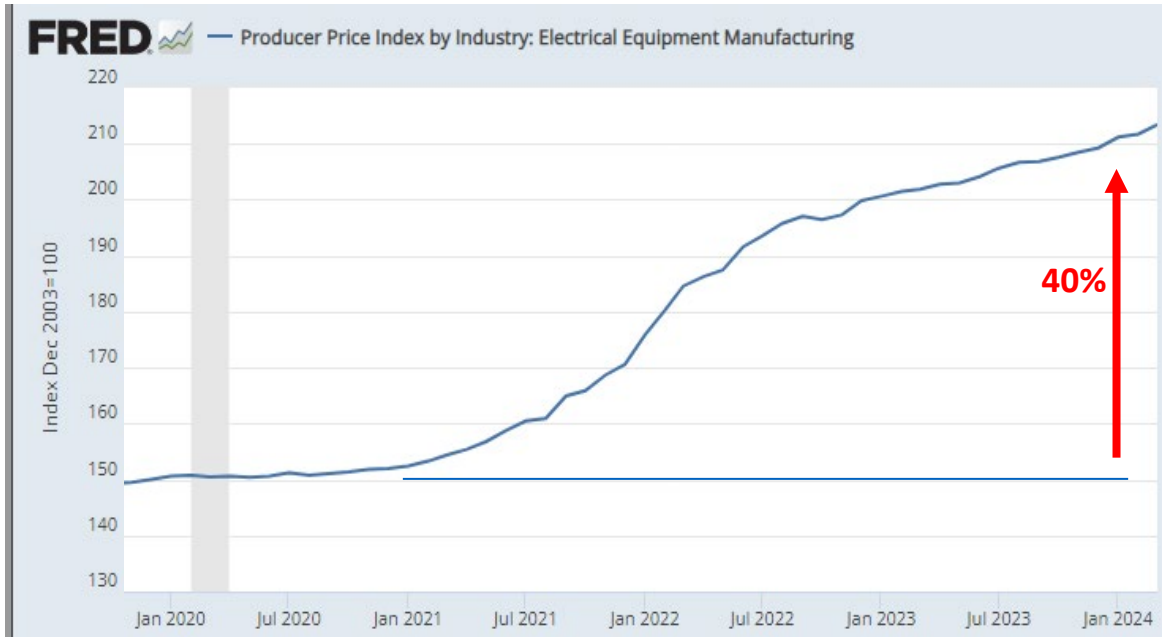
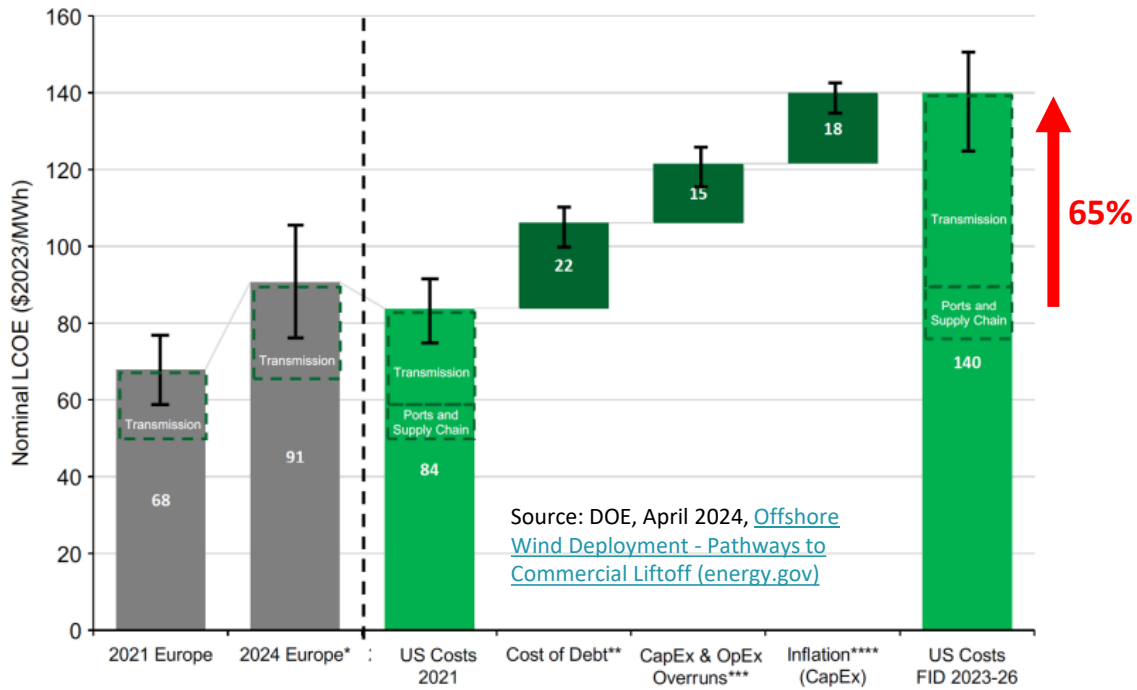


Figure 11 – Historical cost increases affecting "Tranche 2" projects, 2021-2024

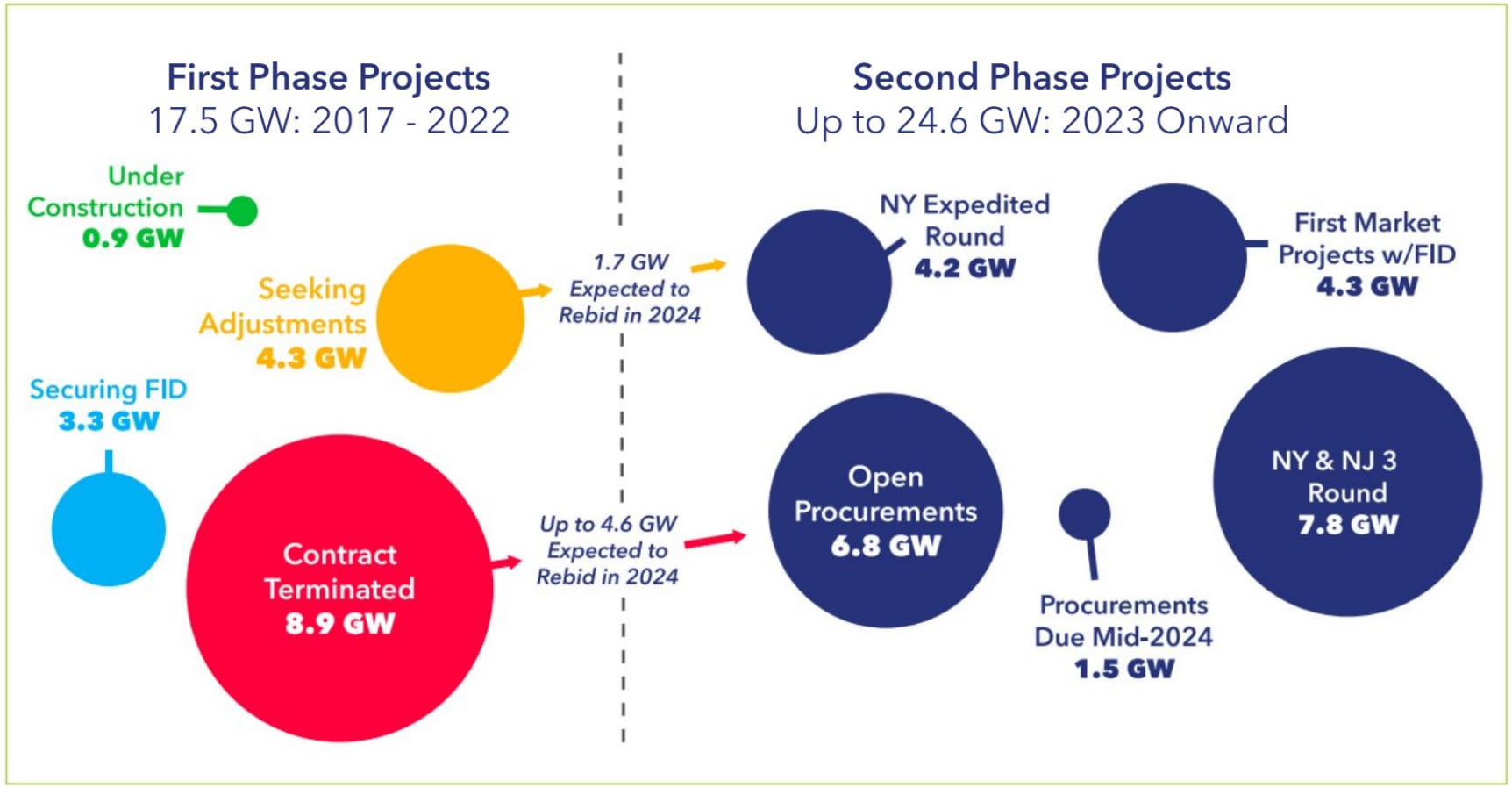


Data source: DOE analysis, quarterly earnings reports, public utilities commission filings

Equipment cost escalation and supply chain disruptions have affected the entire electricity industry, significantly increasing costs for new generation and transmission projects

- Offshore and onshore renewable generation projects have been affected as well – although supply chain challenges are more severe for offshore facilities and installation (and worsened by high international demand)
- Significantly higher financing costs further add to increased PPA prices, possibly doubling the total costs for technologies with high investment cost (and low variable costs), such as renewable generation

Resulting impacts: 2023 Termination of OSW Contracts



Source: [2024 U.S. Offshore Wind Market Report - Oceantic Network] (Feb 2024)
Does not reflect additional adjustments to NY OSW procurement in early 2024.

In 2023:

- Developers terminated 51% of OSW contracts and seeking financial support for 24%
- This has pushed back development timeline for first 30 GW beyond 2030

Still, by 2025:

- 20-25 GW will likely be procured by states
- 14 GW likely fully permitted

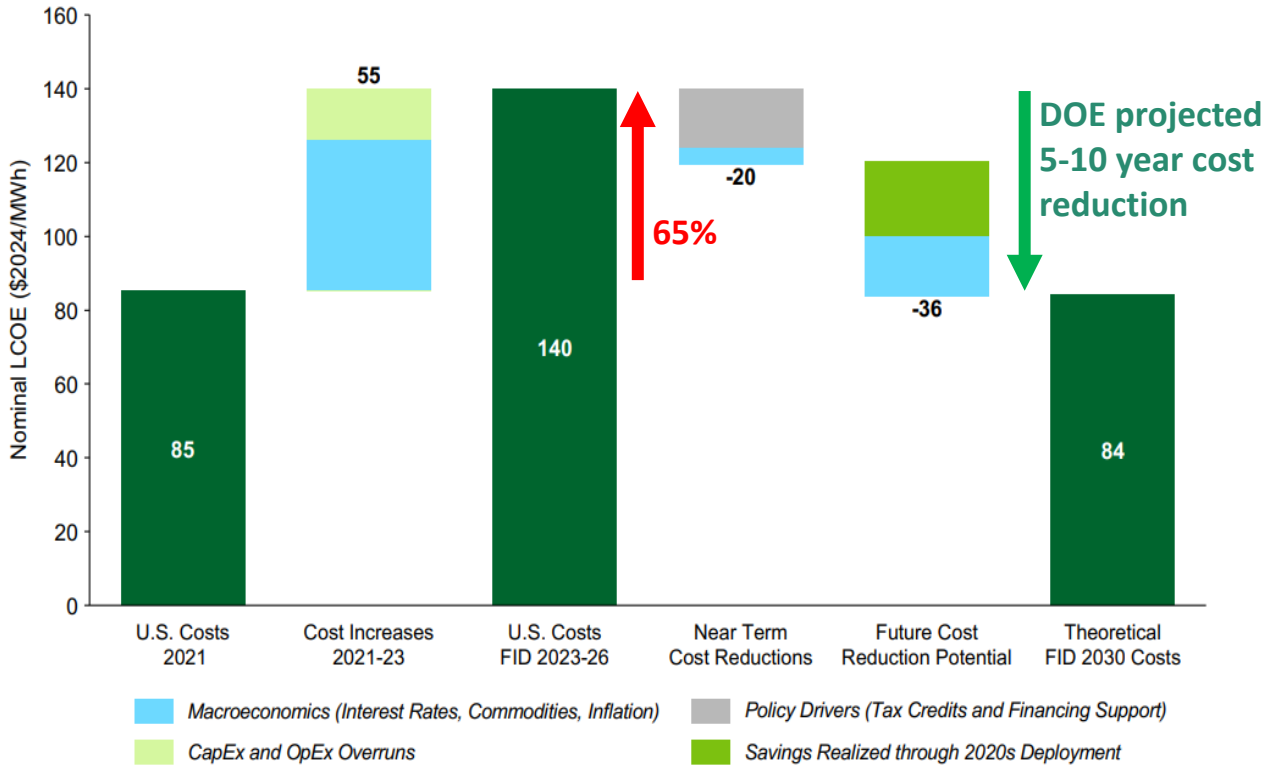
In the meantime:

- Investments in OSW equipment manufacturing, harbors, and vessels are easing supply chain constraints

Higher Costs and Supply Chain Challenges are Hoped to Subside

DOE Estimate of 2023-26 and 2030 OSW Costs (per MWh)

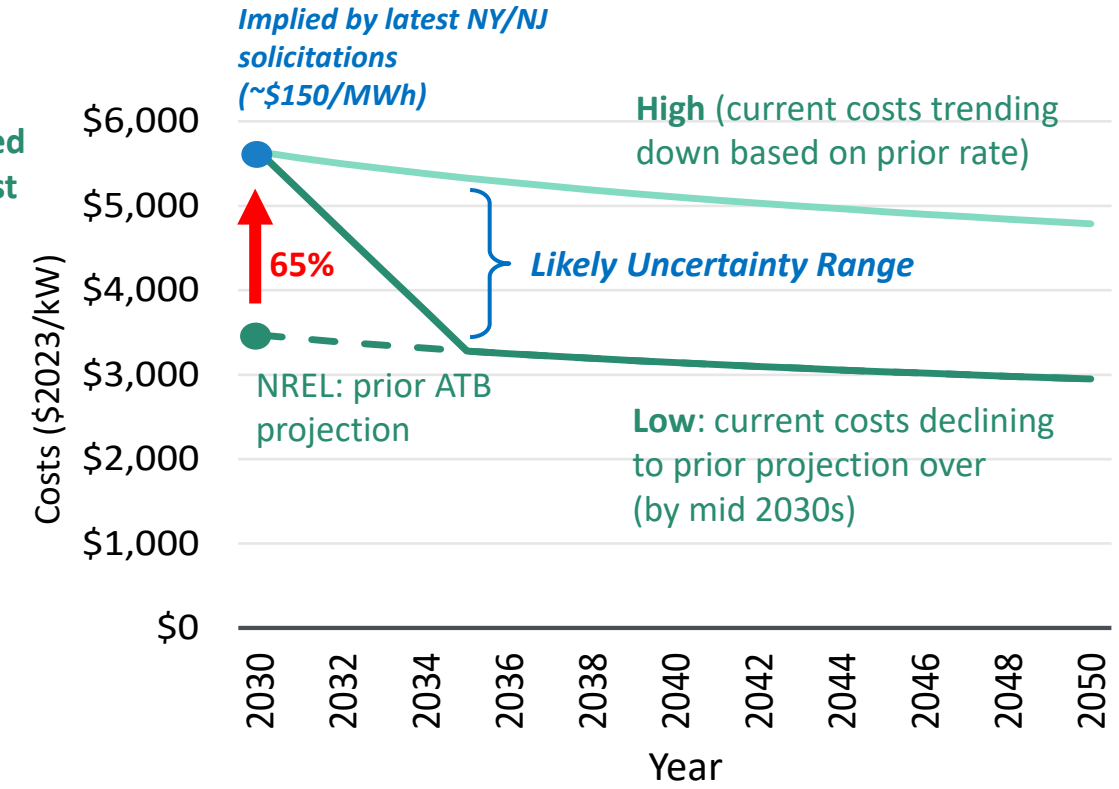
E.S. Figure 3 – Historical cost increases for a representative 2020s project, and cost reduction levers for future projects (FID 2030+)



Data source: DOE analysis, quarterly earnings reports, public utilities commission filings

Source: DOE, April 2024, Offshore Wind Deployment - Pathways to Commercial Liftoff (energy.gov)

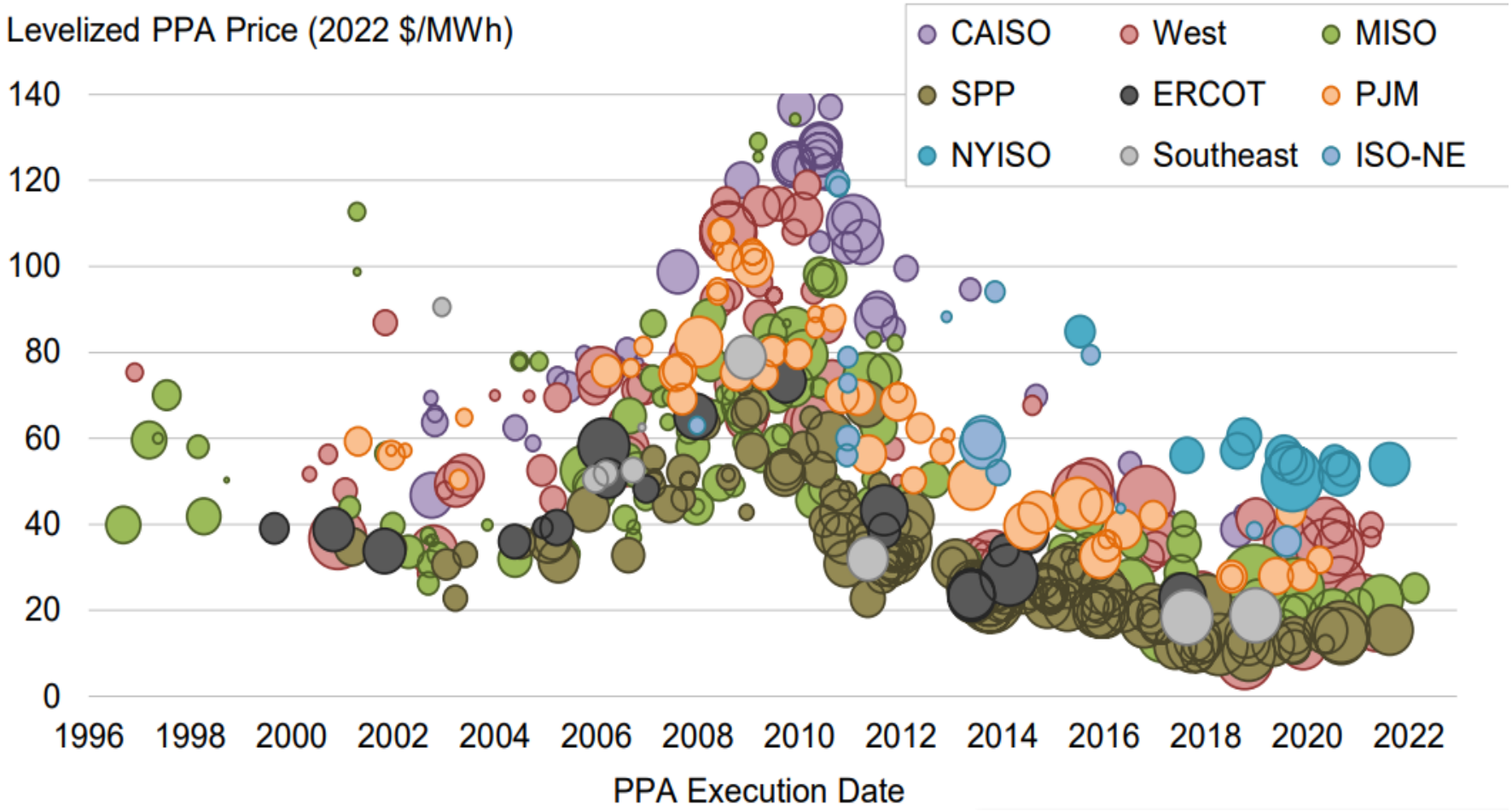
Brattle Range of 2030+ OSW Development Costs ($/kW installed)



Source: Brattle Group Analysis

We've Been There Before: 2010 Spike in Onshore Wind Costs!

Power Purchase Agreement (PPA) Prices for Land Based Wind



Inflationary spikes in project development costs have similarly affected land-based wind generation (and other electrical infrastructure) after the 2008 recession

- The spike in wind generation procurement costs lasted approximately 5 years
- By 2012, PPA prices were lower than in 2006

Source: NREL, https://emp.lbl.gov/sites/default/files/emp-files/land-based_wind_market_report_2023_edition_final.pdf

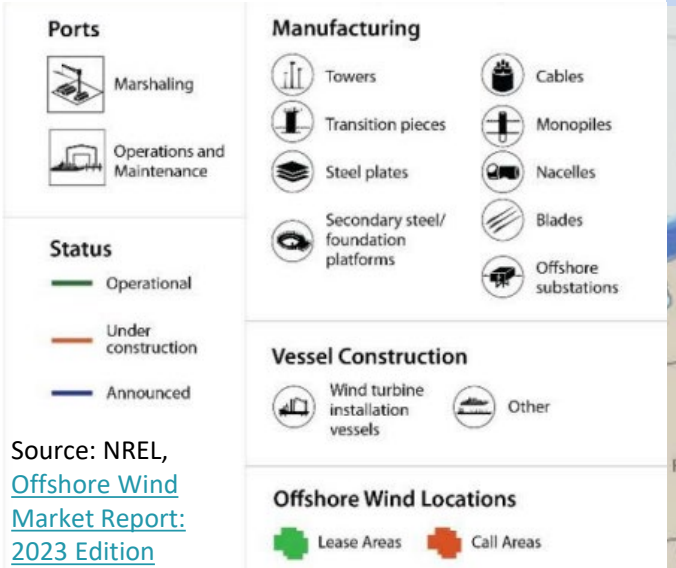
U.S. OSW Supply Chain is Slowly Getting Built

Progress is being made:

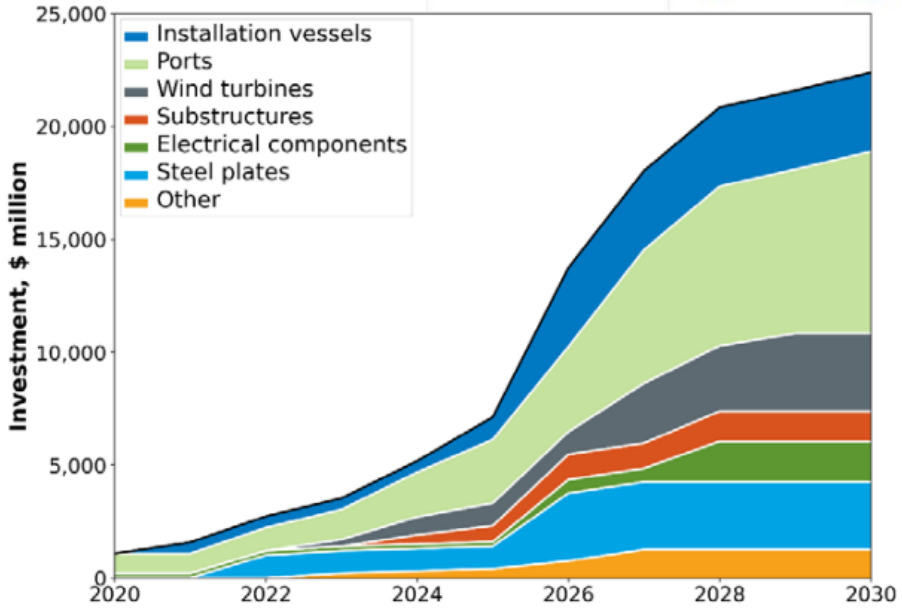
- Significant numbers of U.S.-flagged OSW vessels have been commissioned, announced, or are under construction
- Almost $10 billion in OSW port and supply-chain investment since 2020

- NREL estimates at least $22 billion in ports, large installation vessels, and major manufacturing facilities would be needed to achieve the 30 GW OSW target

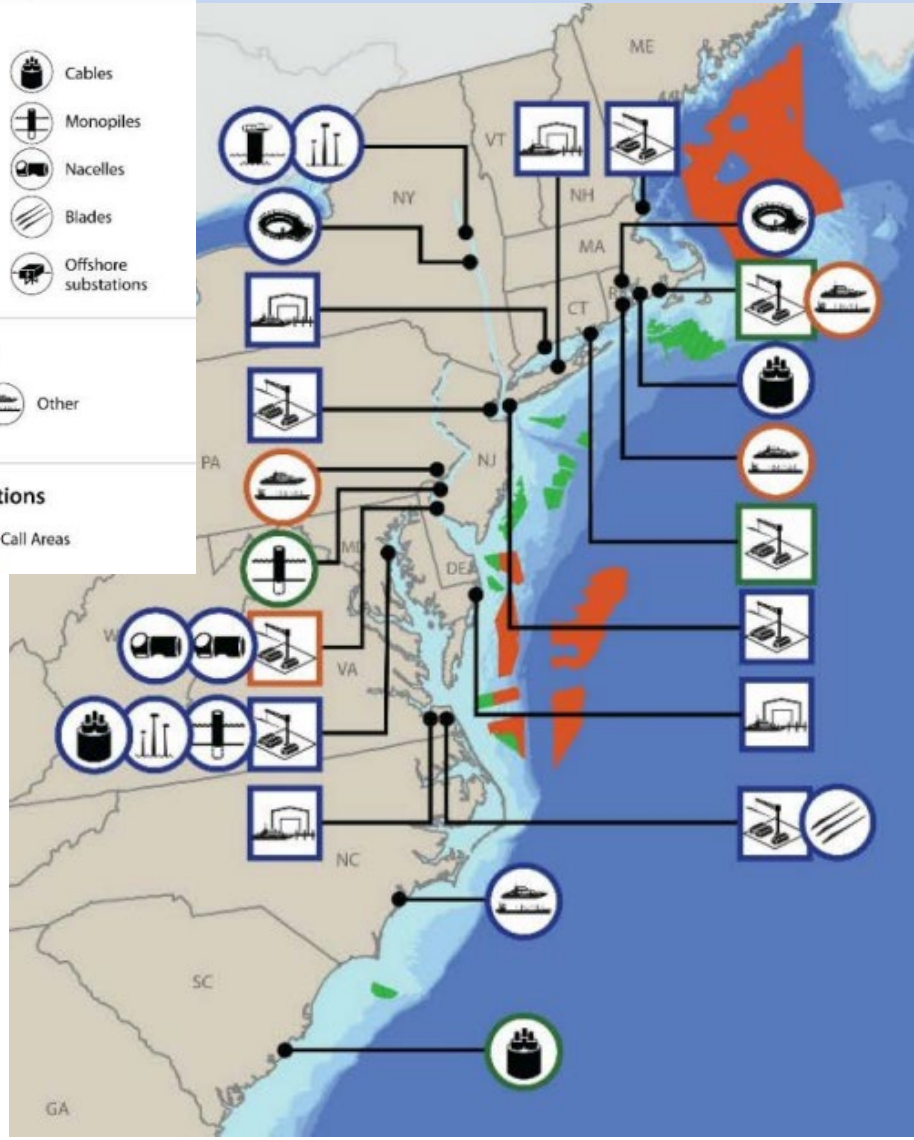
Source: A Supply Chain Road Map for Offshore Wind Energy in the United States (nrel.gov)



Source: NREL, Offshore Wind Market Report: 2023 Edition

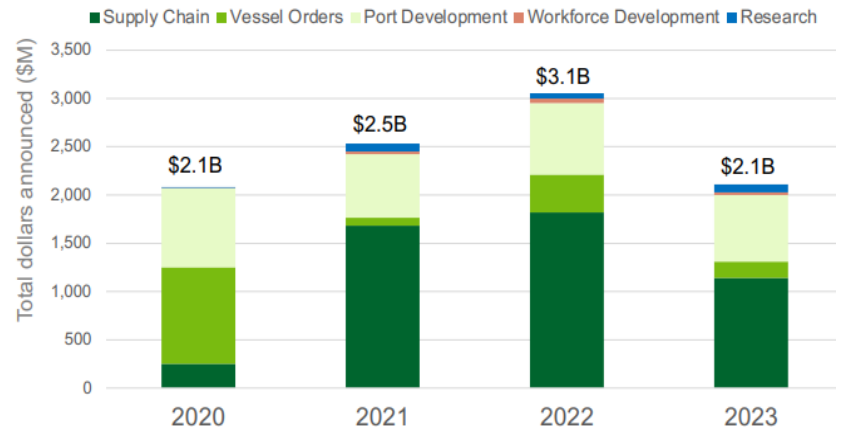


Announced and active port, vessel, and supply chain activity



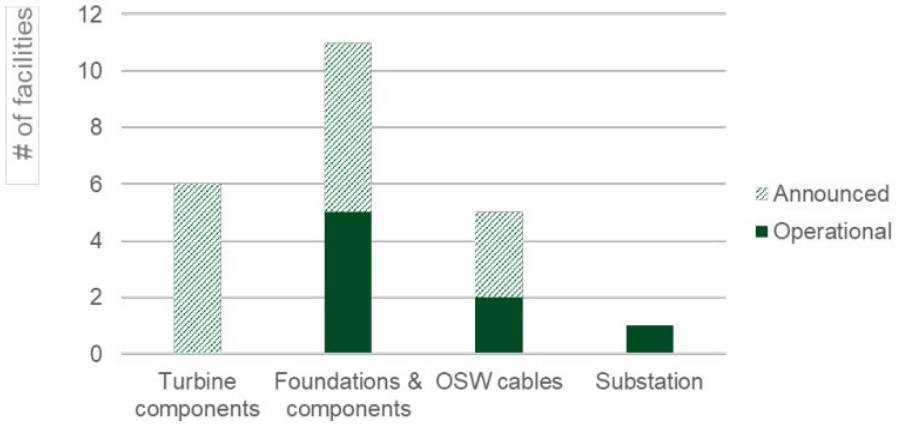
DOE's OSW Liftoff Report: Progress is Being Made

Figure 18 – Recent supply chain investments, based on manufacturing announcements



Data Source: Oceantic 2024 Offshore Wind Market Report

Figure 19 – Announced and operational manufacturing facilities for offshore wind components[7]



Challenge	Solutions Underway
1. **Recent offtake cancellations, driven by macroeconomic conditions, create timing uncertainty and funding gaps for sector buildout.**	• Competitive procurements ("re-bids") for 2020s projects that secured offtake pre-2023 • Revised projects that are deliverable under current market conditions, and that reaffirm commitments to fund long-term enabling infrastructure (vessels, ports, etc.)
2. Current market structures expose the sector to exogenous risks and require early mover projects to carry the costs and execution complexity of **long-term industry** buildout **needs.**	• Improved sequencing of offtake with permitting and project FID • Offtake refinements to incorporate risk mitigations • Targeted investments in enabling infrastructure, especially during the pre-FID funding gap
3. **Industry lacks market visibility to plan long-term investment cases, especially for supply chain needs.**	• Clear procurement schedules that provide demand visibility and consistency • Collaboration to support supply chain and transmission buildout on a regional level • Industry consensus on technology specifications and standards for supply chain buildout
4. **Transmission risks development bottlenecks and grid inefficiencies via onshore interconnection, offshore project design, and wider network buildout.**	• Coordinated POI identification and solicitations for onshore upgrades across multiple OSW projects • OSW project sizes and standards tailored to low-cost offshore transmission and efficient interconnection • Mobilization of interregional transmission planning

Source: DOE, April 2024, Offshore Wind Deployment - Pathways to Commercial Liftoff (energy.gov)

Challenges Ahead

Despite the progress that has been made, OSW generation development continues to face challenges:

1. Supply chain: challenges remain, have increased costs and delayed OSW schedules by several years
2. Lease areas: undersupplied in some regions, which has increased lease auction procurement costs
3. State procurements: not yet sufficiently coordinated and standardized (e.g., to allow for proactive planning and integration into a future offshore transmission network, though efforts are underway)
4. Grid connections: imposing delays and high costs, despite FERC orders and reforms
5. Holistic transmission grid planning: not yet fully embraced by East-coast regional grid operators; inter-regional planning largely ineffective; numerous studies (such as DOE AOWTS) not actionable
6. State permitting and community opposition: growing challenges, despite efforts to streamline state permitting (e.g., in NY and MA)

Unique Challenge: The silo-ed U.S. Lease and Procurement Process

U.S. separation of OSW leasing, procurements, and transmission planning is particularly challenging:

- **Lease area auctions** requires OSW generators to commit before they know which state will procure their generation, which ISO/RTO region to which they will have to deliver, and which transmission upgrades will be necessary to interconnect
- **OSW generator permitting**, including cable routes and applying for grid interconnections, will have to start before they know which state will procure their resources or how expensive interconnection-related upgrades will be
- **State procurements** of OSW generation before they know which generators from which lease areas will make the most attractive offer or how expensive the winner's interconnection costs will be
  - The number of OSW generators able to bid into state procurements is limited to those with nearby lease areas
  - Delivery infrastructure cannot be pre-developed because the location of winning bidders' lease areas will not be known until after the procurement is completed
- **Transmission solutions** can be finalized only after procurement decisions have been made, creating uncertainties about the feasibility and cost of onshore transmission upgrades for the selected POI

An integrated process (increasingly used in Europe) would resolve uncertainties prior to soliciation:

1. States make commitments on how much OSW generation they would like to procure over what timeframes (2030-2050)
2. BOEM develops specific wind energy areas for states that, at a minimum, can meet each state's commitments
3. States and ISOs/RTOs (in collaboration with BOEM) develop permittable and cost-effective transmission solutions (and costs) for delivering the OSW generation from designated lease areas to shore
4. States issue **one-stop solicitations** for the development of OSW generation within the state's specified wind lease areas (which already have permittable transmission and interconnection solutions)
   - More competitive procurements (because bidders are not limited to those with wind-energy leases)
   - Less risk for developers and states (because delivery routes are pre-permitted and cost-effective interconnection solutions are already specified)
   - Allows for pre-development of the delivery and transmission interconnection infrastructure

Recommendations

Challenges are not surprising given the early stage of the OSW industry. They can be addressed:

1. Maintain long-term procurement goals to support supply-chain investments (and enable cost reductions) for at least 4-5 GW of predictable annual U.S. OSW investments
2. Be flexible on development schedule (to avoid supply-chain bottlenecks and high costs)
3. Coordinate with other states to:
   - Optimize procurements and standardize requirements
   - Pre-plan OSW grid connections and cost-effective regional and interregional transmission solutions
   - Ensure ramp-up of OSW procurement goals does not exceed availability of BOEM lease areas (to avoid spikes in lease-auction prices)
4. Encourage efforts by grid operators/owners to (a) more proactively plan transmission needs and (b) enhance the capabilities of the existing grid (and better use of existing rights of way) through improved grid operations and advanced technologies
5. Work with DOE and others to coordinate supply-chain and grid-planning investments
6. Streamline state and local permitting; facilitate community engagement and support

Thank You!

Comments and Questions?

Additional links:

US Offshore Wind Transmission: Holistic Planning and Challenges

The Benefits of Collaborative Planning Process for Offshore Wind Transmission, Challenges, and Recommendations

About the Speaker

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Johannes (Hannes) Pfeifenberger, a Principal at The Brattle Group, is an economist with a background in electrical engineering and over twenty-five years of experience in wholesale power market design, renewable energy, electricity storage, and transmission. He also is a Visiting Scholar at MIT's Center for Energy and Environmental Policy Research (CEEPR), a Senior Fellow at Boston University's Institute of Sustainable Energy (BU-ISE), a IEEE Senior Member, and currently serves as an advisor to research initiatives by the U.S. Department of Energy, the National Labs, and the Energy Systems Integration Group (ESIG).

Hannes specializes in wholesale power markets and transmission. He has analyzed transmission needs, transmission benefits and costs, transmission cost allocations, and renewable generation interconnection challenges for independent system operators, transmission companies, generation developers, public power companies, industry groups, and regulatory agencies across North America. He has worked on transmission matters in SPP, MISO, PJM, New York, New England, ERCOT, CAISO, WECC, and Canada and has analyzed offshore-wind transmission challenges in New York, New England, and New Jersey.

He received an M.A. in Economics and Finance from Brandeis University's International Business School and an M.S. and B.S. ("Diplom Ingenieur") in Power Engineering and Energy Economics from the University of Technology in Vienna, Austria.

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