U.S. DEPARTMENT OF ENERGY

Offshore Wind Liftoff Report

Webinar – Tuesday, June 25, 2024

Overview: DOE Pathways to Commercial Liftoff

DOE-wide approach to deep **engagement between the public and private sectors**

Catalyzing commercialization and deployment of technologies for our nation's net-zero goals

Pathways to Commercial Liftoff started in 2022 to:

- **collaborate, coordinate, and align with the private sector** on what it will take to commercialize technologies
- provide a **common fact base** on key challenges (e.g., cost curve)
- establish **a live tool and forum** to update the fact base and pathways

Publications and webinar content can be found at ***liftoff.energy.gov***

Inquiries and input welcome - send to liftoff@hq.doe.gov

Offshore Wind Liftoff – Report Overview

- **Chapter 1: Overview & Value Proposition** introduces offshore wind technology and summarizes its value proposition, including the overall deployment potential.
- **Chapter 2: Offshore Wind Technology & Market Outlook** summarizes the U.S. project pipeline and near-term deployment forecasts, analyzes recent market trends, and provides a framework for offshore wind cost reduction opportunities.
- **Chapter 3: Pathway to Commercial Liftoff** describes the opportunity for offshore wind to reach liftoff this decade and outlines the key conditions required to reach liftoff, including detail on priorities for enabling infrastructure such as transmission and supply chain.
- **Chapter 4: Market Challenges & Solutions Underway** discusses 4 key challenges associated with commercial liftoff and associated solutions underway in the market.
- **Chapter 5: Metrics & Milestones** suggests metrics for tracking indicators and outcomes of offshore wind liftoff.

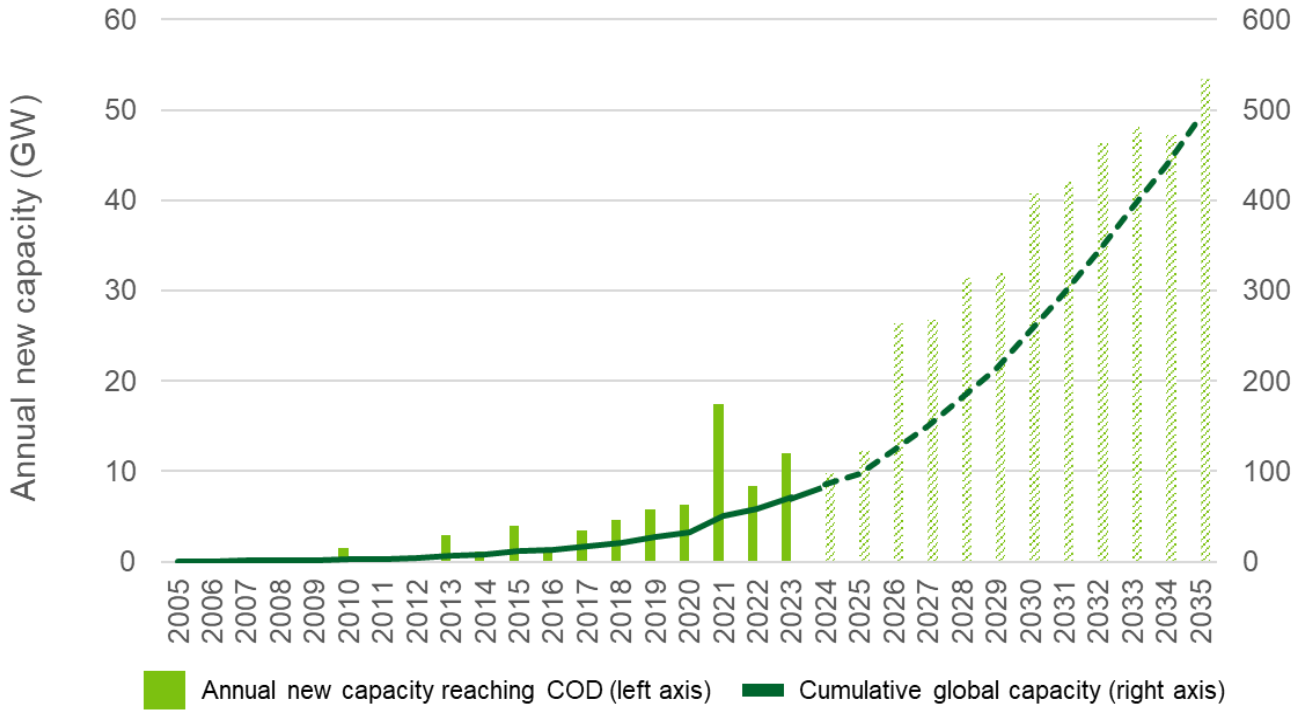
These reports are meant for a **diverse audience of stakeholder**s who can help accelerate liftoff for offshore wind. For the audience unfamiliar with offshore wind, this report aims to build **foundational understanding of the value proposition, market trends, market outlook, and drivers of success of this technology and sector**. Among more experienced audiences, the report aims to catalyze and organize a dialogue between DOE, energy corporations, policymakers, utilities, ISOs/RTOs, research organizations, advocacy groups, and more around challenges and potential solutions for liftoff. Building on this report, future efforts can include near-term actions as well as continued analysis and longer-term roadmaps for scaling offshore wind deployment.

Primer: A Globally Mature Industry with Significant US Resource

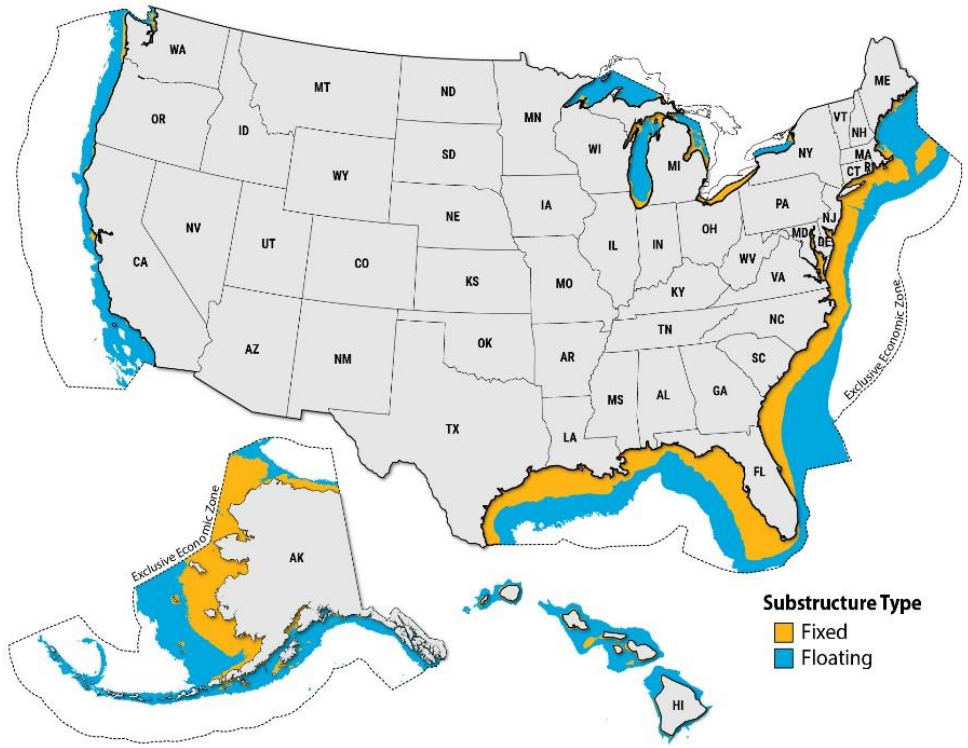
Key Takeaways:

- Offshore wind is a commercially mature technology deploying at scale—roughly 70 GW is operational globally today.
- The global market has scaled by over 10X in just the past decade and is projected to grow another fivefold over the next 10 years.
- The U.S. has over 4,200 GW of offshore wind technical potential, enough to power 3x U.S. electric load today.

Global Offshore Wind Deployment: Past and Future (GW)



U.S. Offshore Wind Resource



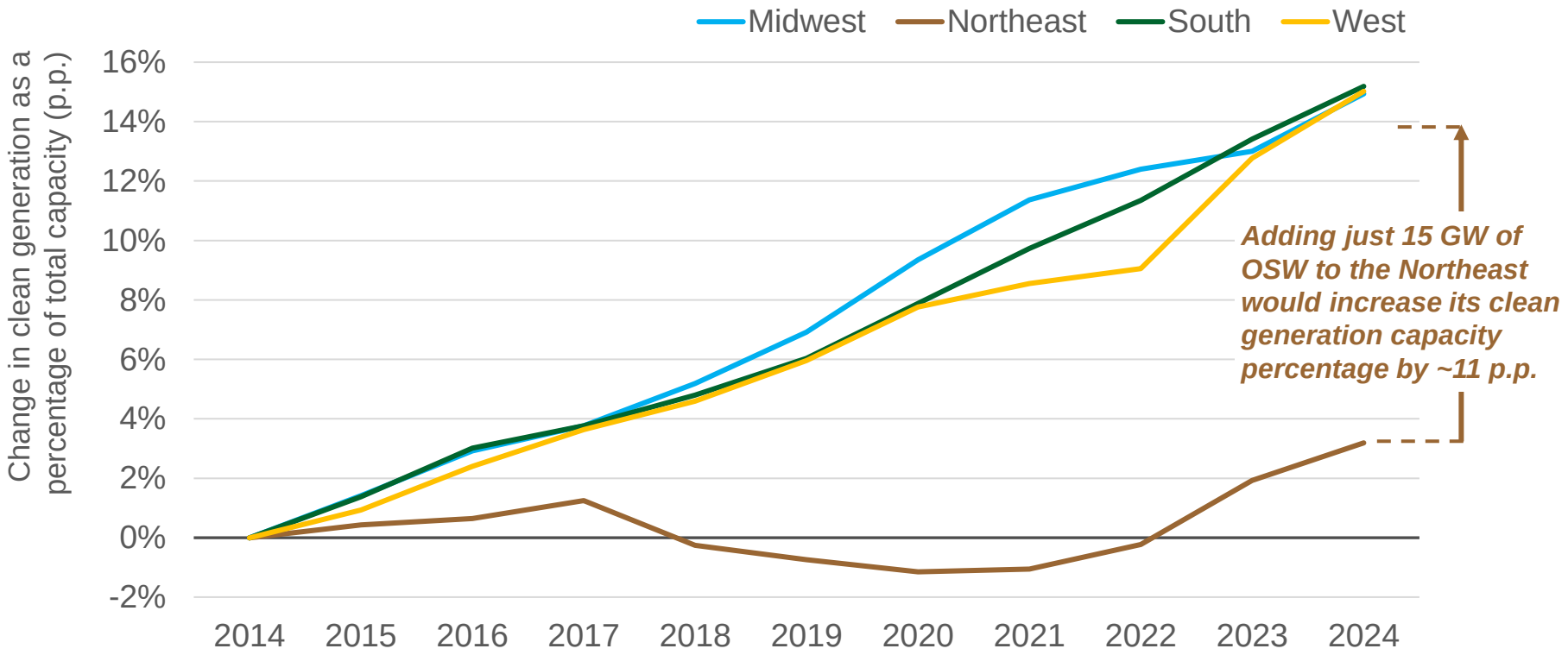
The value of offshore wind

The Value of Offshore Wind

- GWs of clean power deployable today
- Commercially mature technology
- Mature project pipeline & robust state targets
- High growth potential across U.S. waters
- Cost reduction potential
- Energy security
- Economic development & U.S. manufacturing
- Jobs & workforce development
- Revitalizes maritime infrastructure
- Opportunity for necessary grid upgrades
- Transmission directly to coastal load centers
- Relieves siting pressure for onshore renewables
- High capacity factor
- Strong winter generation to match winter peak
- Reliability via generation resource diversity

Decarbonizing while matching load growth will require fast deployment of clean sources

Increase in clean energy capacity as a percentage of total capacity (percentage point increase)

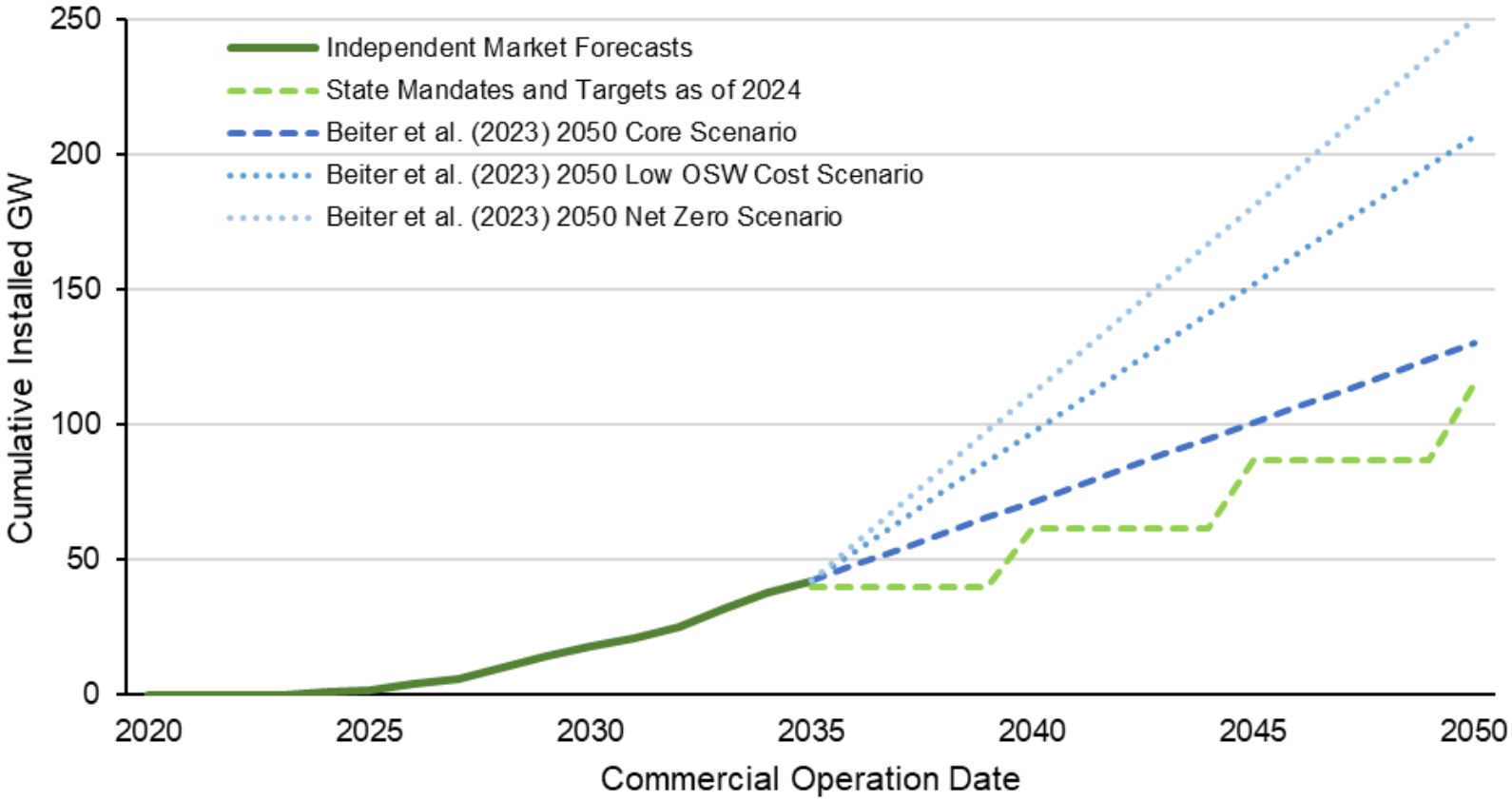


Over the past decade, the Northeast increased clean capacity by only 3 p.p. (from 30% to 33%), adding only net ~6 GW of clean generation, primarily solar. During this same time period, the Northeast added ~25 GW in gas capacity.

OSW can help meet load demands by providing near-term deployment at scale, particularly for regions that would otherwise need to add natural gas or delay fossil retirement

Long-term deployment potential for U.S. offshore wind

U.S. Offshore Wind Deployment:
~40 GW projected by 2035, and over 100 GW targeted by 2050

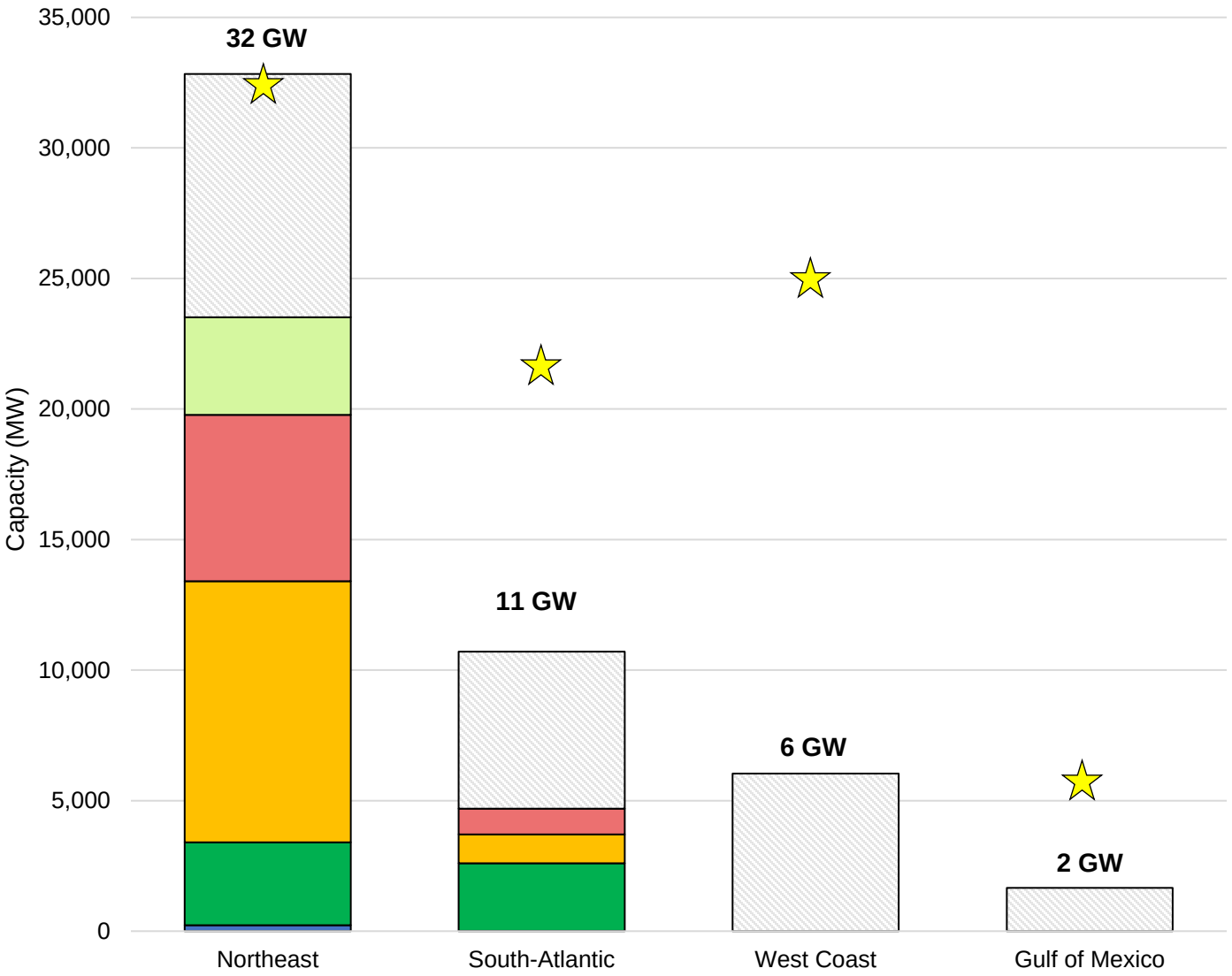


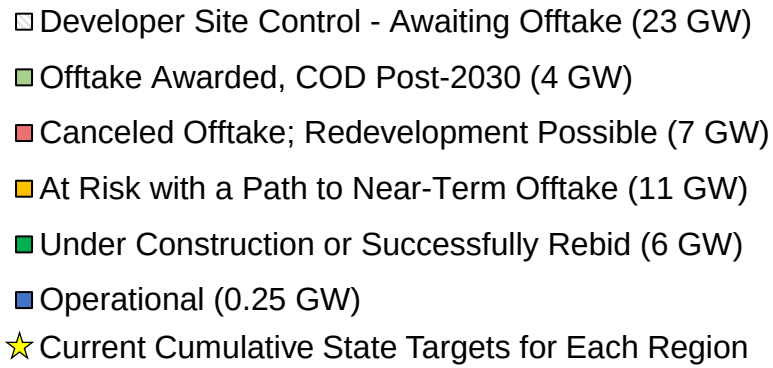
Key Takeaways:

- Current industry market forecasts project ~40 GW built by 2035, largely in the Northeast. Forecasts built on real-world project pipeline and state procurement targets set in statute – and account for recent project cancellations and offtake rebids.
- Meeting the 115 GW cumulative 2050 state targets would require annual deployments of 5 GW per year—achievable with a 25% increase above projected deployments in the next decade (up from 4 GW/yr projected 2025-2035)

U.S. OSW Project pipeline

April 2024 Snapshot, with up to 15 GW of additional offtake that could be awarded by states in 2024





Key Takeaways:

- In the U.S. market, approximately 250 MW of offshore wind is operational and 5 GW are under construction as of April 2024.
- In the next few years, an additional 5-10 GW of projects have a path to reach Final Investment Decision (FID) and begin construction.
- The full U.S. project pipeline today includes roughly 50 GW of seabed under developer control.

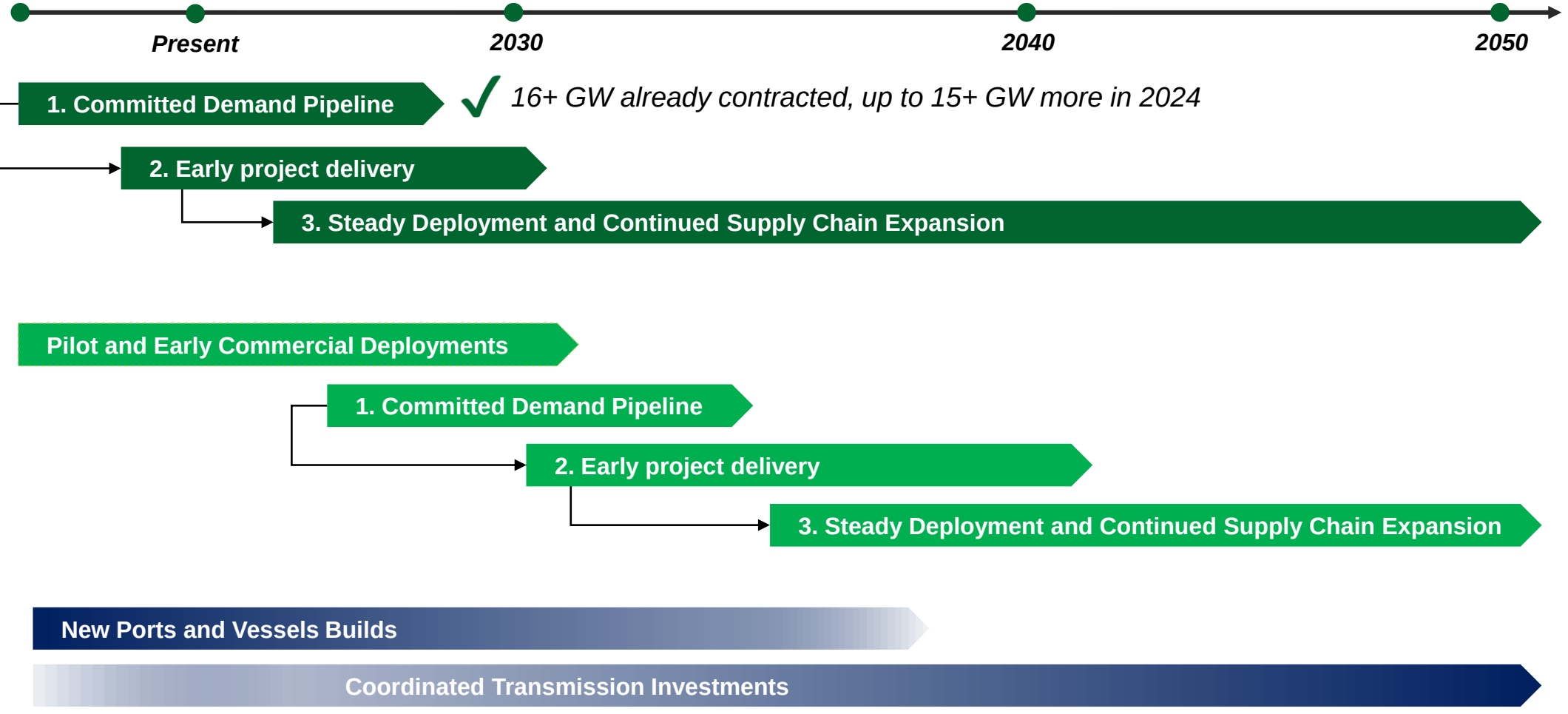
Note: Northeast refers to Northeast census region (states from ME to NJ), South Atlantic relates to South Atlantic census division (MD to FL)

“Liftoff” defined for U.S. offshore wind – Stages of development

U.S. Offshore Wind “Liftoff” Defined:

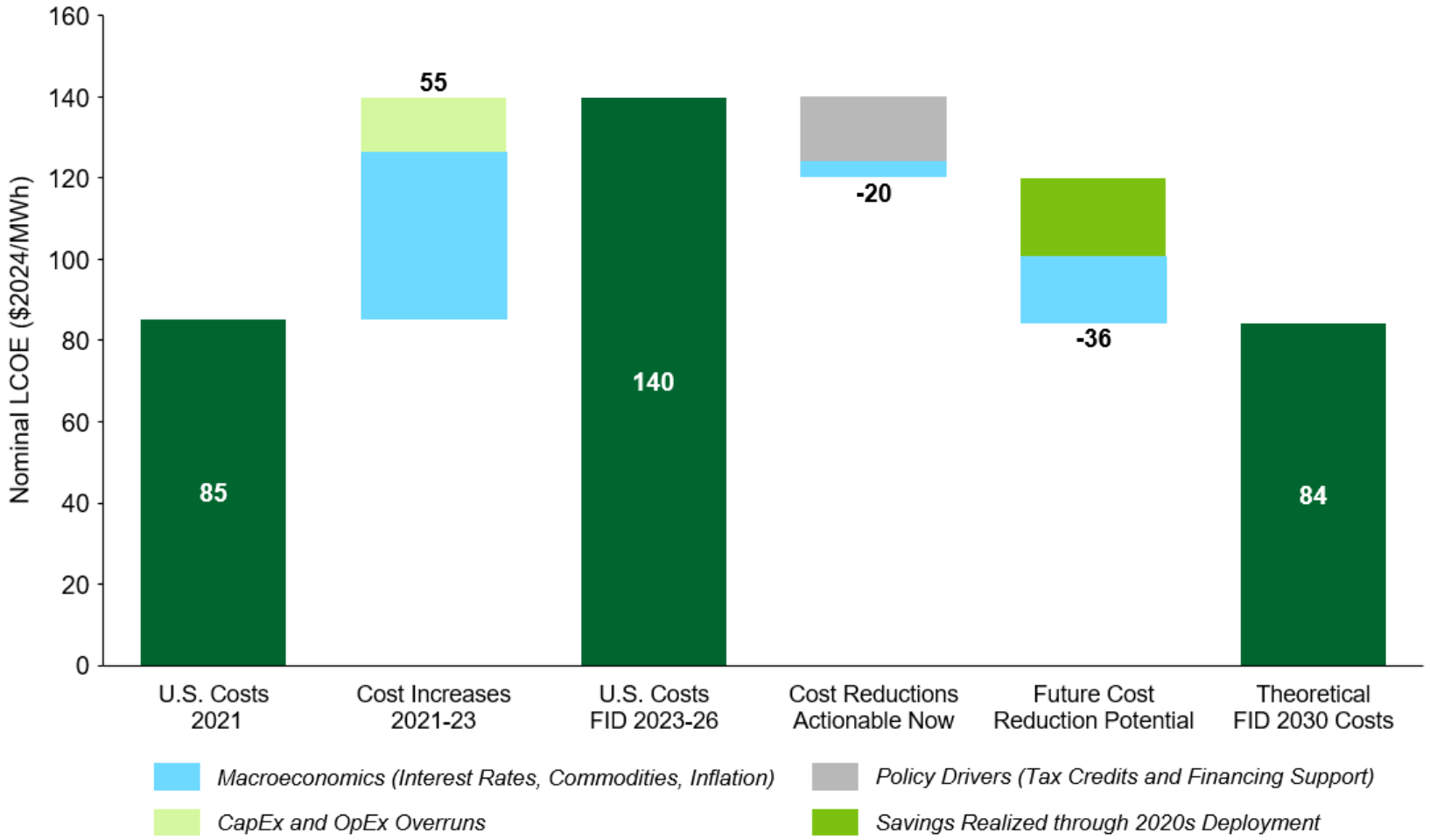
Liftoff defined: U.S. offshore wind will achieve “liftoff” when the sector is actively contributing to state decarbonization targets, with a sustained project pipeline and regular deployment.

The sector will leverage OSW-ready maritime infrastructure, an ecosystem of suppliers with U.S. experience, and a streamlined and predictable project development and offtake process, all to produce competitive cost levels and steady sector expansion.



Market outlook: Recent cost challenges and path forward

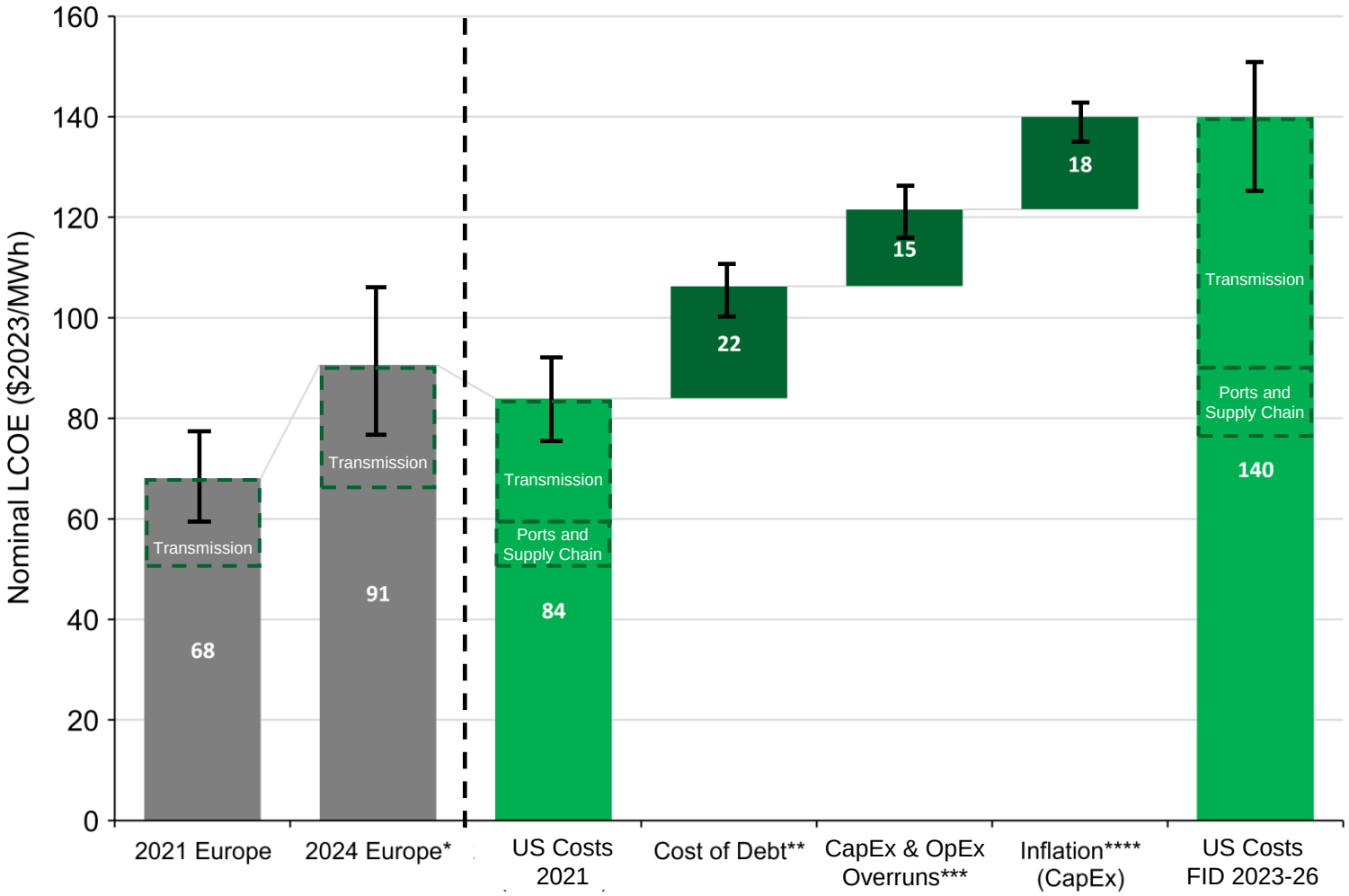
Historical cost increases for a representative 2020s project, and cost reduction levers for future projects (FID 2030+)



Key takeaways:

- **Early mover projects faced a "perfect storm" of challenges and have provided valuable lessons on how to sequence and structure investments for a sustainable offshore wind industry.** The LCOE of U.S. OSW projects rose from approximately $85 to $140 per MWh from 2021 to the end of 2023, though individual projects vary.
- **Lessons learned from the challenges of the past few years will shape the market moving forward.** These include ongoing efforts by states and industry to refine project and supplier procurement, fostering regional collaboration for supply chain and transmission planning, and government investments to support necessary enabling infrastructure.
- **LCOEs below $100/MWh ($2024) are achievable for fixed-bottom projects by FID 2030, enabled by prior supply chain and infrastructure development.** Costs are dependent on macroeconomic conditions, state and federal offshore wind policy, offtake design, and the number of early movers that reach FID and begin construction in the next few years.

Tranche 2: Indicative Historical Cost Increases



- This chart shows a generic view of **cost pressures faced by at-risk projects** (Tranche 2, FID in 2023-26)
- Costs increased globally due to a combination of **rising interest rates, supply chain bottlenecks, and raw materials price increases** (inflation).
- **Every project experienced financial pressures differently** (largely stabilized today) depending on its offtake terms, developer strategy, and project maturity.

** Note: High variation and uncertainty. European experiences vary by project and country, and offtake mechanisms are often inflation-indexed, unlike in the US (e.g. UK's CfD). LCOE values here include transmission.*

*** Cost of equity not considered, on the assumption that an offtake price bid is based on a nominal hurdle-rate commitment*

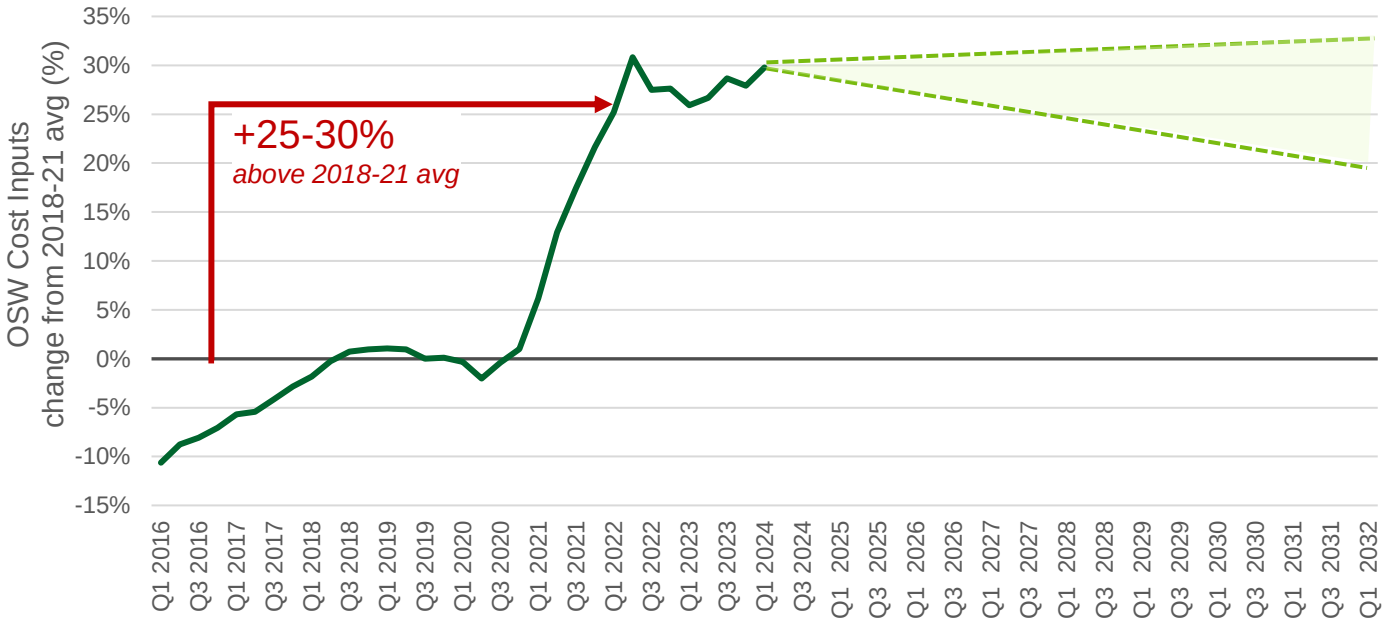
**** Includes all CapEx and OpEx increases not related to indexed inflation, e.g. supply chain bottlenecks and previously unforeseen budget additions (esp. port, grid, vessels, local set-up, etc.).*

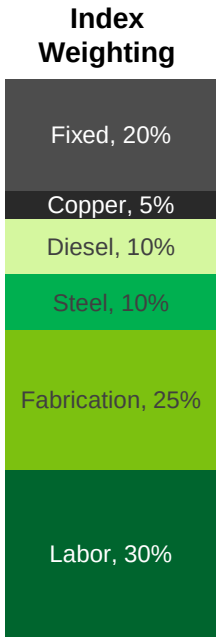
***** Estimated using NYSERDA's NY3 offshore wind inflation index (see following slide)*

Macroeconomic Challenges

Composite trend of underlying offshore wind cost inputs

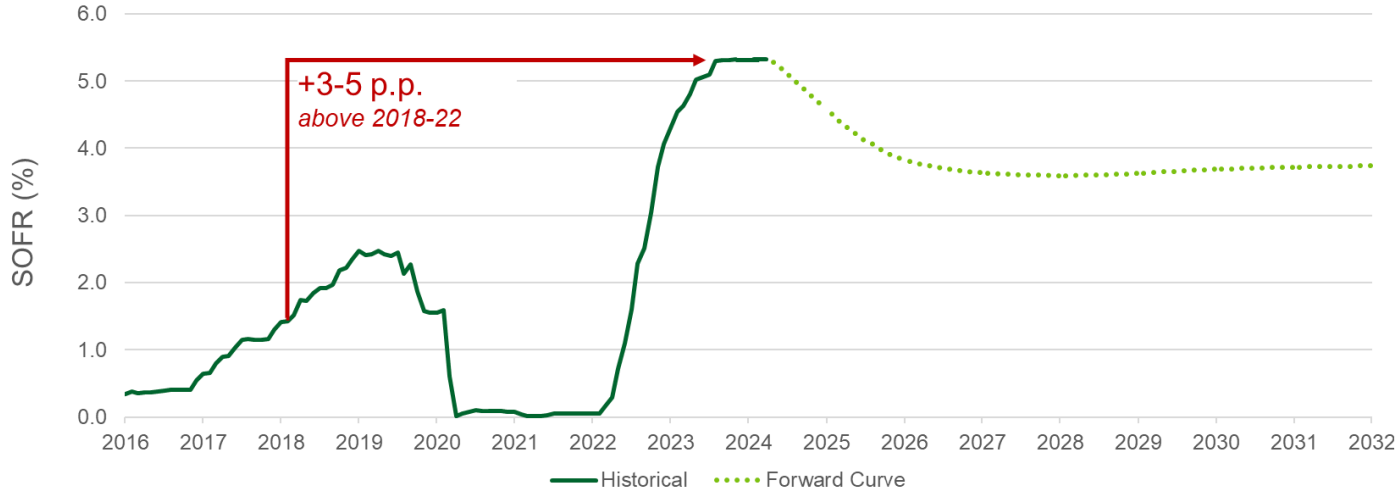
Normalized to 2018-21 avg baseline





- Key commodities for offshore wind spiked in mid-2021 and remain elevated
- These are exogenous risks, which can be reduced at least in part by hedging, Risk-sharing mechanisms in offtake contracts, and condensing project timelines
- Despite intrinsic uncertainty, forecasts for these commodities and interest rates suggest tailwinds rather than headwinds in the future

Changes in financing costs over time (SOFR %)



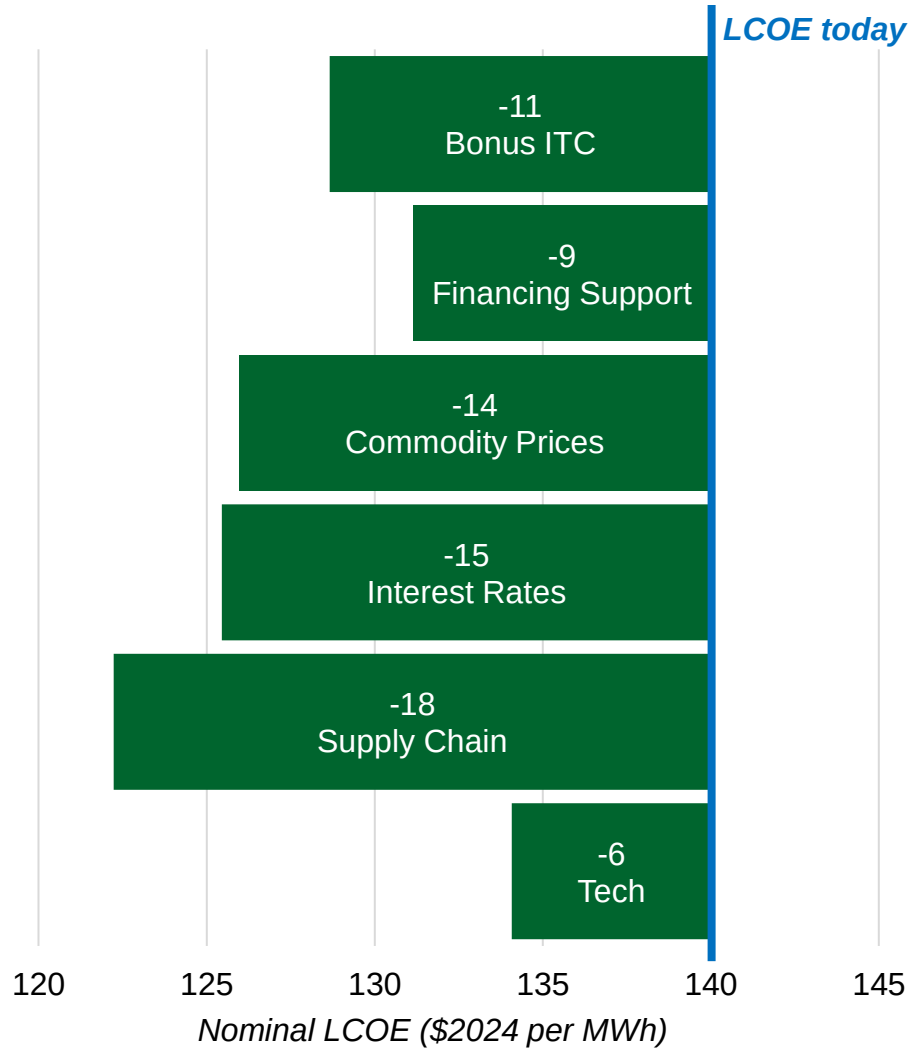
- Interest rates (and in turn, OSW cost of capital) spiked in 2022 and remain elevated
- The forward curve shows **SOFR reducing to ~3.50%**, down from 5.3% today (a weighted average across multiple uncertain scenarios)
- **Offshore wind is highly sensitive to cost of capital**: the ~**2% increase** in cost of capital estimated on the previous slide (from debt alone) **leads to a ~20% increase in LCOE** in and of itself.

Opportunities for fixed-bottom cost reductions through FID 2030

Despite recent cost challenges, there are opportunities for cost reductions

Key levers to reduce costs	*Driven by*	*Impact through FID 2030*
Bonus ITC – 10% bonus ITC for qualifying projects (primarily Energy Communities)*	Policy (available for qualifying projects)	High – Many projects could qualify
Financing Support– such as LPO financing for eligible projects (potential to lower cost of debt by 75 to 150+ bps)**	Policy (available for qualifying projects)	Moderate – reduction in cost of capital for projects and supply chain
Commodity price reversion – Reduction in raw materials prices from 2022-2023 peaks	Macroeconomic conditions	High – Partial savings realized today, though lag between indices and supplier quotes
Interest rate / WACC reduction – Potential decrease in WACC from a 2% reduction in SOFR rates	Macroeconomic conditions	High – Many projects expected to benefit as rates might decline 2024-onwards
Supply chain buildout – Fewer cost overruns, delays, infrastructure upgrades, and inefficiencies	Policy, investments, US deployment & strong demand signals	High – Many projects expected to benefit (but first movers bear the cost of initial buildout)
Technology improvements – Innovation in design and construction	Investments & global deployment	Low – Limited benefit for near-term projects, with greater opportunities long term

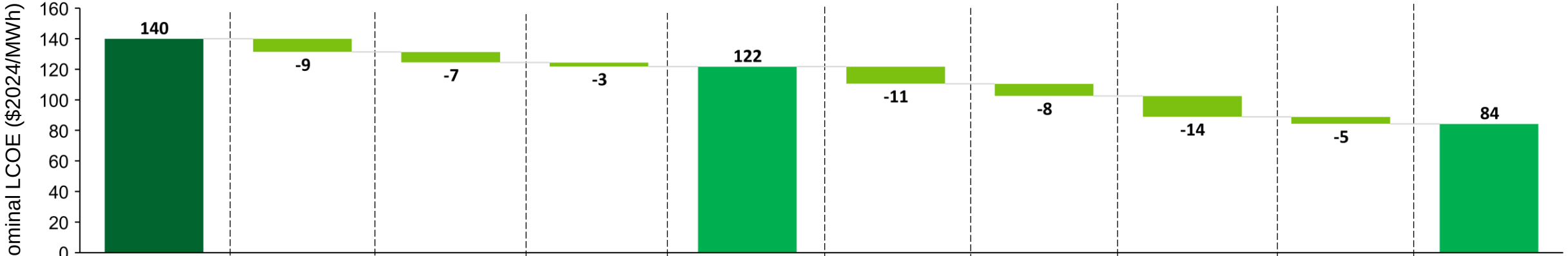
Individual LCOE Reduction Potential



** Industry expects additional 10% bonus ITC for Domestic Content to be inaccessible to OSW until late 2020s and go primarily to supply chain, not OSW projects*

*** This $6 reduction assesses a 130 bps reduction in cost of debt. Secondary benefits include replacing corporate finance with non-recourse loans, which may add substantial added value*

Cost reduction opportunities for fixed-bottom projects reaching FID by 2030



	2023 US Costs	Bonus ITC	Financing Support	Commodities (since peak)	Theoretically Actionable Now	Interest Rates	Commodities (to historical)	Deployment & Supply Chain	Tech	*Theoretical 2030 FID Costs*
Assumptions:		10% bonus ITC for qualifying projects (primarily Energy Communities)*	Financing support such as LPO financing for qualifying projects (potential to lower cost of capital by 75 to 150+ bps)**	Reduction in commodities (steel, copper, diesel only) from 2022 averages when prices peaked	Cost to execute a project today with access to a 40% total ITC, LPO debt, and current commodities prices	Potential decrease in WACC from a 2% reduction in SOFR rates (based on forward curve for late 2020s)	Reversion of NY3 raw materials to 10-year average (2013-23)	As supply chain matures, fewer cost overruns due to scarcity, delays, port upgrades, and lack of US experience	Innovation in design and construction (modest short term, with greater opportunities long term)	
Certainty & actionability:		*Actionable now, pending project eligibility*	*Actionable now for projects in LPO pipeline*	*Indices known but actionability dependent on supplier pricing*	*Tranche 2 projects are unlikely to access all 3 of these upsides*	*Uncertain and based on macroeconomic conditions*	*Uncertain and based on macroeconomic conditions*	*Likely to take 5-10 years to realize; dependent on investment and US buildout*	*Likely to take 5-10 years to realize; dependent on investment and global buildout*	
		Federal Policy		**Macro driver**		**Future external macro-drivers, not in decisionmakers' control**		**Savings realized through investments and deployment**		

Potential reduction of up to ~$40-60/MWh by FID 2030, driving project cost down as low as ~$84 per MWh

** Industry expects additional 10% bonus ITC for Domestic Content may be realized for selected projects by late 2020s, but with value primarily captured by the supply chain (limited impact on project LCOEs).*

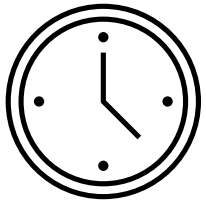
*** This $7 reduction assesses a 130 bps reduction in cost of debt. Additional benefits may include potential higher leverage and better terms (e.g. recourse), which may add additional value (weighed against potential added compliance costs and slower financing processes)*

Challenges and solutions underway

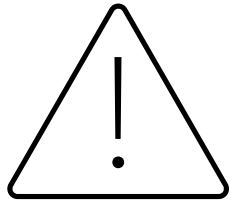
Challenges	Solutions underway
1 **Recent offtake cancellations**, driven by macroeconomic conditions, create timing uncertainty and funding gaps for sector buildout.	• Competitive procurements (“re-bids”) for 2020s projects that secured offtake pre-2023 • Revised projects that are deliverable under current market conditions, and that reaffirm commitments to fund long-term enabling infrastructure needs (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 & project FID • Offtake refinements to incorporate risk mitigations and prioritize project deliverability • 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

Market Structures

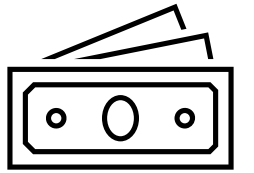
These five risk areas have amplified project deployment risks and are the target of risk mitigation measures



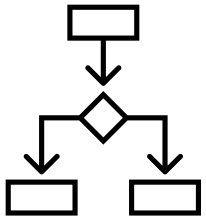
Offtake Sequencing with Project Permitting and FID



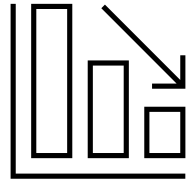
Cost Exposure to Macroeconomic and Interconnection Uncertainties



Pre-OSW FID Funding Gap for Enabling Infrastructure



Long Term Industry Needs Tied to Early-Mover Offtake Commitments



Competitive Auctions Reward Ambitious Project Plans and Costs

- Offtake revenues for early mover projects are a primary engine to fund long-term ecosystem buildout: namely the enabling infrastructure of ports, vessels, and supply chain.
- This combination of market structures amplified project deployment risks by closely linking funding sources and timelines between project deployment and this critical enabling infrastructure.
- Recent market turbulence was in part due to risk exposures that can be limited moving forward, even if an uncertain macroeconomic environment persists.

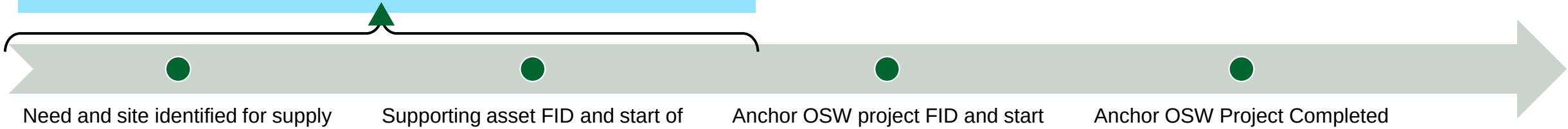
Supply Chain and Transmission

The pre-FID funding gap for enabling infrastructure

Ports, vessels, and manufacturing facilities typically require construction and investment prior to their anchor-customer reaching FID. This is increasingly true for onshore grid reinforcements as well.

- Targeted government support can facilitate the early stages of development for supply chain and transmission pre-OSW project FID, in turn stimulating private investment.
- Sustained project deployment is dependent on the successful FID and completion of early mover projects. In addition to macroeconomic pressures, projects have faced higher costs due to the need to fund early investment in enabling infrastructure (e.g. local supply chain).
- Globally, it is uncommon for individual project cost and scope to include this level of investment in enabling infrastructure, especially through pre-FID project expenditures. A reliance on these types of investments risks positioning the U.S. market, particularly early movers, as a high-risk market in developers' international OSW portfolios, which could impact their portfolio-level investment decisions.

Key funding gap for supply chain and transmission assets. Public and private investment needed, backed by regional planning, to enable OSW market liftoff



Need and site identified for supply chain or transmission investment to support OSW project

Supporting asset FID and start of construction to ensure readiness for downstream OSW project

Anchor OSW project FID and start of construction

Anchor OSW Project Completed (supply chain facilities continue on to serving other projects)

Key components & infrastructure: opportunities and critical path for deployment

Category	*Purpose*	*Needs*
Critical path to Liftoff	Essential enabling infrastructure required to build U.S projects	• **Domestic ports** – today, adequate sites are identified for ports but some lack funding; pre-OSW project FID funding is a key pinch point for scaling up domestic manufacturing. Today's procurement models challenge efficient port development. • **Domestic vessels** – Like ports, vessel shortages could constrain buildout rate. Industry faces acute global shortages and a need to expand domestic fleet for project installation and O&M. • **Local workforce & training centers** – OSW construction and operations, including specialized component manufacturing will require a skilled workforce; training efforts require lead time to preemptively train and certify workforce
Opportunities & risk mitigation	Opportunities to build U.S. manufacturing base, economic development, supply chain security, leverage subsidies –without U.S. buildout, may still be able to source internationally, but at risk of global market undersupply or other constraints	• **Towers and jackets,** key to unlocking domestic content bonus (10% additional on 30% ITC). US supply chains exist today for limited volumes of jackets. No U.S. facilities are operational for OSW towers today, but multiple planned projects expect to come online in the next five years. • **Monopiles, Transition Pieces, and Monopile-grade steel** – significant shipping costs and global supply constraints. • **Blades and Nacelles** – opportunity to increase local content to help projects qualify for domestic content bonus. • **Subsea cables and substations** – face global shortage. HVDC substations from global supply chain are fully booked through 2032. Substations challenged by shortages in large power transformers, HVDC converters, and offshore topside structure assembly yards, challenged by cost and lead time for new manufacturing

Transmission for offshore wind

OSW projects face transmission cost/risk challenges today but with long-term planning, interregional transmission has the potential to drive a more resilient and efficient grid.

Challenges

- **Long Term Need & Opportunity** – Long term, the coastal grid across the country is insufficient to accept the level of incoming power from planned offshore wind (OSW):
- **Siloed Planning** – offshore transmission planning today is largely siloed by project and by state, leading to piecemeal transmission buildout with inefficient outcomes.
- **HVDC Supply Chains** – Offshore HVDC transmission will be essential for US offshore wind. Globally, supply chains are over-subscribed and will be challenged to serve US demand post-2030.

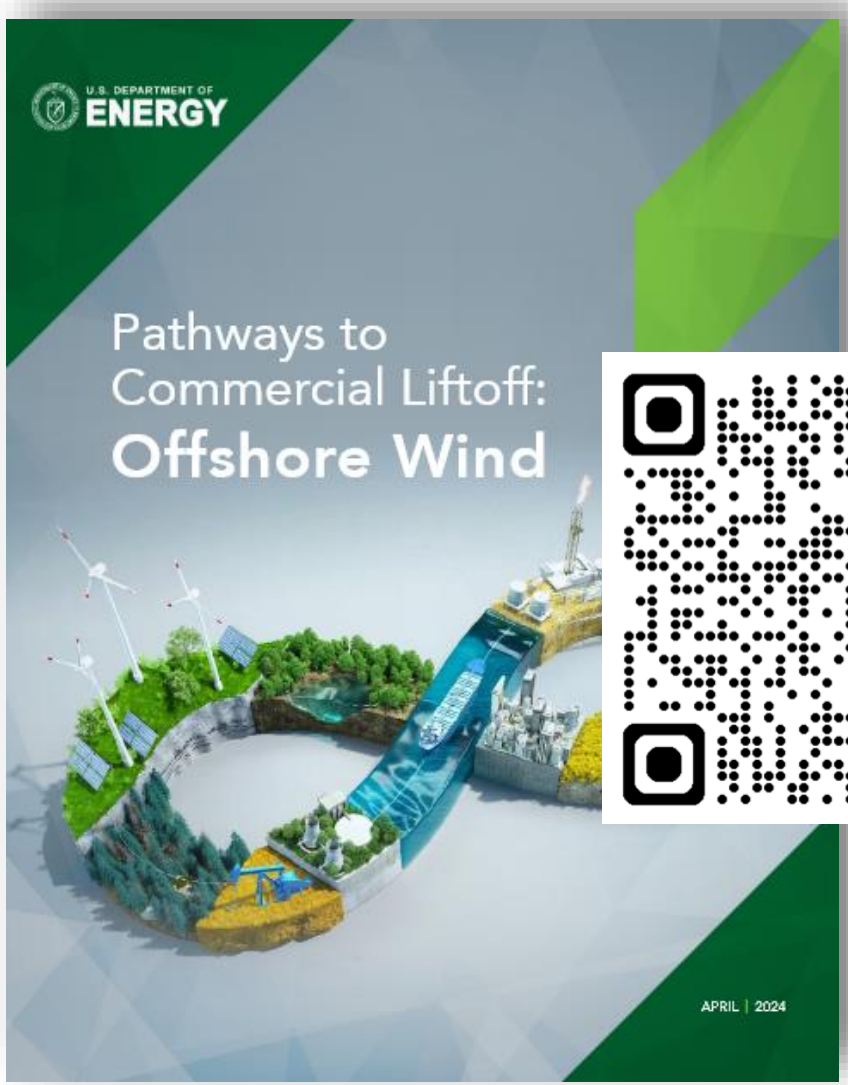
Solutions

- **Coordinated planning**: There is broad consensus of the need for better coordinated onshore network upgrades and better offshore planning
- **Separate Transmission Solicitations,** regardless of transmission topology, may be valuable long term, likely under a competitively procured framework with an initial focus on onshore upgrades for OSW injection points for multiple OSW projects close to shore.
- **Interregional Transmission –** Offshore wind offers a pathway to inter-regional transmission between system operators, and requires early planning and early actions today

The 2024 Atlantic OSW Transmission Study (AOSWTS) found that coordinated offshore transmission offers a potential cost-benefit ratio for ratepayers of over 2:1. For 85 GW of OSW by 2050, the study calls for 7.6 to 21.6 GW of networked offshore transmission, unlocking $600m to $3,940m of annual net benefits to ratepayers.

→ *The full AOSWTS analysis is available here.*

Offshore Wind Liftoff Report



Federal OSW Resources Summary