ENERGY earthshots
U.S. DEPARTMENT OF ENERGY

Floating Offshore Wind™

# PROGRESS AND PRIORITIES

September 2022–April 2024

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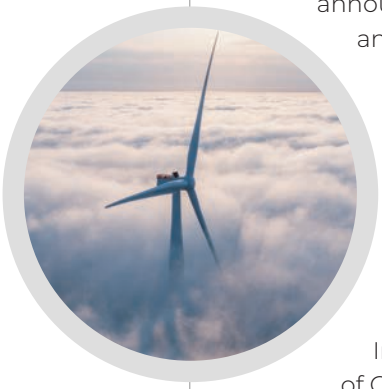
# Energy Earthshots Initiative

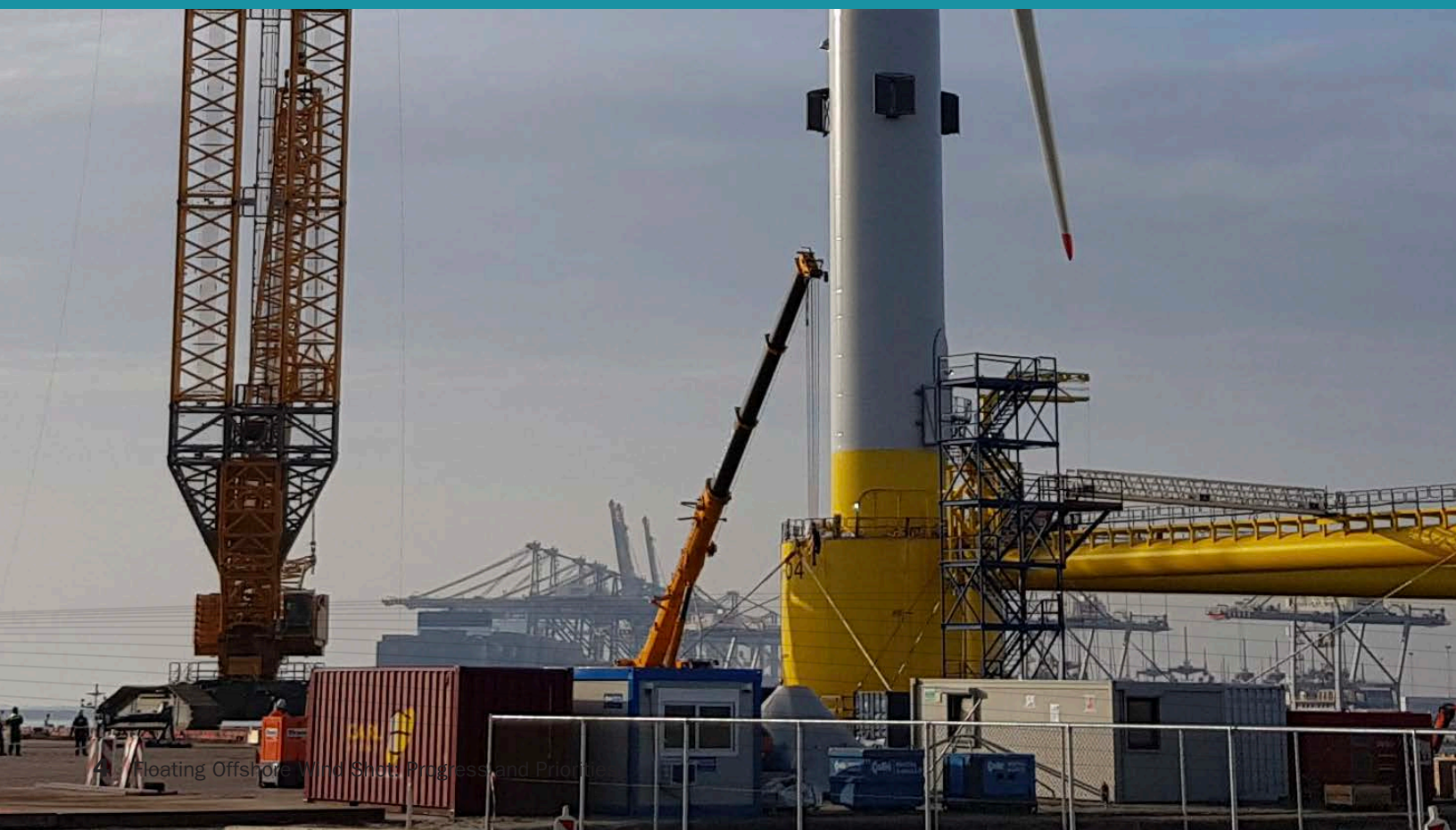
In June 2021, the U.S. Department of Energy (DOE) launched the Energy Earthshots™ Initiative to accelerate breakthroughs of more abundant, affordable, and reliable clean energy solutions within the decade. Energy Earthshots set ambitious targets to address tough technological challenges and cost hurdles, and rapidly advance solutions to help achieve the nation's clean energy and economic competitiveness goals. This report focuses on the Floating Offshore Wind Shot™, announced in September 2022, and describes progress since this Energy Earthshot was established and identifies priorities for future work. The Floating Offshore Wind Shot is a multiagency initiative, leveraging resources and authorities across DOE, the U.S. Department of the Interior (DOI), U.S. Department of Commerce (DOC), and U.S. Department of Transportation (DOT).

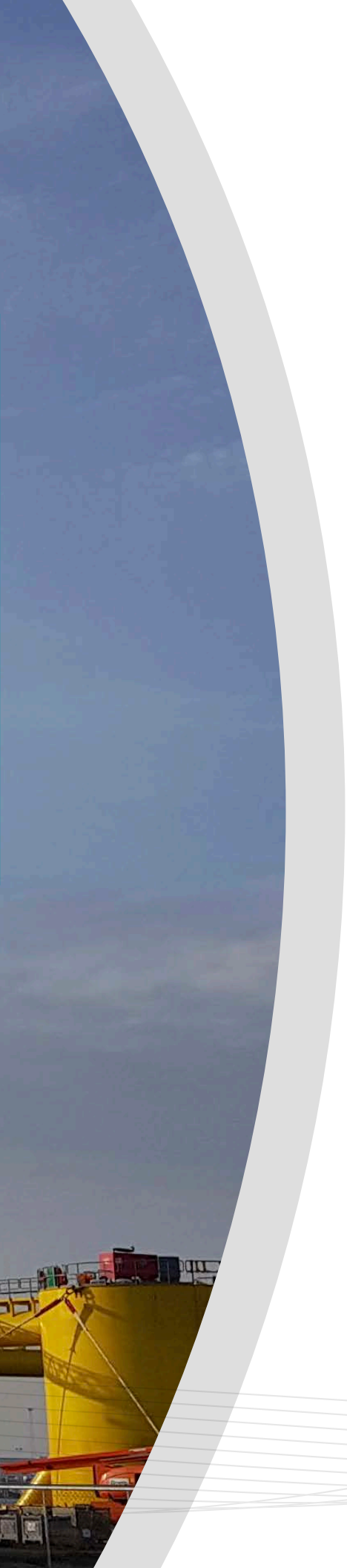


ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Floating Offshore Wind™

# Opportunity for Floating Offshore Wind Energy

Floating offshore wind energy has the potential to support coastal and national decarbonization in the United States. Researchers have estimated that U.S. offshore wind has a total resource potential of 4.2 terawatts,[1] which is three times greater than the total electricity-generating capacity operating in the country in 2023.[2] Approximately two-thirds of this offshore wind energy potential is located where the water is too deep for standard fixed-bottom offshore wind technologies (assuming a 60-meter [m] limit), so floating technologies are needed.[3] These technologies will open up resources along the U.S. West Coast, Gulf of Maine, and in deeper waters off all U.S. coastlines (Figure 1). Currently, floating offshore wind is just entering the commercial phase, with a project pipeline of over 100 gigawatts (GW) around the world, most in early stages of development.[4] Given the vast floating offshore wind energy resource in the United States, coupled with its status as a new industry, the nation has a powerful opportunity to assume a leadership role in advancing and scaling up these innovative technologies for commercial use.





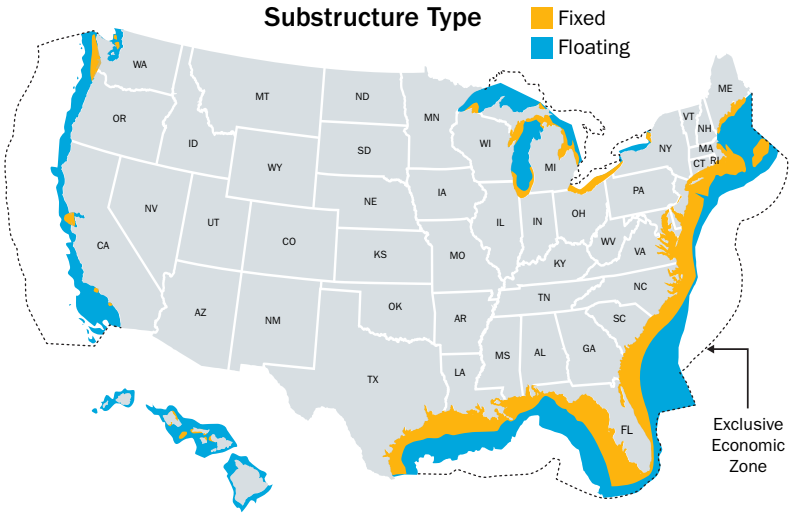



Figure 1. Offshore wind turbine substructure type by water depth (floating needed over 60 m). *Image from the National Renewable Energy Laboratory (NREL)*

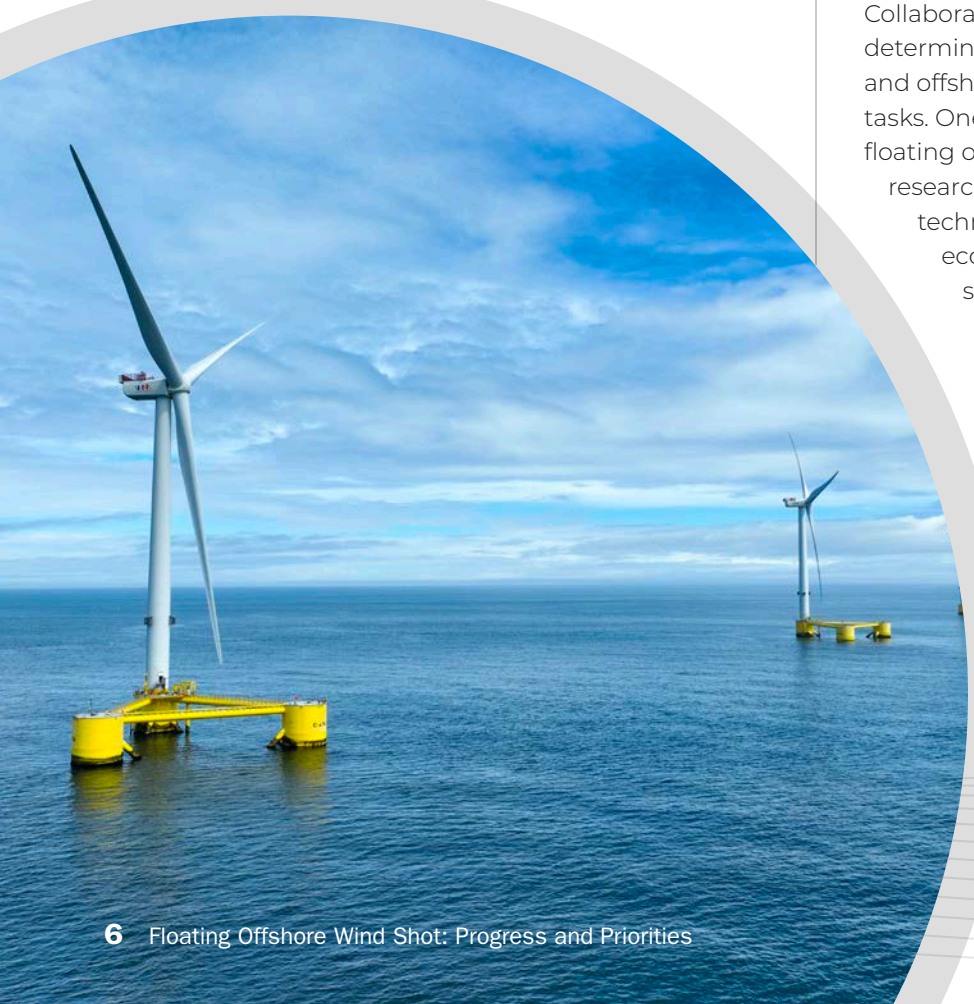
## Floating Offshore Wind Shot Target

For large offshore wind farms, the costs associated with first-generation floating offshore wind energy facilities are expected to exceed those of fixed-bottom offshore wind facilities by over 50%. The United States has a critical window of opportunity to make this technology more affordable as well as to become a world leader in floating offshore wind design, deployment, and manufacturing. In response to this opportunity, the Floating Offshore Wind Shot seeks to reduce the cost of floating offshore wind energy by more than 70%, to $45 per megawatt-hour (MWh), by 2035 for deep-water sites far from shore (Figure 2).[5] Reducing the cost of floating offshore wind is also likely to benefit fixed-bottom developments.


Figure 2. The Floating Offshore Wind Shot aims to reduce costs 70% by 2035

## Floating Offshore Wind Progress in the United States

Alongside the announcement of the Floating Offshore Wind Shot, DOI established a goal to deploy 15 GW of floating offshore wind energy by 2035.[6] This goal complements a broader objective to install 30 GW of offshore wind capacity by 2030. Of the 52.7 GW in the U.S. offshore wind development pipeline as of May 2023, over 6.2 GW were floating offshore wind energy projects.[7] In December 2022, DOI's Bureau of Ocean Energy Management (BOEM) held the first sale on the U.S. West Coast for lease areas in water depths suitable for commercial-scale floating offshore wind energy development. BOEM's lease sale offered five lease areas covering 373,268 total acres off central and northern California and were awarded for a total of $757 million. The leased areas have the potential to produce enough offshore wind energy to power over 1.5 million homes.[8] Leasing processes for areas with water depths suitable for floating offshore wind are underway off the coast of Oregon and in the Gulf of Maine.[9]



## International Collaboration

Floating offshore wind is a rapidly growing industry globally, and collaboration with international partners can accelerate the progress of the Floating Offshore Wind Shot by leveraging lessons learned and informing strategic planning for domestic resources. In April 2024, Japan announced that they will become the first international collaborator in the Floating Offshore Wind Shot, aligning their strategy and ambitions for floating offshore wind with those of the United States. This is intended to be the first such collaboration, with the potential for future international partnerships to maximize coordination around floating offshore wind. The U.S. government participates in several multilateral programs to coordinate the development of offshore wind. BOEM is part of the Global Offshore Wind Regulators Forum that provides offshore wind regulators with a venue to exchange and enhance collective expertise; discuss regulatory approaches and best practices; share scientific, technical, and environmental information; and discuss industry trends and market developments.

The United States is also a member of the International Energy Agency Wind Technology Collaboration Programme.[10] This program determines joint research initiatives for land-based and offshore wind and currently has 21 active tasks. One of these tasks focuses on the design for floating offshore wind arrays while others focus on research topics relevant to both fixed and floating technologies, such as environmental impacts, economics, forecasting, grid integration, and social acceptance.

In addition, the United States is a member of the Global Offshore Wind Alliance[11] that aims to contribute to a total global offshore wind capacity of at least 380 GW by 2030, with 35 GW installed on average each year across the 2020s and a minimum of 70 GW each year from 2030, including both fixed and floating offshore wind developments.

# Floating Offshore Wind Shot

## Setting the Target

The Energy Earthshot target of reducing the cost of floating offshore wind by 70% by 2035 represents a highly ambitious goal and seeks to address the hardest technical and economic barriers to achieving that cost reduction. Attaining this target requires a moon-shot-scale effort that would greatly expand the deployment potential for floating offshore wind energy domestically and globally. Inspired by DOE's bold and successful SunShot Initiative,[12] the Floating Offshore Wind Shot target goes far beyond a "business-as-usual" or "most likely" scenario and aims to inspire major innovation breakthroughs and infrastructure upgrades to address the most challenging floating offshore wind needs within the decade.

## Impacts of Reaching the Target

DOE's National Renewable Energy Laboratory (NREL) conducted initial national-scale analyses to understand the potential impacts of achieving the Floating Offshore Wind Shot. The analysis found that in scenarios prioritizing decarbonization and electrification, achieving this Energy Earthshot target by 2035 could result in economic deployment of an estimated 96–121 GW of floating offshore wind energy by 2050.[13]

Based on associated analyses, floating offshore wind deployment at that scale would also spur economic, workforce, health, and environmental benefits. Along the West Coast alone, port and supply chain investments could reach $30 billion to meet state-

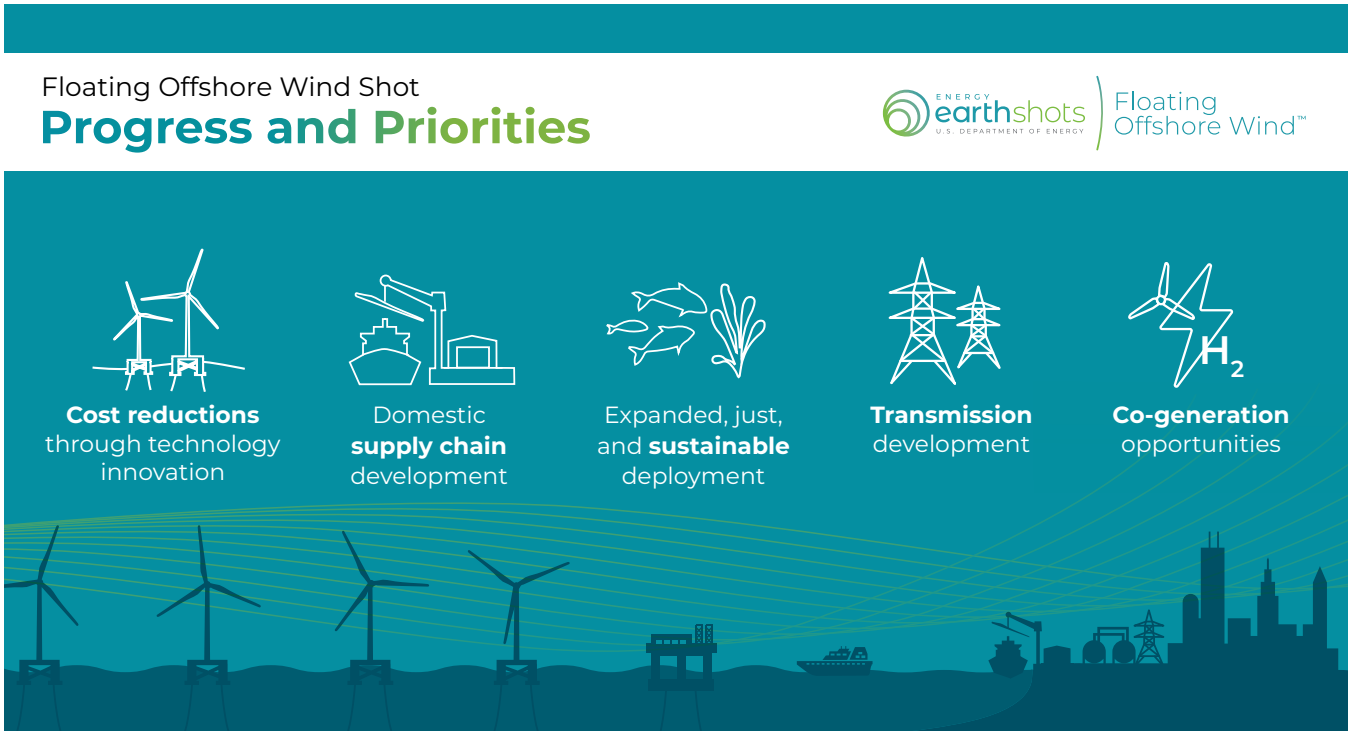



Figure 3. The five pillars of the Floating Offshore Wind Shot capture the primary areas of opportunity and need for the deployment of floating offshore wind in the United States

level offshore wind deployment goals of 35–55 GW by 2045.[14] Achieving the national goal of 15 GW of floating offshore wind capacity by 2035 would translate to significant job potential associated with offshore wind activity that would continue to grow as more offshore wind energy is deployed.

Floating offshore wind energy can also help reduce carbon emissions and air pollution and offset water consumption from conventional (e.g., coal and fossil fuels) power generation sources. Air quality benefits include reduced sulfur dioxide, nitrogen oxides, fine particulate matter, and carbon dioxide. Further studies are needed to estimate the broader impacts on health, the environment, and society from floating offshore wind deployment, more systematically and broadly.

## Floating Offshore Wind Shot Pillars

The Floating Offshore Wind Shot is focused on reducing the overall cost of floating offshore wind to expand deployment potential, provide new, family-supporting jobs, and make low-emission, reliable energy more accessible. A cost reduction as significant as envisioned by this Energy Earthshot requires both ground-breaking technologies and high deployment levels to achieve cost advantages of production at scale. To focus efforts on addressing areas of technical innovation, as well as barriers to widescale deployment, this Energy Earthshot is organized into the following five technical pillars (Figure 3):

- Reducing costs through research and development (R&D) focused on technology, materials, and manufacturing advances.
- Supporting the development of regional supply chain infrastructure, including port development and vessel solutions.
- Supporting expanded, just, and sustainable deployment that builds on an enhanced understanding of potential sites and environmental and socio-economic trade-offs.
- Supporting transmission system innovation, planning, and development.
- Identifying and developing co-generation opportunities for floating offshore wind to support the broader decarbonization of the economy, through Wind-to-X solutions (where X represents hydrogen generation, energy storage, and other possibilities), energy hubs where energy generation might be co-located with other infrastructure, and the conversion of wind energy to clean fuels.

DOE's strategic approach for work in these areas is outlined in more detail in *Advancing Offshore Wind Energy in the United States*.[15]

## Participating Federal Agencies

The challenges associated with floating offshore wind energy development require the expertise, resources, and authorities of many federal agencies. The Floating Offshore Wind Shot works to leverage:

- DOE's research grants and loan authorities that can advance R&D and deployment of floating systems, including technical innovation, social science, community engagement, and technical assistance, as well as enabling commercial project, supply chain, and transmission development.
- DOI-BOEM's jurisdiction pertaining to planning and authorization of offshore wind energy, coupled with its robust environmental studies program.
- DOC-National Oceanic and Atmospheric Administration's (NOAA's) environmental intelligence, stewardship of living marine resources, and community outreach and engagement.
- DOT's loan and grant programs for vessel and port development.

DOE also partners with the National Science Foundation (NSF) to support critical R&D to advance offshore wind energy development.

Table 1. Agency and Office Capabilities Associated With the Five Pillars of the Floating Offshore Wind Shot[16]

| Federal Program | Cost Reductions | Supply Chain Development | Sustainable & Just Deployment | Transmission Development | Co-Generation Opportunities |
|---|---|---|---|---|---|
| Bureau of Ocean Energy Management (BOEM) | ● | ● | ● | ● | ● |
| DOE Advanced Materials and Manufacturing Technologies Office (AMMTO) | ● | ● | | ● | ● |
| DOE Advanced Research Projects Agency-Energy (ARPA-E) | ● | | | ● | ● |
| DOE Grid Deployment Office (GDO) | | ● | ● | ● | ● |
| DOE Hydrogen and Fuel Cell Technologies Office (HFTO) | | ● | | | ● |
| DOE Loan Programs Office (LPO) | ● | ● | | ● | ● |
| DOE Office of Clean Energy Demonstrations (OCED) | ● | | | | ● |
| DOE Office of Electricity (OE) | | | | ● | ● |
| DOE Office of Energy Justice and Equity (EJE) | | ● | ● | ● | ● |
| DOE Office of Science (SC) | ● | | ● | ● | |
| DOE Office of Manufacturing and Energy Supply Chains (MESC) | | ● | | ● | ● |
| DOE Water Power Technologies Office (WPTO) | ● | ● | ● | ● | ● |
| DOE Wind Energy Technologies Office (WETO) | ● | ● | ● | ● | ● |
| U.S. Department of Transportation (DOT) | | ● | | ● | ● |
| National Oceanic and Atmospheric Administration (NOAA) | ● | | ● | ● | ● |

Based on the unique expertise, resources, and authorities described earlier, each agency can contribute to the Floating Offshore Wind Shot in one or more areas. Table 1 describes the five pillars of this Energy Earthshot and where each agency or office has capabilities to support work in that pillar.

## Progress to Date

The participating federal agencies have dedicated significant resources and expertise to the Floating Offshore Wind Shot. In addition to ongoing planning, leasing, and other supporting actions, these agencies have resulted in over $950 million[i] in support for research, development, demonstration, and deployment efforts associated with this Energy Earthshot since it was announced in September 2022. This support includes direct federal investments, associated cost share, and lease-related bidding credits. Figure 4 describes the approximate investment in the Floating Offshore Wind Shot. The sections that follow characterize the specific goals, agency engagement and leadership, stakeholder feedback, highlighted accomplishments, and near-term priorities for each pillar.

[i] Details of this funding are given within the individual pillar accomplishments sections.

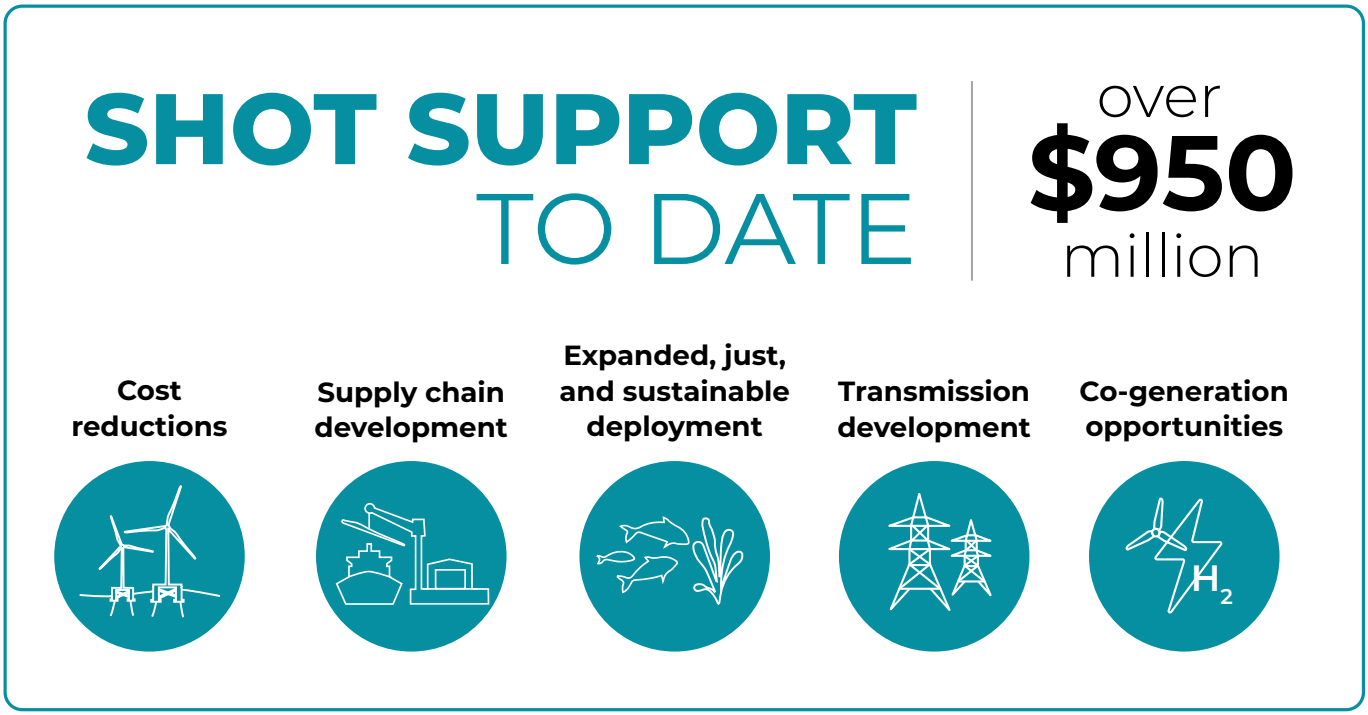



Figure 4. Approximate amount of support dedicated to the Floating Offshore Wind Shot since it's establishment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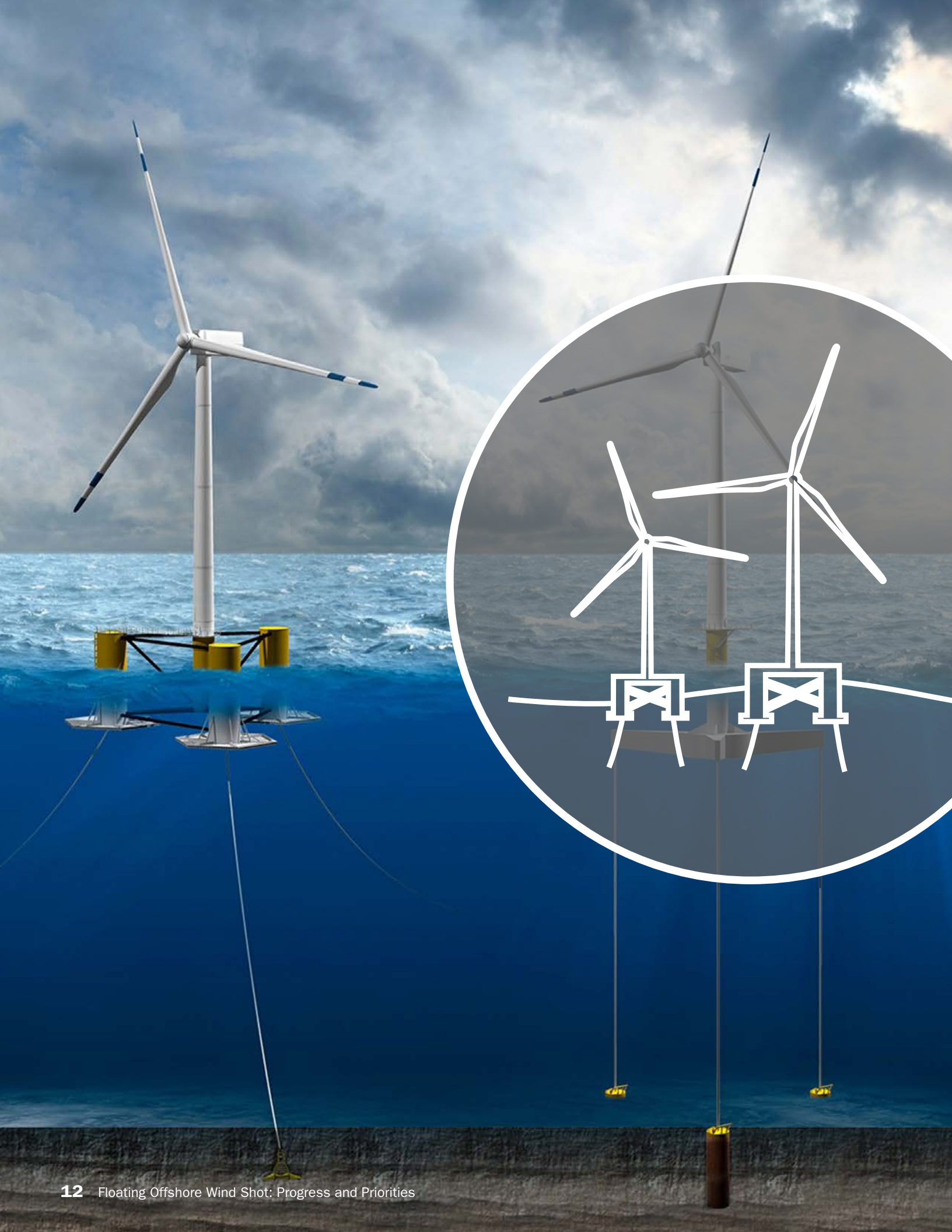
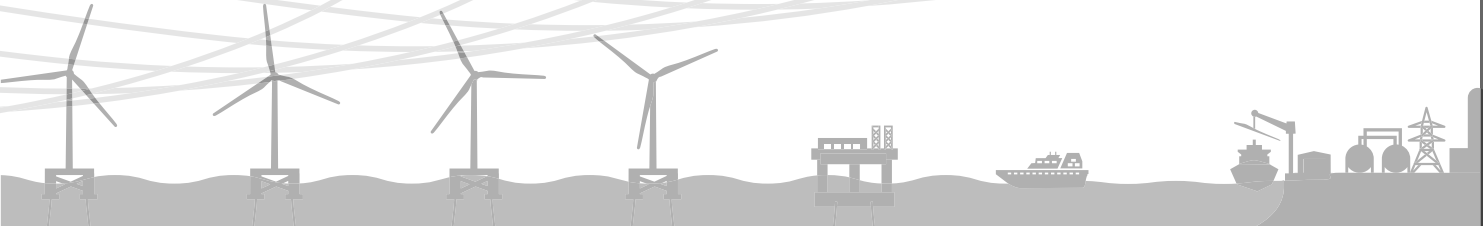


# Cost Reductions Through Technology Innovation and Deployment

**GOAL**

Reduce the levelized cost of floating offshore wind energy systems through technological advances.



There are several areas spanning research, development, demonstration, and deployment (RDD&D) that can reduce the cost of floating offshore wind; these are aligned with the activity areas identified in DOE's offshore wind strategy entitled *Advancing Offshore Wind Energy in the United States.*[17]

### Wind resource and site characterization

*Goal:* Increase the understanding of offshore meteorological and ocean conditions through modeling and measurements to improve system design and plant energy forecasting.

### Wind turbine system innovation

*Goal:* Reduce costs by developing more efficient, higher-capacity wind turbines and integrated turbine and floating platform system designs while exploring pathways to standardization.

### Installation, operations, and maintenance

*Goal:* Improve safety, reduce costs, and minimize environmental impacts by developing innovative and cost-effective installation, operations, and maintenance procedures.

### Industrial-scale manufacturing

*Goal:* Adapt domestic manufacturing facilities and practices to meet the demand for commercial-scale deployment.

## Agency Engagement and Leadership

Through the Floating Offshore Wind Shot, the interagency partners aim to address the largest cost drivers, focusing on areas in which U.S. government investments can make meaningful contributions to lowering the levelized cost of energy for floating offshore wind. DOE is the primary agency involved in the cost reduction work, with significant RDD&D activities underway to advance floating offshore wind. NOAA and NSF are also contributing their expertise in atmospheric data collection and modeling research.

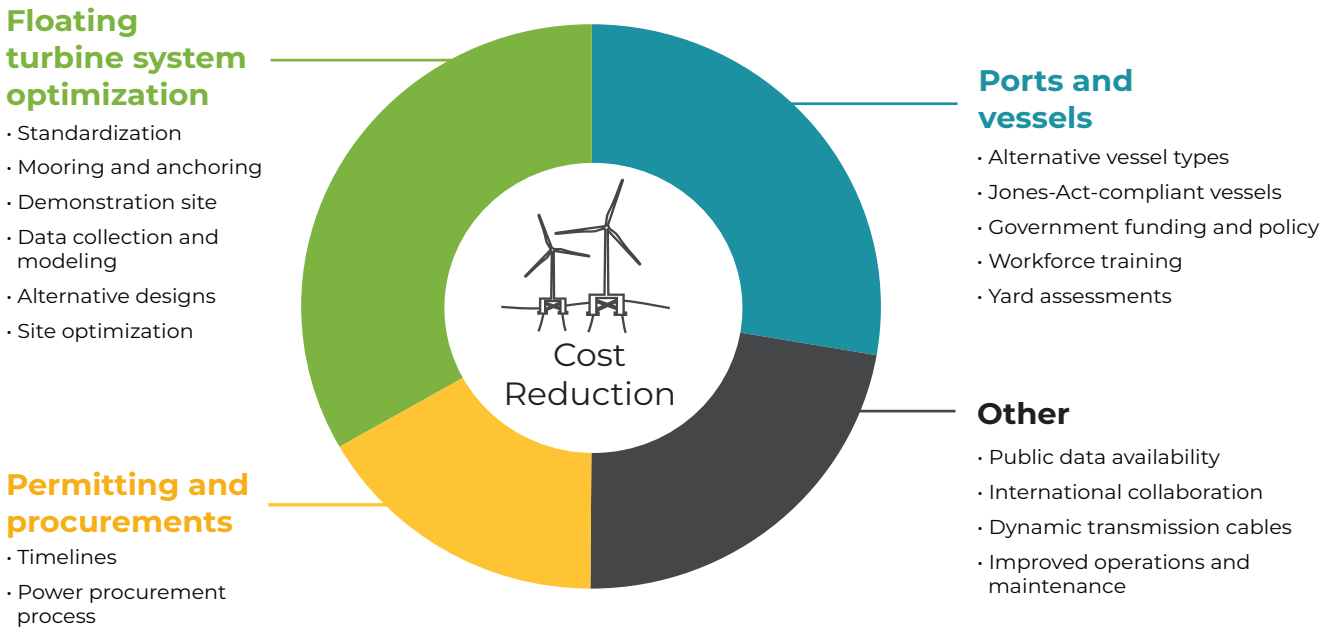



Figure 5. Key cost reduction needs and opportunities from stakeholder feedback. Relative proportion represents the number of subtopics described.

## Stakeholder Feedback

Stakeholder engagement and feedback are vital to the Floating Offshore Wind Shot. Feedback received during the Floating Offshore Wind Shot Summit in February 2023 and the Floating Offshore Wind Shot Workshop in May 2023 helped inform the priorities identified in the following section, which will shape future Floating Offshore Wind Shot activities and programs. Stakeholders identified the topic areas depicted in Figure 5 as critical needs and opportunities associated with reducing the costs of floating offshore wind energy.

## Foundational Analysis

To inform the most effective strategies for reducing costs through technology development, researchers at NREL are conducting ongoing analysis to assess potential pathways to achieve the Floating Offshore Wind Shot's cost goal.[18] NREL has introduced a framework to enable decision makers to prioritize R&D resources. This framework is structured around five mechanisms, each of which can result in cost reductions and be used to characterize innovation pathways: materials, equipment, labor, energy yield, and risk.

The pathway to a 70% cost reduction will reflect a combination of these cost mechanisms but the emphasis on each mechanism may vary. Examples of ways to reduce floating offshore wind's levelized cost of energy cover a broad set of innovation areas (Table 2). When combined, they comprise impactful innovation pathways. As part of its national offshore wind strategy,[19] DOE highlighted the potential impact from more efficient and larger wind turbines and floating platform system designs; mass manufacturing of floating offshore wind components; systems engineering and controls; co-design of turbine system components; new mooring, anchoring, dynamic cables, and floating substation concepts for deep-water environments; and improved operations and maintenance (O&M) strategies.

Table 2. Cost Reduction Mechanisms for Floating Offshore Wind With Examples[20]

| Mechanism | Impact on System Cost Parameters | Example Innovations or Strategies for Floating Offshore Wind Energy |
|---|---|---|
| Materials | Using fewer and/or cheaper materials without decreasing output | • Substituting lighter and more durable materials, like carbon fiber, for concrete and steel<br>• Reducing material intensity with shared export cable systems or anchor and mooring points<br>• Reducing direct-drive generator weight by using higher flux magnets and superconducting materials<br>• Optimizing system-level design |
| Equipment | Maximizing output for every unit of time that a piece of equipment is used for | • Standardizing processes for high volume manufacturing throughput<br>• Advanced operations and maintenance<br>• Designing for rapid assembly and tow-out<br>• Using specialized vessels, ports, and manufacturing facilities |
| Labor | Increasing output per dollar spent on wages | • Designing facilities to accommodate assembly-line-style manufacturing<br>• Sharing anchor and mooring points<br>• Automating manufacturing and maintenance<br>• Enabling a robust domestic workforce through training and registered apprentice programs |
| Energy Yield | Optimizing product performance and availability | • Improving wind farm controls<br>• Optimizing system layout to reduce wake losses<br>• Developing efficient operations and maintenance strategies<br>• Extending wind turbine and plant lifetimes |
| Risk Reduction | Improving financing terms and reducing contingencies | • Defining turbine design standards<br>• Gaining experience through project volume<br>• Developing a holistic analysis of uncertainties |

Cost Reduction

# ACCOMPLISHMENTS

Building on the major areas of need identified for cost reduction in the *Advancing Offshore Wind Energy in the United States* strategy, the Floating Offshore Wind Shot partner agencies have executed a variety of funding opportunities and new projects in the first year of this Energy Earthshot. These accomplishments are grouped by theme, each focusing on different approaches to reducing cost.

## Wind Resource and Site Characterization Research

### Floating Offshore Wind Resource Assessment

A new wind resource assessment identified 2.8 terawatts of floating offshore wind energy potential. This latest assessment considers technology advancements and improving economics of offshore wind energy in more moderate resource sites and in deeper waters, resulting in a notable increase relative to prior assessments.[21]

- Performer: NREL
- Supporting Office: DOE WETO

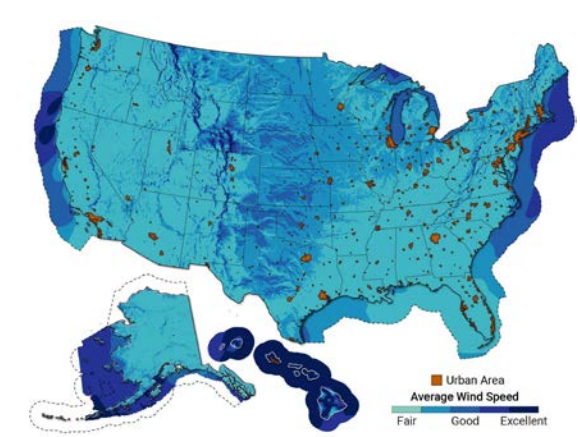



Image caption. The United States wind resource map that indicates higher wind speeds in darker blue and urban areas in orange. *Image from NREL*

### Wind Resource Data Collection

A lidar buoy was deployed east of O'ahu to collect accurate offshore wind resource, meteorological, and oceanographic data to help compare wind model predictions with actual data, preparing Hawai'i for floating offshore wind energy development. Two buoys were also deployed off the coast of California near the lease areas.[22]

- Performer: Pacific Northwest National Laboratory (PNNL)
- Supporting Offices/Agencies: DOE WETO, BOEM

Image caption. A lidar buoy deployed off the coast off Hawaii. *Image from PNNL*

## Wind Resource and Site Characterization Research

### Energy Earthshot Research Centers (EERCs)

These centers represent multi-investigator, multidisciplinary teams that will perform energy-relevant research with a scope and complexity beyond what is possible in standard single-investigator or small-group awards. Two projects are focused on the Floating Offshore Wind Shot and both emphasize wind resource modeling (DOE SC).[23]

### Scientific Challenges To Characterizing the Wind Resource in the Marine Atmospheric Boundary Layer

This 2022 report outlined the scientific "grand challenges" for evaluating offshore wind resources and identified gaps in models, datasets, and model validation to help accurately characterize the wind resource in terms of energy potential as well as operating conditions affecting wind plant performance, maintenance, and life span. (WETO and PNNL).[24]

## Wind Turbine System Innovation

### Aerodynamic Turbines Lighter and Afloat with Nautical Technologies and Integrated Servo-control[25] (ATLANTIS) program

In 2023, DOE kicked off Phase 2 of the program with additional funding to six projects to develop their revolutionary floating offshore wind designs. ATLANTIS seeks to design radically new floating offshore wind turbine design concepts that minimize mass and maximize productive rotor area to provide economical offshore wind power.

- Funding: $38 million
- Supporting Office: DOE ARPA-e

Image caption. An ARPA-e funded floating platform design incorporating motion damping technology. *Image from ARPA-E ATLANTIS*

### Anchoring and Mooring Research

DOE announced funding to improve the reliability of floating offshore wind anchoring and mooring systems through testing, monitoring, and validation. This includes testing mooring ropes for fatigue, developing sensor systems for mooring condition monitoring, and validating shared anchor/shared mooring array configurations.[26]

- Funding: $6.4 million
- Supporting Offices/Agencies: DOE WETO, DOE WPTO, BOEM, the Bureau of Safety and Environmental Enforcement (BSEE)

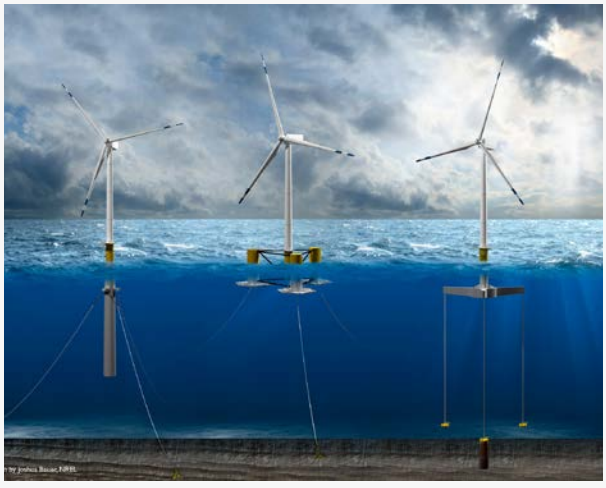


Image caption. Examples of various floating offshore wind mooring designs. *Image by Joshua Bauer, NREL*

### Seeding Critical Advances for Leading Energy Technologies with Untapped Potential (SCALE-UP) Program

DOE announced $100 million in funding, including $20 million to develop motion-dampening controls for floating platforms to reduce the overall cost. This program seeks to help businesses address market adoption risks and demonstrate cost and performance at commercial scale (ARPA-E).[27]

### Small Business Technology Development

DOE made three Phase II Small Business Innovation Research (SBIR) awards focused on floating offshore wind anchor systems, blade recycling, and atmospheric monitoring tools to accelerate wind energy deployment (WETO).[28]

### Floating Offshore Wind Array Design

This project is working to develop a modeling tool set to optimize large-scale floating offshore wind farm array designs and create reference designs for several U.S. sites. This project will fill key gaps in analysis capabilities for floating offshore wind turbine arrays and integrate these tools in a holistic framework that addresses the unique challenges of floating offshore wind turbine array design (WETO and NREL).[29]

## Installation, Operations, and Maintenance

### An Industry-Informed Operations and Maintenance (O&M) Roadmap

Published in April 2024, this roadmap includes the development of new O&M technologies and processes to enhance the cost-effectiveness, efficiency, and performance reliability of O&M tasks at offshore wind energy sites, including floating sites. The roadmap will identify knowledge gaps and emerging technology solutions that are primed for government investment, thereby enabling sustained offshore wind energy deployment through higher confidence in the ability to effectively operate and maintain offshore wind energy systems.[30]

- Performers: Sandia National Laboratories and NREL
- Supporting Office/Agency: DOE WETO

Image caption. Two maintenance workers servicing a wind turbine nacelle.
*Image from Siemens*

### Safety and Operations Research and Development

The Ocean Energy Safety Institute announced up to $2.8 million in funding for improved safety in the offshore wind energy industry, including floating systems (WETO, WPTO, and BSEE).[31]

## FLoating Offshore Wind ReadINess (FLOWIN) Prize

This three-phase, $6.85 million investment prize aims to develop the domestic supply chain for floating offshore wind energy by connecting floating platform designers with manufacturing, assembly, and installation partners to ensure that platforms can use existing domestic supply chains, and manufacturers can meet production demands. In March 2023, DOE's WETO announced nine winners of the first phase, with five winners for the second phase due to be announced in spring 2024, and the final phase continuing into 2025.[32]

- Funding: $6.85 million
- Performers (Phase I): Aikido Technologies, Beridi USA, FloatHOME, OCG-Wind Full Cycle, PelaStar, Technip Energies, Tetra Triple-One, VolturnUS+ Domestically Produced Concrete Hull, WHEEL U.S.

Image caption. A digital representation of a floating offshore wind array. *Image from NREL*

## Offshore Wind Manufacturing Research

DOE's AMMTO announced $30 million in funding to 13 projects to advance the manufacturing of composite materials and additive manufacturing for large wind turbines[33] and $15 million in funding to advance the domestic production of large metallic near net shape components, both applicable to floating offshore wind energy.[34] These efforts will promote the development of broadly applicable technologies that strengthen U.S. manufacturing.

- Funding: $15 million
- Performer: GE Research
- Funding: $30 million
- Performers: RCAM Technologies Inc., Collaborative Composite Solutions, Purdue University, University of Massachusetts Lowell, GE Research, Virginia Tech, Oak Ridge National Laboratory, Orbital Composites, Inc., University of Texas at Dallas, WEI7 LLC, University of North Dakota, and University of Delaware

Image caption. Offshore wind, a significant asset at the Port of New Bedford Massachusetts. *Photo from Cynthia Bothwell*

## Loan Programs Office Federal Financing

In 2023, LPO discussed financing options with more than 75 firms across the offshore wind energy industry. To date, LPO has received several applications from offshore wind industry participants with loan requests ranging from $100 million to over $1 billion through its Title 17 Innovative Clean Energy Loan Guarantee Program. While these projects are largely focused on fixed-bottom offshore wind, their deployment will help accelerate the scale-up and industrialization of floating offshore wind energy (LPO).[35]

## Near-Term Priorities

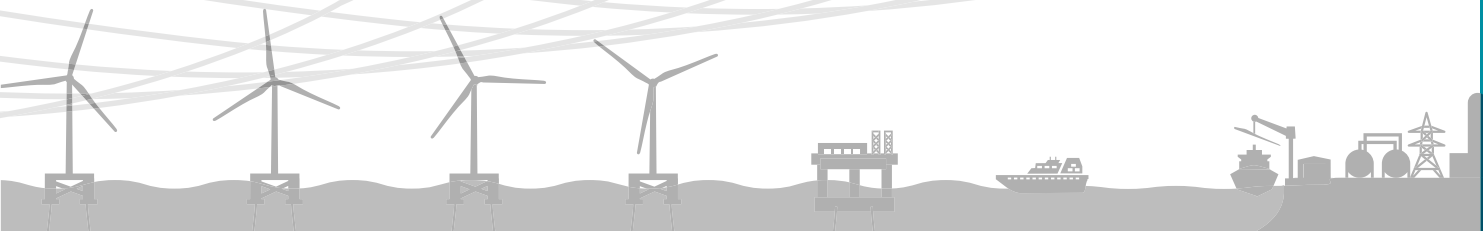
Building on the *Advancing Offshore Wind Energy in the United States* strategy and stakeholder feedback, the Floating Offshore Wind Shot partner agencies have identified the following near-term priorities associated with technical innovation.

- Develop more accurate resource assessment and wind variation modeling, with a future focus on offshore dynamics at predicted blade heights and wake interaction between individual turbines and wind farm arrays to enable more precise designs, suited to offshore conditions to avoid overengineering, and improve operational forecasting.
- Advance high-fidelity modeling of operational scenarios, including wind profiles and turbine system interactions to enable more precise designs, improve stress calculations, and improve operational forecasting.
- Create and validate integrated floating wind turbine system designs to reduce weight, cost, and environmental impacts. Potential research areas to achieve this include solid-state converters, generators, use of different materials, designs that maximize the existing supply chain, mooring and anchoring methods, and manufacturing techniques. These can reduce the cost of the system and potentially enable a broader range of handling techniques.
- Identify manufacturing needs for more efficient industrialization, including the role of "smart" manufacturing for blades (i.e., using real-time data to improve productivity and efficiency) and modular components for floating platforms to enable both automated manufacturing and distributed manufacturing for a faster throughput and more diverse supply chain.
- Advance operations and maintenance systems, including the potential use of autonomous monitoring systems to reduce overall costs and improve safety techniques.
- Assess the impact that individual RDD&D activities might contribute to overall cost reductions to help future prioritization of investment.

# Domestic Supply Chain Development

**GOAL**

Accelerate the development of the floating offshore wind supply chain to support commercial-scale deployment by identifying existing gaps and working across government and industry to find solutions.



There are several areas spanning RDD&D that can help facilitate the development of a floating offshore wind supply chain; these are aligned with the activity areas identified in DOE's *Advancing Offshore Wind Energy in the United States*.[36]

### Supply chain assessment

***Goal:*** Better understand barriers to a robust domestic supply chain for floating offshore wind and coordinate stakeholders to address them.

### Vessel and port development

***Goal:*** Support development of ports and vessels to meet long-term floating offshore wind energy deployment goals.

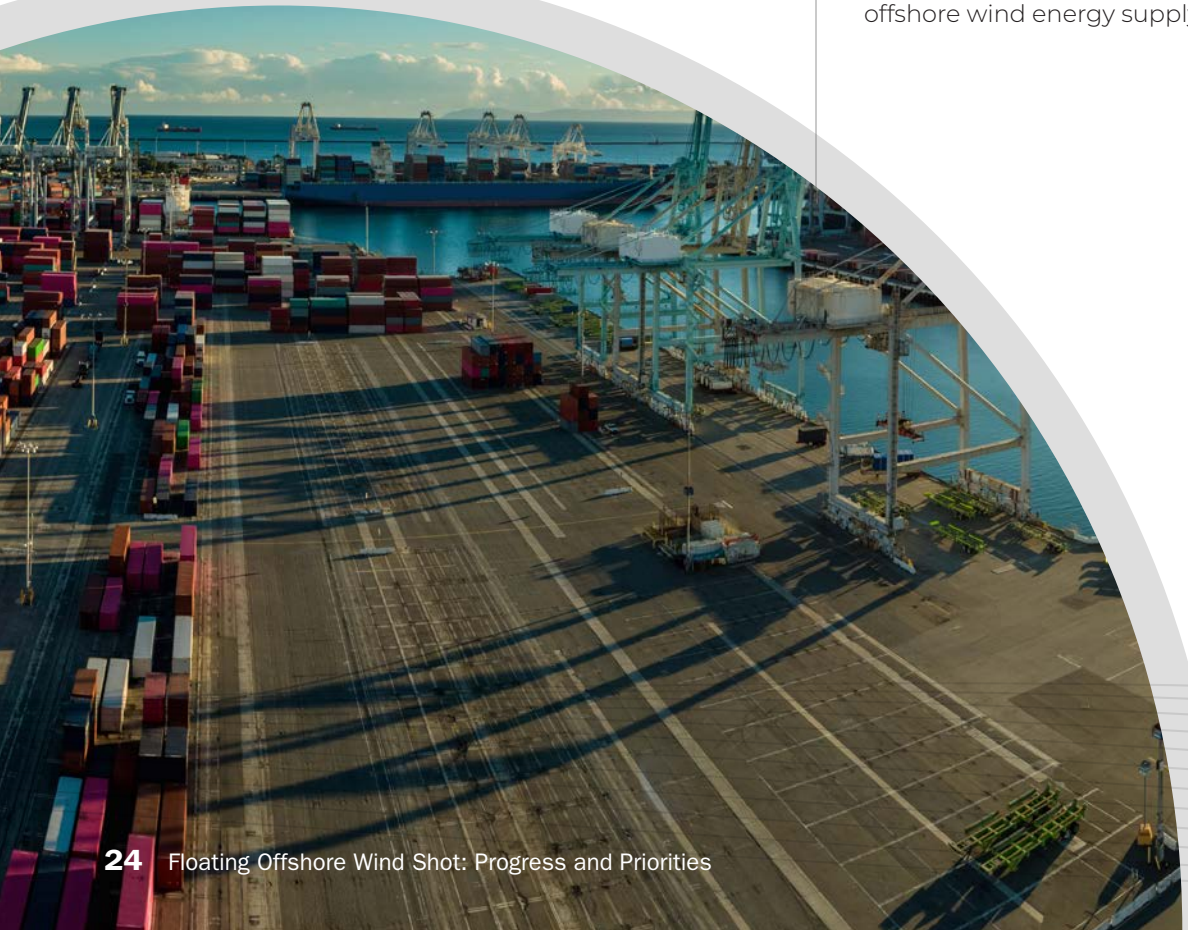
### Leasing and permitting actions

***Goal:*** Maximize the effectiveness of bidding credits within offshore wind leases to support regional supply chain and workforce development.

Key areas for supply chain development include staging and integration port sites, manufacturing port sites, installation and maintenance vessels, major component fabrication, manufacturing and installation logistics, and activating small- and medium-sized businesses as part of a supporting supply chain.

## Agency Engagement and Leadership

The scale of floating offshore wind deployment in the United States will require significant investments in supply chain development. Through the Floating Offshore Wind Shot, interagency partners aim to address the largest supply chain needs for floating offshore wind, where U.S. government investments can make meaningful contributions to developing domestic supply chain infrastructure (including port sites, U.S.-built vessels, assembly and installation logistics, and manufacturing facilities). DOE is lending its expertise in materials and manufacturing R&D, as well as technical and economic analyses. Several DOE offices have resources and expertise to contribute to this pillar. DOT has programming and funds to support port and vessel development, which are critical components of the floating offshore wind energy supply chain.



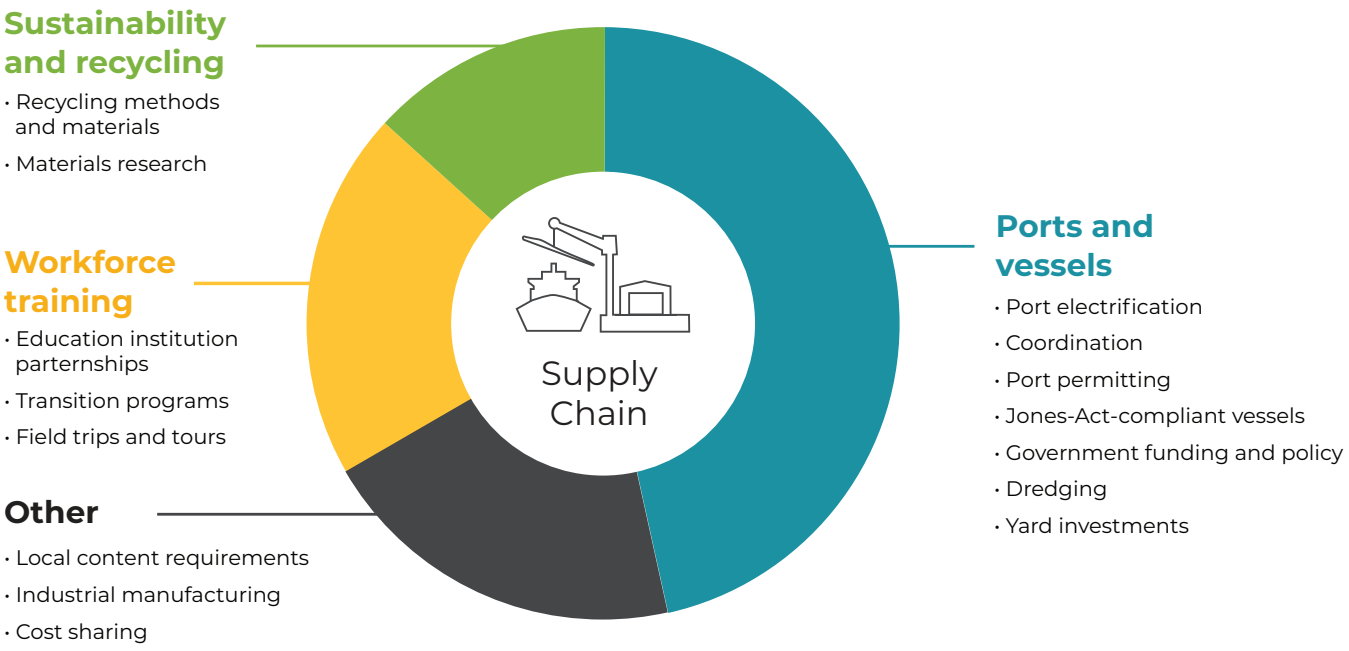



Figure 6. Key supply chain development needs and opportunities from stakeholder feedback. Relative proportion represents the number of subtopics described.

## Stakeholder Feedback

Stakeholder engagement and feedback are vital to the Floating Offshore Wind Shot. Feedback received during the Floating Offshore Wind Shot Summit in February 2023 and the Floating Offshore Wind Shot Workshop in May 2023 helped inform the priorities identified in the next section, which will shape future Floating Offshore Wind Shot activities and programs. Stakeholders identified the topic areas depicted in Figure 6 as critical needs and opportunities associated with floating offshore wind energy supply chain development.

Supply Chain Development

# ACCOMPLISHMENTS

Building on the major areas of need identified for supply chain development in the *Advancing Offshore Wind Energy in the United States* strategy, the Floating Offshore Wind Shot partner agencies have executed a variety of funding opportunities and new projects in the first year of the Floating Offshore Wind Shot.

## Supply Chain Assessments

### Federal-State Offshore Wind Implementation Partnership

The partnership brings together federal agencies with states to work together on offshore wind energy priorities.[37, 38] A memorandum of understanding was published in September 2023[39] facilitating agency and state collaboration to address building regional sustainable supply chains and national priority supply chain gaps. While the memorandum of understanding mainly focuses on East Coast development, partnership efforts encompass both fixed-bottom and floating offshore wind, so these mechanisms will apply to floating supply chain development and can be used more.

- Performers: DOE, DOC, DOI, DOT, state governments
- Supporting Office/Agency: White House

Image caption. The memorandum of understanding will facilitate regional supply chain development and collaboration. *Image from Getty 1431662879*

### West Coast Ports Analysis

The *Impacts of Developing a Port Network for Floating Offshore Wind Energy on the West Coast of the United States* was published in September 2023, which will inform future convening and collaboration opportunities on the West Coast. The report identifies five primary needs to fund, plan, and develop a robust U.S. West Coast ports network capable of supporting floating offshore wind energy deployment.[40]

- Performer: NREL
- Supporting Office: DOE WETO

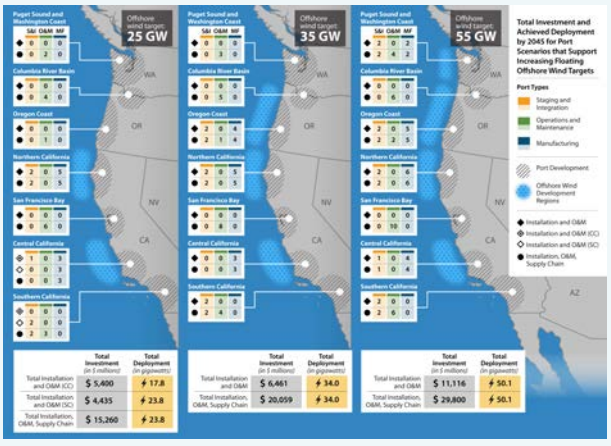



Image caption. Scenarios for port development and achievable offshore wind deployment levels. *Image from NREL*

## Supply Chain Assessments

### Supply Chain Roadmap for Offshore Wind Energy Report

This report identified challenges and solutions to develop a nationally focused offshore wind energy supply chain to meet the 2030 offshore wind target. While the report considers all offshore wind energy, it highlights some key points for floating offshore wind (WETO and NREL).[41]

### Regional Infrastructure Studies

BOEM funded port studies to inform port infrastructure needs, including *Port of Coos Bay Infrastructure Assessment for Offshore Wind Development*,[42] *California Floating Offshore Wind Regional Ports Assessment*,[43] and *California Floating Offshore Wind Regional Ports Feasibility Analysis* (BOEM).[44]

## Vessel and Port Development

### Humboldt Port Award

In January 2024, the Humboldt Bay Offshore Wind Port Project was awarded funds through the DOT Infrastructure For Rebuilding America (INFRA) program. The project will construct a marine terminal to assemble and maintain offshore wind turbine devices to serve as California's first hub for offshore wind energy installations.[45]

- Funding: $426.7 million
- Performer: Humboldt Bay Harbor, Recreation, and Conservation District

Image caption. Humboldt Bay Offshore Wind Terminal Project Site. *Photo courtesy of Humboldt Bay Harbor, Recreation, and Conservation District*

### Port Infrastructure Development Program

Offshore-wind-energy-related developments received more than $140 million in grant awards through the Port Infrastructure Development Program since September 2022. This program supports efforts by ports and industry stakeholders to improve port and related freight infrastructure to meet the nation's needs and ensure our port infrastructure can meet anticipated growth (DOT Maritime Administration).

### The Federal Ship Financing Program (Title XI)

The Title XI provides loans for vessels. In 2022, United States Maritime Administration designated vessels for construction, service, and maintenance of offshore wind facilities as Vessels of National Interest that will therefore be prioritized for financing (United States Maritime Administration).[46]

## Related Leasing and Permitting Actions[47]

### Bidding Credits

Recent offshore wind auctions incorporated nonmonetary criteria via the use of bidding credits. Bidding credits in California were specifically targeted for floating offshore wind.[48]

The workforce training bidding credit requires actions that result in a better trained and/or larger domestic floating offshore wind energy workforce that would provide more efficient operations via an increase in the supply of fully trained personnel.

The supply chain bidding credit ($117 million) requires actions that result in benefits to the domestic floating offshore wind supply chain with either demonstratable new domestic capacity or buildout or by reducing the upfront capital or certification cost for manufacturing offshore wind components, including building facilities, purchasing capital equipment, and certifying existing manufacturing facilities.

- Funding: Supply chain bidding credit: $117 million, workforce training bidding yet: not yet quantified
- Supporting Agency: BOEM

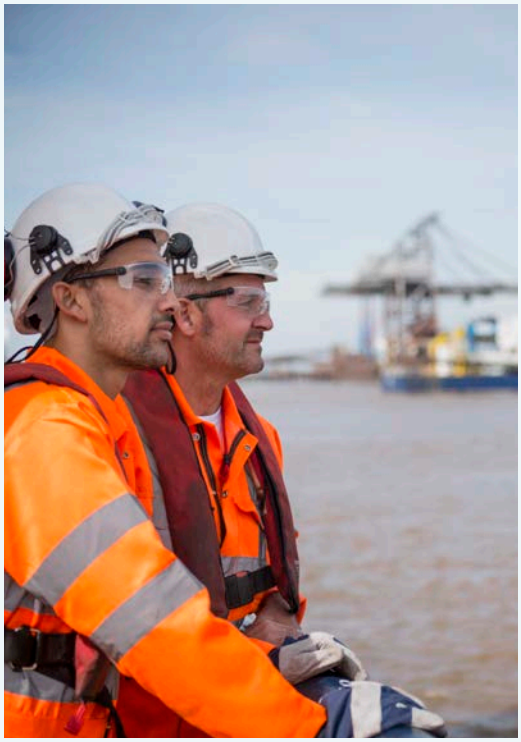


Image caption. Port workers will be essential for offshore wind energy deployment. *Image from Getty Images 158926763*

## Near-Term Priorities

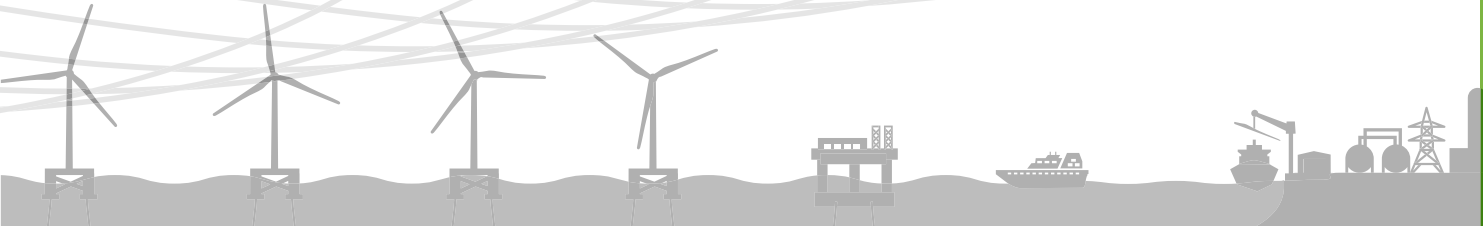
Through the development of the *Advancing Offshore Wind Energy in the United States* strategy, stakeholder feedback, and federal and state discussions, the Floating Offshore Wind Shot partner agencies have identified the following near-term priorities to promote supply chain readiness for floating offshore wind:

- Develop robust, regional supply chains that can support short-term needs but also be sustainable for the longer-term future of floating offshore wind, which will be executed by convening states at all levels (from community members to governor's offices) to work together. These efforts include activities that build on the West Coast port network study[42] and other initiatives to enable collaboration between ports and build a network of infrastructure.
- Continue analyzing supply chain needs to inform decision-making at regional and national scales.
- Mobilize investment in the supply chain through existing mechanisms, such as federal loan programs and grants. Federal agencies are assessing mechanisms to collate funding and leasing and procurement schedules, and to have a website that collates information in a single location to improve access to information about timing and suitable federal resources.
- Assess key vessel and port infrastructure gaps, including financing and availability of resources, and identify existing mechanisms that can be used or critical actions for addressing these gaps.
- Evaluate the most effective use of auction bidding credits in accordance with BOEM regulations. This includes defining how bidding credits are used, establishing or identifying programs to receive bidding credits, and working with developers and stakeholders to ensure that bidding credits maximize community benefits and support workforce or supply chain development.

## Expanded, Just, and Sustainable Deployment

**GOAL**

Build a just, sustainable, and timely floating offshore wind energy industry that seeks to avoid, minimize, and mitigate any negative environmental, economic, or social impacts.



There are several areas spanning RDD&D activities that can promote the expanded, just, and sustainable deployment of floating offshore wind; these are aligned with the activity areas identified in DOE's *Advancing Offshore Wind Energy in the United States*.[49]

### Delineation of lease areas

***Goal:*** Collect and analyze data to further support informed decisions about offshore wind lease area delineation for floating facilities.

### Workforce development

***Goal:*** Support the development of skills and education pathways needed to install floating offshore wind energy systems, promote diversity, and attract skilled workers, including those from overburdened and disadvantaged communities.

### Community engagement and ocean interests

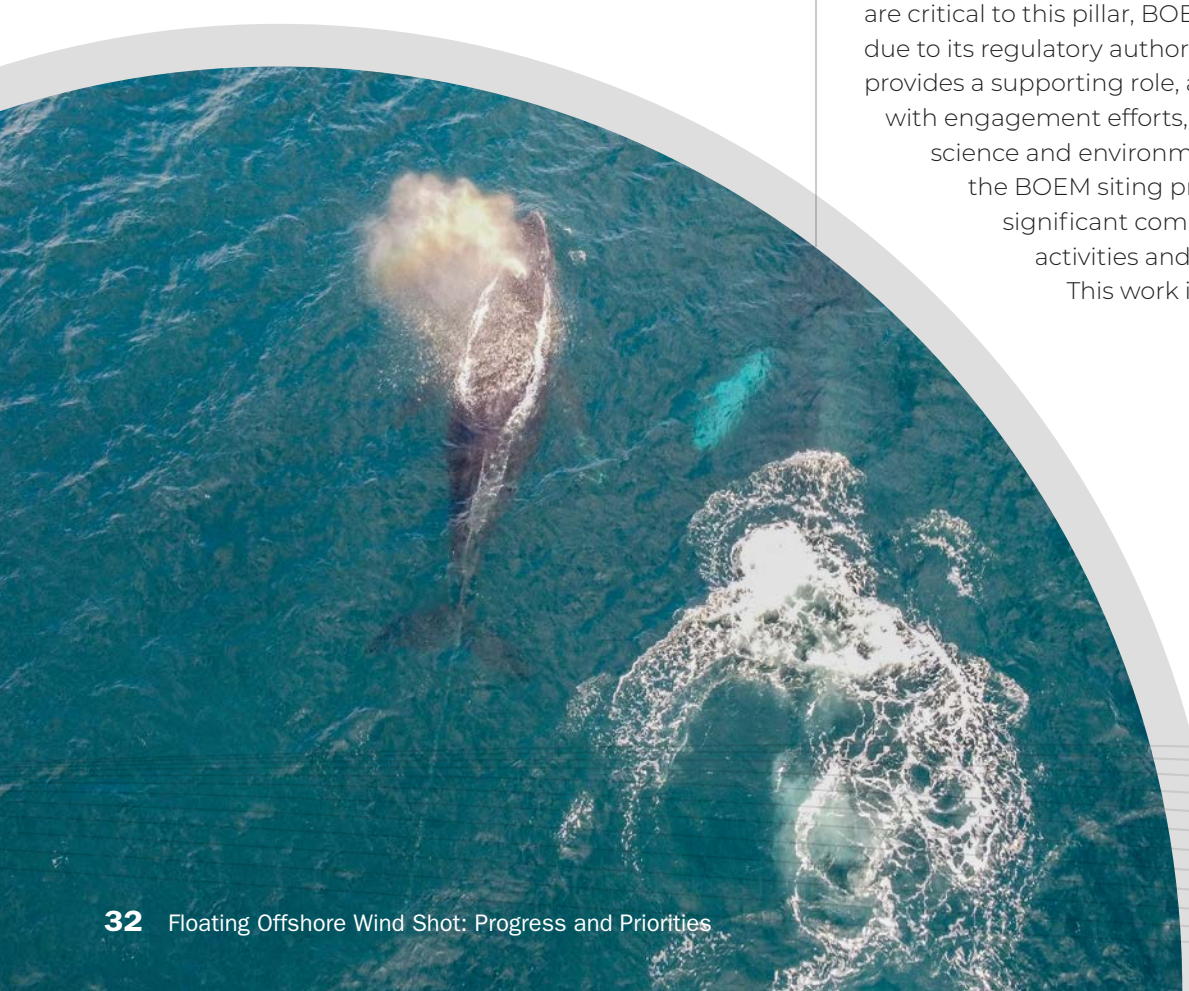
***Goal:*** Engage communities in offshore wind planning, socioeconomic analyses, and R&D to understand the perspectives of those living and working in the communities; increase opportunities for engagement; and avoid, minimize, and mitigate impacts for all ocean users and communities that may be impacted.

### Environmental research

***Goal:*** Understand and reduce environmental impacts of floating offshore wind energy deployment to promote sustainability, equitable communities, fisheries interests, and efficient permitting.

## Agency Engagement and Leadership

All offshore wind energy, including floating offshore wind, must be deployed in a way that carefully considers all communities and marine resources that could be affected by offshore wind construction and operation. Through the Floating Offshore Wind Shot, the federal government has a role to play in addressing knowledge gaps regarding impacts; developing solutions to avoid, minimize, and mitigate impacts to other marine activities where needed; and supporting community engagement. As siting and stakeholder engagement activities are critical to this pillar, BOEM is the lead agency due to its regulatory authority in this space. DOE provides a supporting role, assisting communities with engagement efforts, and performing social science and environmental research to aid the BOEM siting process. WETO funds significant community engagement activities and environmental research. This work is occasionally co-funded



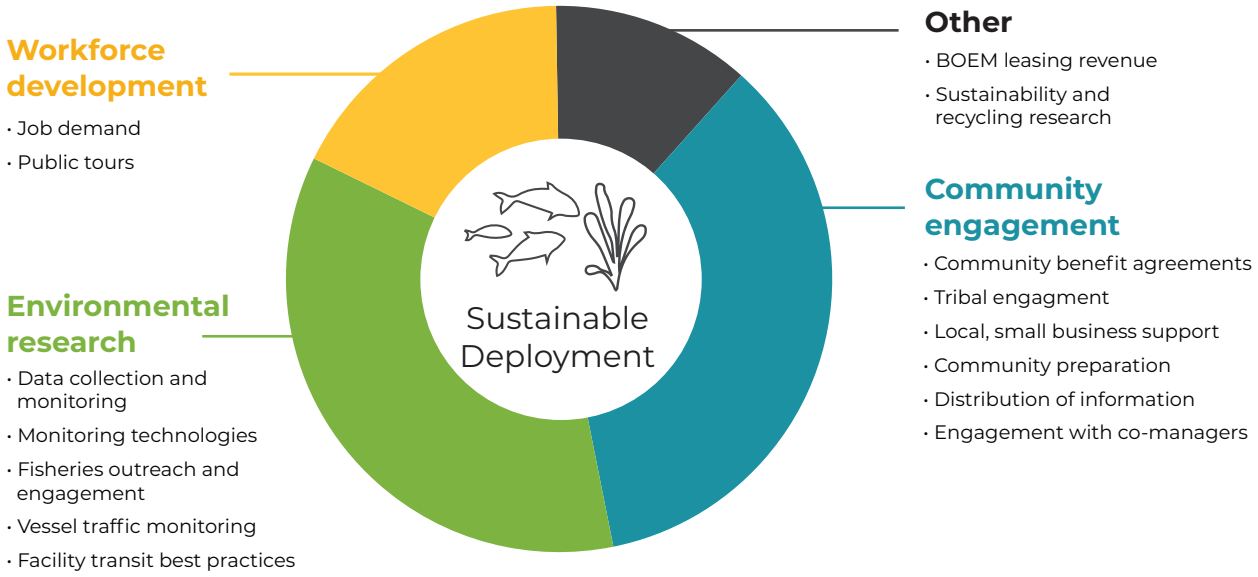



Figure 7. Key expanded, just, and sustainable deployment needs and opportunities from stakeholder feedback. Relative proportion represents the number of subtopics described.

by WPTO, as there are some similarities in regional and technical needs of offshore wind and marine energy floating platforms. The DOE Office of Energy Justice and Equity (EJE) helps support energy justice principles and promote the development of a diverse workforce, along with several other DOE offices. EJE coordinates the implementation of community benefit plans to promote equitable distribution of benefits resulting from projects funded by the Bipartisan Infrastructure Law and Inflation Reduction Act. These efforts ensure 40% of the benefits flow to disadvantaged communities pursuant to the White House's Justice40 Initiative. NOAA and the U.S. Fish and Wildlife Service also contribute to this pillar, helping BOEM by providing environmental intelligence and site delineation support, as well as ensuring compliance with relevant marine resource management laws.

## Stakeholder Feedback

Stakeholder engagement and feedback are vital to the Floating Offshore Wind Shot. Feedback received during the Floating Offshore Wind Shot Summit in February 2023 and the Floating Offshore Wind Shot Workshop in May 2023 helped inform the priorities identified in the following section, which will shape future Floating Offshore Wind Shot activities and programs. Stakeholders identified the specific topic areas (Figure 7) as critical needs and opportunities associated with expanded, just, and sustainable floating offshore wind energy deployment.


27 A

Expanded, Just, and Sustainable Deployment

# ACCOMPLISHMENTS

Building on the major areas of need identified for expanded, just, and sustainable deployment in the *Advancing Offshore Wind Energy in the United States* strategy, the Floating Offshore Wind Shot partner agencies have executed a variety of funding opportunities and new projects in the first year of this Energy Earthshot.

## Delineation of Lease Areas

### Floating Offshore Wind Leasing Milestones

BOEM's 5-year plan, "Offshore Wind Leasing Path Forward 2021–2025," describes the regional sequencing of seven offshore wind leasing auctions across the country, which allows for regional industry planning. BOEM also auctioned five deep-water lease areas off the California coast for a total of $757 million, to support the first U.S. floating offshore wind deployment (BOEM).[50]

- Supporting Agency: BOEM

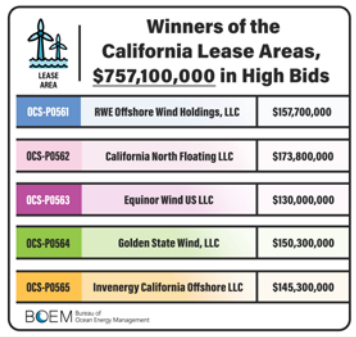



Image caption. The results of the California offshore wind lease auction totaled $757 million. *Image from BOEM*

### New Wind Energy Areas for Floating Offshore Wind

Efforts are underway to improve visibility into how potential areas for wind energy development are identified, balancing and evaluating the multiples uses and resources of the U.S. Outer Continental Shelf. The identification of potential lease areas promotes additional offshore wind deployment that will contribute to the national deployment goals. In the past year, spatial models were established for:

- The final wind energy areas off the coast of Oregon (February 2024)[51]
- The final wind energy area in the Gulf of Maine (March 2024)[52]
- Supporting Offices/Agencies: BOEM and NOAA-National Centers for Coastal Ocean Science's Coastal and Marine Planning

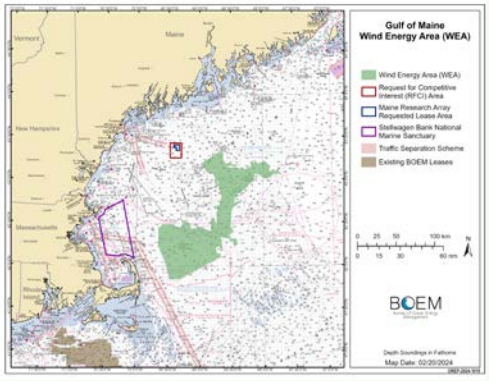



Image caption. The final designated wind energy area for offshore wind in the Gulf of Maine. *Image from BOEM*

## Offshore Wind Center of Excellence

In February 2024, DOE's WETO awarded funding to create a university-led Center of Excellence to increase offshore wind expertise at U.S. universities, develop partnerships to address key offshore wind energy development challenges, and educate the next generation of offshore wind experts in the United States.[53]

- Funding: $4.75 million
- Performers: University of Massachusetts Amherst, Clemson University, Morgan State University, Johns Hopkins University, Northeastern University, University of Massachusetts Dartmouth, University of Massachusetts Lowell, University of Puerto Rico at Mayagüez, Argonne National Laboratory, NREL, PNNL, the Massachusetts Clean Energy Center, and the Maryland Energy Administration.

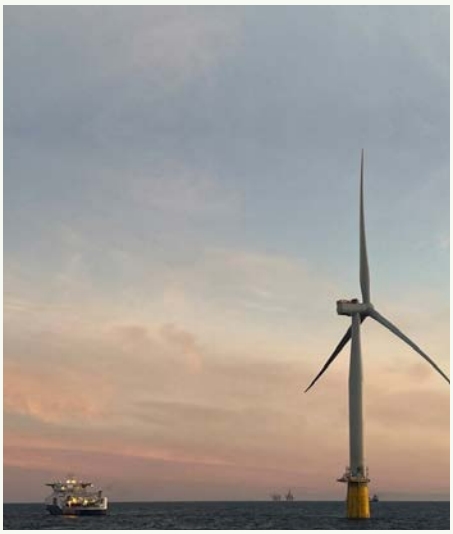


Image caption. An Equinor offshore wind turbine. *Image from Equinor*

## *Offshore Wind Workforce Assessment* Report

This report provides estimates of the current and future workforce needs to better understand what the industry—and its workforce—may need to achieve national offshore wind deployment goals. This report identifies relevant occupations and requirements; highlights emerging educational institutions, training programs, and initiatives; and identifies workforce gaps.[54]

- During the International Partnering Forum in April 2023, DOE and NREL hosted an offshore wind workforce summit to bring together wind energy workforce leaders to discuss industry needs and strengths (WETO and NREL).
- Performer: NREL
- Supporting Office: DOE WETO

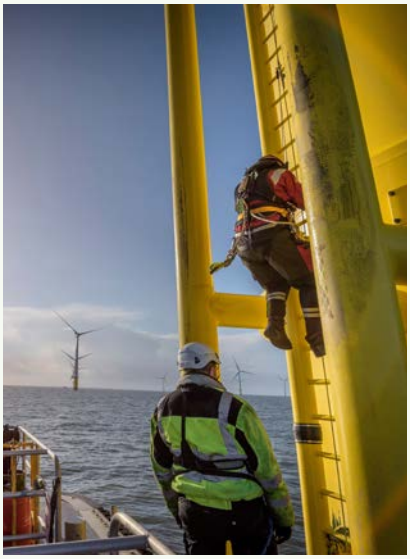


Image caption. Offshore wind engineers performing maintanence on an offshore wind farm. *Image from Getty 565783097*

## Collegiate Wind Competition

The 2023 competition called on teams to develop solutions to the siting, development, and outreach challenges associated with offshore wind energy projects. This annual event helps college students prepare for jobs in the workforce through real-world experiences with wind energy technology, project development, finance, communications, and outreach (WETO).[55]

## DOE's Justice Week

DOE hosted its second annual Justice Week hybrid event in late 2023 in support of an equitable and just clean energy transition focusing on community engagement and workforce development (EJE, WETO).

## Social Science Research and Engagement

DOE awarded five research projects to advance social science research and community engagement. These awards will help characterize economic and other impacts of offshore wind development on local communities and build capacity for communities to better participate in, and benefit from, offshore wind development.[56]

- Funding: $6.5 million
- Performers: Oregon State University, University of Rhode Island, Gulf of Maine Research Institute, Sandia National Laboratories, Yurok Tribe


Image caption. The Gulf of Maine Research Institute facility, where one of the five social science projects will be conducted. *Image from Gulf of Maine Research Institute*

## NOAA Sea Grant Offshore Wind Liaison Program

This program was expanded to Washington, Oregon, and California to ensure continued discussion with communities related to floating offshore wind energy (WETO and NOAA). NOAA's National Marine Fisheries Service (NOAA Fisheries) and BOEM have also partnered with the Responsible Offshore Development Alliance, the University of Rhode Island, and Rhode Island Sea Grant to develop an integrated ecosystem assessment for offshore wind in the Gulf of Maine, an area suited to floating offshore wind energy development.[57]

- Performers: NOAA Fisheries, BOEM, Responsible Offshore Development Alliance, universities, and Sea Grant
- Supporting Offices/Agencies: DOE WETO, DOE WPTO, BOEM, and NOAA

Image caption. Rhode Island Sea Grant Port of New Bedford facility tour. *Image from Rhode Island Sea Grant*

## West Coast Cultural Studies

BOEM provided $2.3 million to conduct studies to improve understanding of cultural landscapes and ancient submerged landforms off the West Coast (BOEM).[58]

## Tribal Business Support

BOEM funded two Indian Small Business Economic Enterprises with $350,000 each to support Tribal participation and engagement during environmental reviews of proposed offshore wind energy activities on the Outer Continental Shelf offshore California and Oregon (BOEM).[59]

## BOEM Public Engagement

Community engagement is the cornerstone of BOEM's process, and when identifying potential lease areas the agency engages with various stakeholders through task force meetings, public meetings, targeted engagement meetings with Tribal nations and stakeholder groups, and other avenues. Oregon and Maine both held intergovernmental Renewable Energy Task Force meetings in 2023 to further develop potential floating offshore wind leases (BOEM).

## Wildlife, Fisheries, and Habitat Research

DOE's WETO and BOEM, in collaboration with NOAA Fisheries, awarded several environmental research projects in 2022 to begin data collection to support environmental monitoring ($13.5 million)[60] and announced an additional $1.6 million to support the coexistence of bats with offshore wind energy.[61]

- Studies on the East Coast assess offshore wind risks to wildlife and commercial fisheries, including from floating offshore wind.
- Surveys on the West Coast establish bird, bat, and marine mammal presence in potential energy development areas. In addition, studies are underway to develop autonomous monitoring systems for marine organisms and the seabed.
- Funding: $15.1 million
- Performers: Duke University (and collaborators), Coonamessett Farm Foundation Inc., Oregon State University, Woods Hole Oceanographic Institution, and Electric Power Research Institute

Image caption. A researcher observing bird and marine mammal presence at a potential offshore wind site. *Image from Oregon State University*

## Additional BOEM-Funded Environmental Research

BOEM funded a series of studies that were completed in 2023 related to seabirds, habitat use, and marine mammals along the West Coast and around Hawai'i, with ongoing studies to inform the risks of offshore renewable energy related to birds (BOEM).[62]

## Synthesis of Environmental Effects Research

This initiative facilitates knowledge transfer for offshore wind energy environmental research and informs the application of that research to U.S.-specific considerations. In 2023, the initiative facilitated three public workshops that focused on regional surveys, autonomous environmental monitoring, and bird and bat monitoring technologies, as well as established the Pacific Coast Offshore Wind Environmental Research Project Finder (WETO and PNNL).[63]

## Aquaculture Co-Location With Floating Offshore Wind

DOE announced $1.5 million to fund research on the feasibility of and identify potential synergies and challenges associated with co-location of aquaculture production and commercial-scale floating offshore wind (WETO and WPTO).[64]

### National Offshore Wind R&D Consortium

The consortium funded two new projects in late 2022 to monitor protected marine mammals and design floating offshore wind arrays to be compatible with fishing. These projects will help improve the understanding of how wildlife and fisheries interact with floating offshore wind (WETO and state governments).[65]

### North Atlantic Right Whale Strategy

In January 2024, NOAA Fisheries and BOEM announced the final strategy, informed by a draft strategy released for public comment in December 2022. The strategy identifies the agencies' goals and key actions for continuing to evaluate and mitigate the potential effects of offshore wind energy development on North Atlantic right whales and their habitat. It also builds on existing mitigation measures to protect these whales from the potential impacts of offshore wind energy development (including floating offshore wind; WETO, NOAA, and BOEM).[66]

## Near-Term Priorities

Through the development of the *Advancing Offshore Wind Energy in the United States* strategy and feedback from different forms of engagement, the Floating Offshore Wind Shot partner agencies have identified the following near-term priorities to advance responsible floating offshore wind energy deployment.

#### Delineation of Lease Areas

- Maintain and communicate a leasing schedule and process. BOEM has proposed that the 5-year leasing schedule be updated at least once every 2 years. This effort will lead to continued work assessing the coexistence of offshore wind sites with other ocean users and the potential for project siting in deeper waters.

#### Workforce Development

- Identify remaining wind energy workforce gaps and transition training to be more vocational. Support programs across the country that are leading the way in building a diverse clean energy workforce with more offshore wind capabilities to meet workforce demands.
- Support pathways for career transitions and those from disadvantaged communities to enter the wind energy field through university-based programs, internships, and apprenticeships. Additionally, the 2025 Collegiate Wind Competition will include a floating offshore wind component to help diversify the workforce and support disadvantaged communities as the industry grows.

#### Community Engagement

- Advance our understanding of impacts of offshore wind energy on communities, how to minimize negative impacts, and maximize positive impacts to communities equitably and justly, including through meaningful participation. Lead meaningful and diverse engagement and effective communication.
- Elevate Tribal involvement and consideration throughout planning processes and build capacity for Tribes through federal resources to ensure Tribes can be involved in a meaningful way.

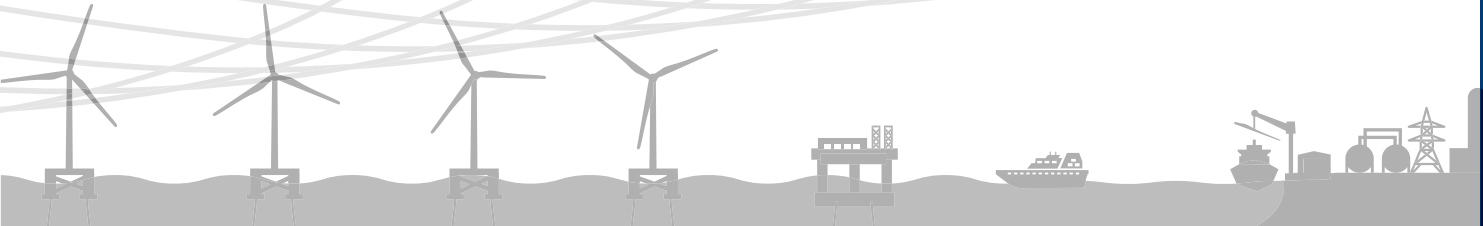
#### Environmental Research

- Understand and mitigate negative impacts of offshore wind on commercial, recreational, and subsistence fishing. Develop and deploy new fishery-related survey technologies and approaches to meet long-term regional monitoring requirements to help identify fisheries-related impacts and appropriate mitigation and management procedures.
- Improve monitoring technology, data collection, modeling, and collaboration in deep-water environments to help understand the potential impacts and effective mitigation measures.
- Increase understanding of interactions between floating offshore wind and wildlife, fisheries, and habitat and advance strategies to avoid, minimize, and mitigate interactions of concern.

# Transmission Development

**GOAL**

Determine feasible solutions for long-distance offshore transmission and system interoperability to capture floating offshore wind generation and enhance the reliability and resilience of the power system.



There are several areas of RDD&D activities that can support transmission development for floating offshore wind; these are aligned with the activity areas identified in DOE's *Advancing Offshore Wind Energy in the United States*.[68]

### Transmission development

***Goal:*** Convene and coordinate planning efforts for the design and construction of an offshore wind transmission network(s).

### Transmission infrastructure solutions

***Goal:*** Inform regional transmission development through data collection and analysis, tailored toward local infrastructure needs for offshore wind energy.

### Cybersecure, reliable, and resilient grid

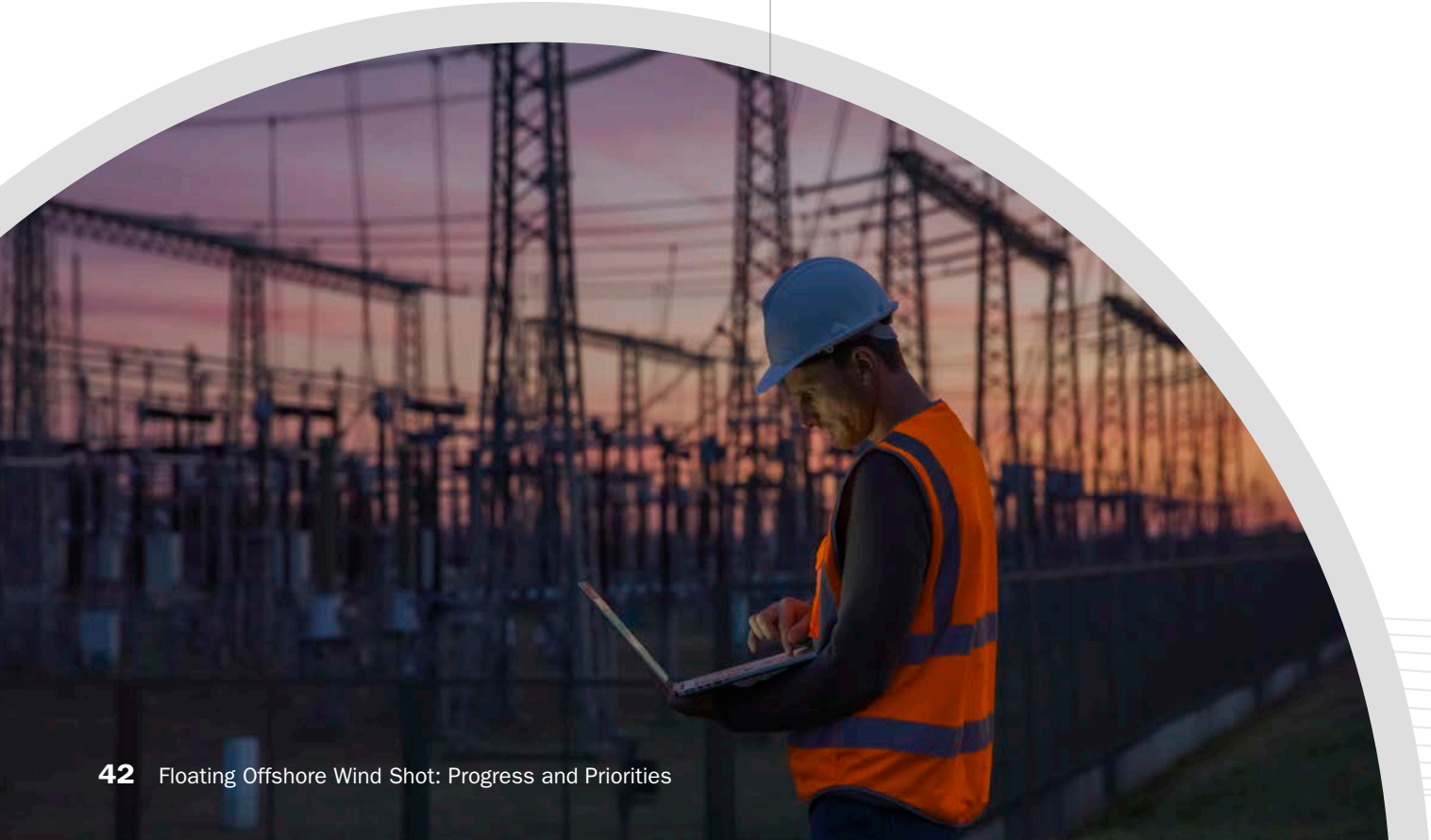
***Goal:*** Protect wind energy systems from cyberattacks and improve reliability and resiliency of offshore wind transmission systems.

### Critical technologies development

***Goal:*** Develop technologies to increase the performance and reliability of offshore wind transmission.

## Agency Engagement and Leadership

Floating offshore wind energy cannot fully benefit the American people without the necessary transmission infrastructure to incorporate that energy into the grid. The challenges range from planning and coordinating transmission infrastructure projects to improving the cables and substation technologies. Through the Floating Offshore Wind Shot, the interagency partners aim to address the critical transmission development needs for floating offshore wind energy, areas for which U.S. government investments can make meaningful contributions to integrating floating offshore wind energy into the grid. WETO and GDO (among other DOE offices) lead the transmission development pillar, in collaboration with BOEM. DOE and BOEM co-lead extensive transmission planning and stakeholder engagement activities while DOE's OE and ARPA-E lead much of the transmission technology R&D. AMMTO and ARPA-E also assist in the technological innovation and manufacturing needs associated with transmission infrastructure, along with other DOE offices, such as LPO and the Office of Technology Transitions. NOAA and DOT also play a role in this pillar, providing environmental and transportation recommendations where applicable.



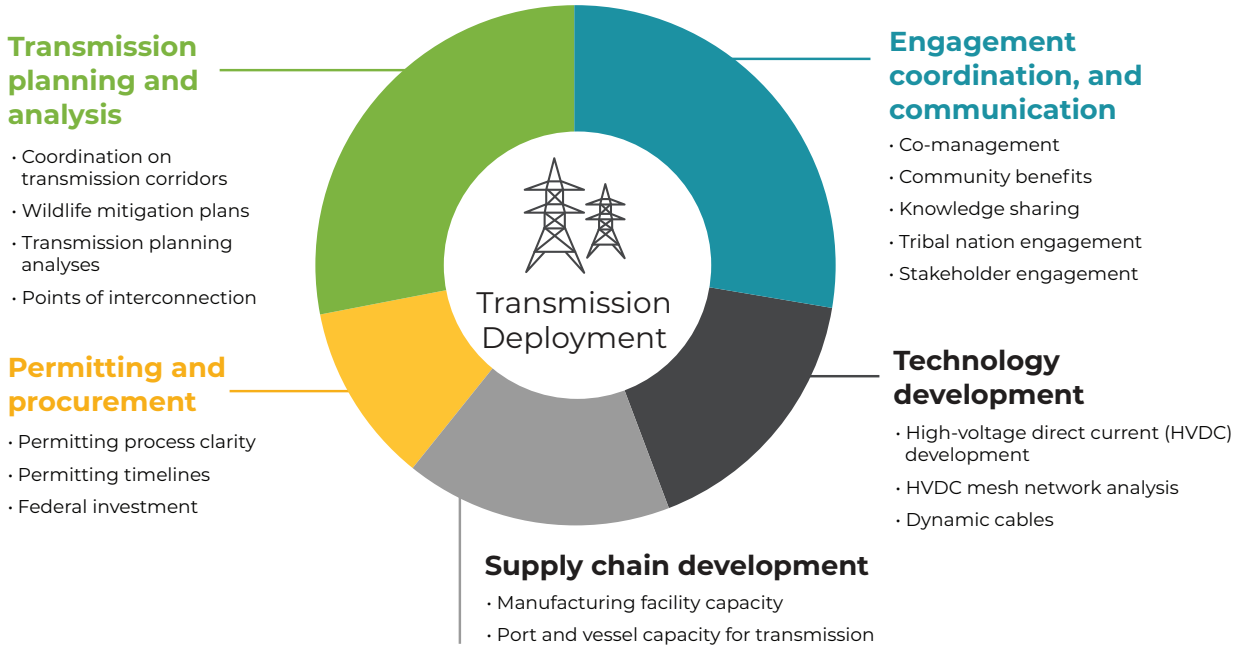
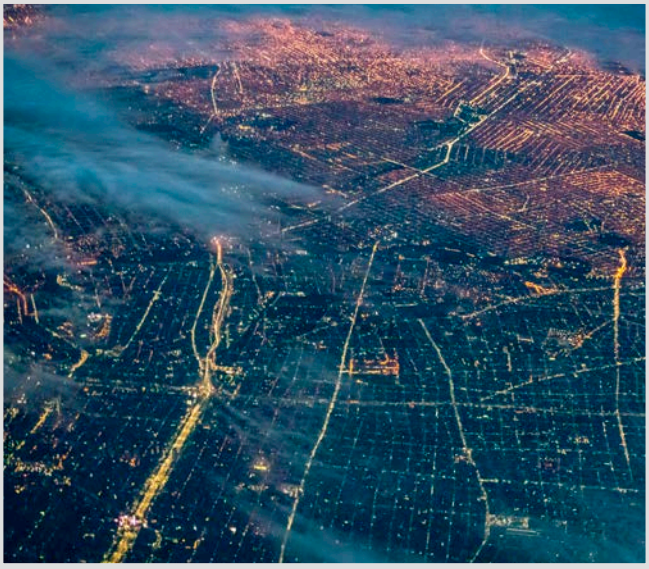



Figure 8. Key transmission development needs and opportunities from stakeholder feedback. Relative proportion represents the number of subtopics described.

## Stakeholder Feedback

Stakeholder engagement and feedback are vital to the Floating Offshore Wind Shot. Feedback received during the Floating Offshore Wind Shot Summit in February 2023 and the Floating Offshore Wind Shot Workshop in May 2023 helped inform the priorities identified in the following section, which will shape future activities and programs. Stakeholders identified the (Figure 8) critical needs and opportunities associated with floating offshore wind transmission development.




BOX
HOUSE

Transmission and Development

# ACCOMPLISHMENTS

Building on the major areas of need identified for transmission development in the *Advancing Offshore Wind Energy in the United States* strategy, the Floating Offshore Wind Shot partner agencies have executed a variety of funding opportunities and new projects in the first year of this Energy Earthshot.

## Transmission Development

### An *Action Plan for Offshore Wind Transmission Development in the U.S. Atlantic Region*

The action plan was published in March 2024 and recommends actions to address transmission system needs and further development to support fixed-bottom and floating offshore wind energy along the coast. It outlines immediate actions needed to connect the first generation of Atlantic offshore wind projects to the electric grid, as well as longer-term efforts to increase transmission over the next several decades.[69]

- Supporting Offices/Agencies: DOE WETO, DOE GDO, BOEM

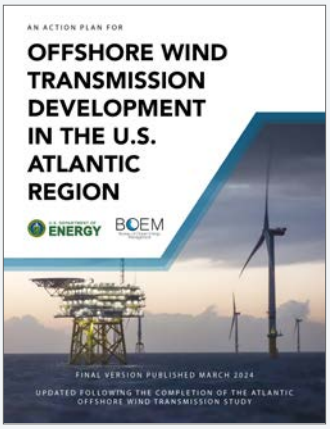



Image caption. The cover image for *An Action Plan for Offshore Wind Transmission Development in the U.S. Atlantic Region*. *Image from DOE*

### The West Coast Offshore Wind Transmission Convening Series

This outreach kicked off in January 2024 and brings stakeholders and communities together to discuss key transmission needs for the region relating to the build-out of offshore wind energy and develop a set of recommendations and an associated action plan for addressing near-, medium-, and long-term transmission challenges specific to the West Coast.[70]

- Supporting Offices/Agencies: DOE GDO and BOEM

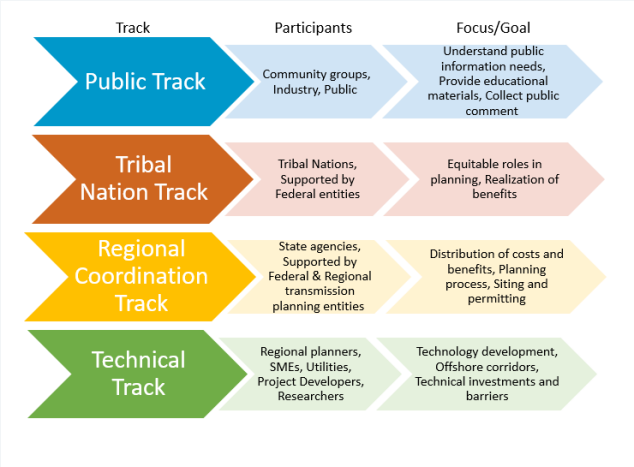



Image caption. West Coast Convening Series tracks designed to garner feedback. *Image from DOE*

## Transmission Development

### *West Coast Offshore Wind Transmission Literature Review and Gaps Analysis* Report

This report was published in February 2023 to inform analysis and data needs for the West Coast. This literature review and gaps analysis will guide future research investments that address transmission requirements for near- and long-term offshore wind energy deployment on the West Coast (WETO, GDO, and PNNL).[71]

### West Coast Offshore Wind Transmission Study

This effort was launched in May 2023 to investigate transmission options that will support offshore wind energy development along the West Coast through 2050 (GDO, WETO, NREL, and PNNL) (Figure 37).[72]

### Interconnection Innovation e-Xchange Program

This program convened stakeholders and developed a draft roadmap to improve interconnection of clean energy resources, including floating offshore wind.[73] The Interconnection Innovation e-Xchange (i2X) program announced a $10 million funding opportunity in March 2024 to address the transmission system interconnection challenges by creating software tools that can accurately simulate the effect of new clean energy plants on existing grid infrastructure, and by providing detailed, secure data to project developers (WETO and DOE Solar Energy Technologies Office [SETO]).[74]

## Transmission Infrastructure Solutions

### Inflation Reduction Act Funding for Transmission

The Inflation Reduction Act provided $100 million in funding for interregional and offshore wind transmission planning and convening. Programs supported since the establishment of the Floating Offshore Wind Shot include the Tribal Nation Offshore Wind Transmission Technical Assistance Program, West Coast Offshore Wind Transmission Study, and West Coast Offshore Wind Transmission Convening Series (GDO).[75]

## Cybersecure, Reliable, and Resilient Grid

### Cybersecurity Research

The Offshore Wind Cybersecurity project performs an offshore wind cybersecurity assessment that will include a reference architecture, a simulation to analyze cybersecurity risks, and recommendations to better secure fixed-bottom and floating offshore wind energy.[76]

- Performers: Idaho National Laboratory (INL), and NREL
- Supporting Office: DOE WETO

Image caption. A digital representation of a cybersecurity network to protect wind energy. *Image from iStock.*

### High-Voltage Direct Current Requirements Analysis

The Protection and HVDC Breaker Needs for Offshore Grid Developments in the Atlantic region project studies the protection of multiterminal, high-voltage direct current (MT-HVDC) systems. This project will enable both fixed-bottom and floating offshore wind energy deployment by reducing costs and improving reliability in long-distance transmission technology, like the HVDC circuit breakers required to connect offshore wind energy to the grid (WETO and NREL).[77]

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### The Wind Security through Hardware Installation, Education, and Layered Defense (WindSHIELD)

This project delivers deployable cybersecurity tools and training specific to the wind energy industry. The toolkit will include a standardized, repeatable cybersecurity financial risk assessment that provides guidance for investment decisions surrounding cybersecurity programs in the wind industry (WETO and INL).[78]

## Critical Technologies Development

### HVDC Converter Systems Research

DOE announced research to drive innovation and reduce costs of HVDC voltage source converter systems to promote grid stability and enable future grid upgrades needed to cost-effectively integrate an increasing amount of renewable energy generation on to the grid, both on land and offshore.[79]

- Funding: $10 million
- Supporting Offices: DOE WETO and DOE OE

Image caption. An offshore wind energy substation in the Baltic Sea. *Image from NREL*

### HVDC Standards Research and Development

DOE awarded funds for projects aimed at developing HVDC standards, innovative controls, and curricula to advance technologies needed to transmit large amounts of electricity from offshore wind over long distances and provide the education and training to equip the workforce.[80]

- Funding: $8.5 million
- Performers: DNV Energy USA Inc., GE Research, Oak Ridge National Laboratory, Iowa State University

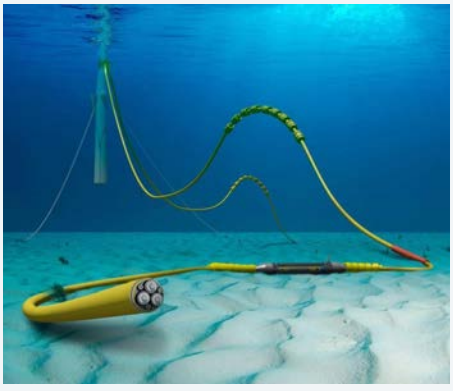

Image caption. A simulated image of a floating HVDC cable. *Image from NREL*.

### High-Voltage Direct Current Prize

This prize provided $200,000 in funding support to develop new energy system solutions to improve renewable distributed generation, transmission to population centers, and integration with the U.S. energy grid (OE).[81]

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### Scalable Hybrid Large-Scale AC-DC Grid Analysis Methods Project

This project seeks to develop characterization methods and tools to evaluate the reliability, transient stability, and economics of large-scale DC or multiterminal direct current (MTDC) architectures in alternating current (AC) grids. This project will help develop MTDC architectures for hybrid integration with AC grids that are optimized around cost and key functional metrics (OE, NREL, Oak Ridge National Laboratory, and PNNL).[82]

## Near-Term Priorities

Through the development of the *Advancing Offshore Wind Energy in the United States* and feedback from stakeholder engagement, the Floating Offshore Wind Shot partner agencies have identified the following near-term priorities to address critical transmission needs:

- Conduct in-depth transmission studies aiming to better understand possible offshore transmission configurations for improved efficiency and reliability. Enhance transmission modeling tools and collaboration in climate modeling to enable more effective planning and deployment strategies. Conduct cost-benefit analyses for various offshore transmission configurations and financing options, aiming to identify economically viable solutions that align with sustainable energy goals.
- Equip system planners and operators with the latest wind and HVDC protection models to improve the industry's confidence in operating a reliable, resilient, and cybersecure grid with more offshore wind energy.
- Develop standards for offshore transmission to promote industrywide practices and support supply chain development. Convene stakeholders, national laboratory staff, and industry experts, and foster a collaborative environment where insights and knowledge are shared to ensure that the resultant standards are well-informed, focused on sustainability, and conducive to the long-term success of offshore energy transmission.
- Expand research and development on other critical offshore HVDC transmission components for bulk power transfer to shore and medium-voltage DC solutions for offshore interconnections to advance energy transfer efficiency and reliability.


H2

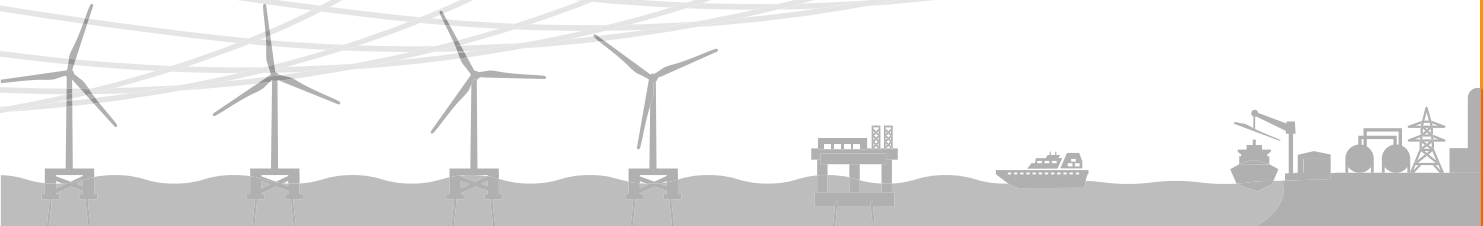
PILLAR 5

Co-Generation Opportunities

# Co-Generation Opportunities

**GOAL**

Advance offshore wind co-generation technologies in support of widespread electrification and a net-zero economy.



There are several areas of RDD&D activities that can promote co-generation opportunities with floating offshore wind; these align with the activity areas identified in DOE's *Advancing Offshore Wind Energy in the United States*.[83]

### Wind energy storage solutions advancement

***Goal:*** Enable widespread adoption of coupled offshore wind storage systems to help balance electricity production and demand and increase the value of offshore wind energy to the power system.

### Wind-to-X solutions advancement

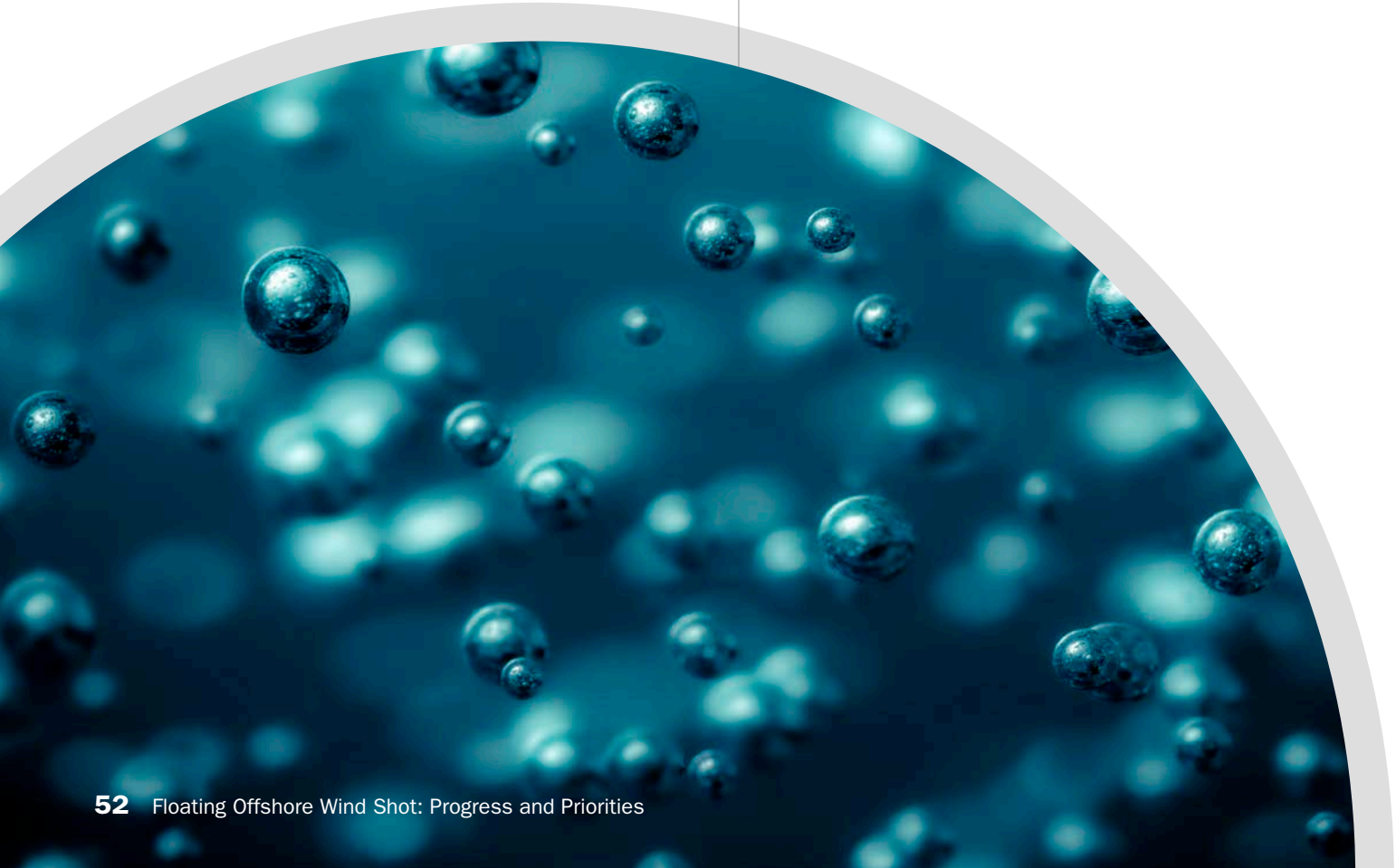
***Goal:*** Optimize wind-to-X technologies that can transition industry and agriculture to full decarbonization, increasing the value and revenue opportunity to the power, industrial, agricultural, transportation, and building sectors.

### Offshore energy hubs evaluation

***Goal:*** Enable regional offshore wind energy hubs that jointly serve the offshore wind, transmission, and maritime economy sectors.

## Agency Engagement and Leadership

Offshore wind represents a unique opportunity to not only provide electrons to the U.S. electric grid but to convert those electrons into other necessary energy products, such as storage and alternative fuels. Across the globe, these co-generation opportunities are at a nascent stage, requiring feasibility assessments and technology development. Given this early stage, the majority of the near-term work will be focused on techno-economic analyses and research led by DOE. WETO and HFTO are collaborating on wind and hydrogen co-generation projects. OCED and LPO help support the demonstration and deployment of floating wind turbine and integrated systems, respectively. BOEM and NOAA act in supporting roles to help identify and address future siting and permitting needs associated with co-generation and storage opportunities. As applicable going forward, DOT may be involved in the transportation of co-generated materials, such as hydrogen, in addition to permitting for maritime fuel bunkering.



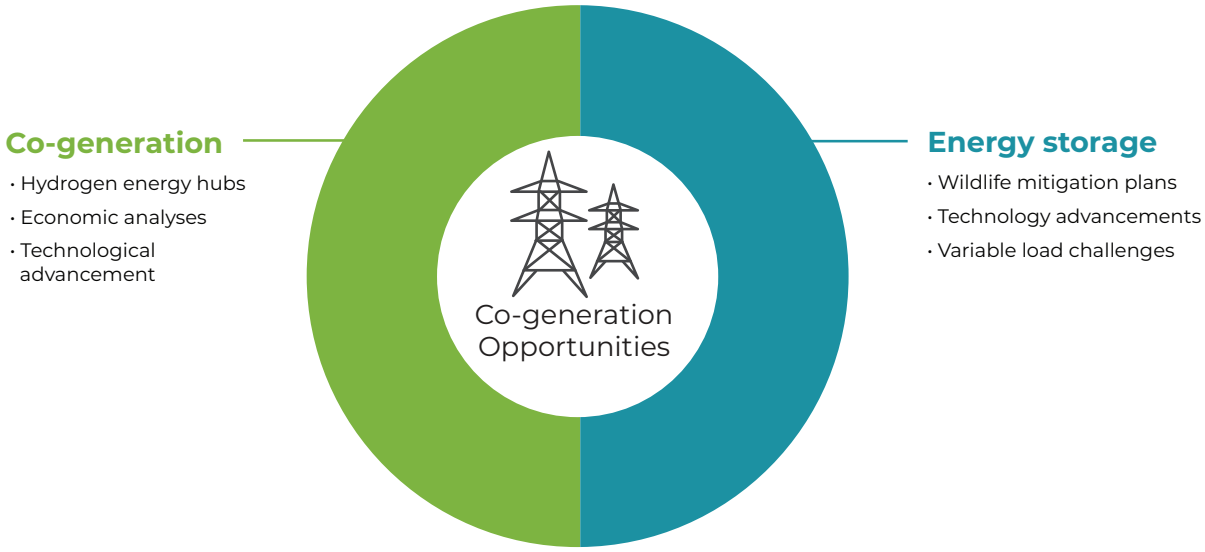



Figure 9. Key co-generation application needs and opportunities from stakeholder feedback. Relative proportion represents the number of subtopics described.

## Stakeholder Feedback

Stakeholder engagement and feedback are vital to the Floating Offshore Wind Shot. Feedback received during the Floating Offshore Wind Shot Summit in February 2023 and the Floating Offshore Wind Shot Workshop in May 2023 helped inform the priorities identified in the following section, which will shape future activities and programs. Stakeholders identified the (Figure 9) critical needs and opportunities associated with floating offshore wind co-generation opportunities. Co-generation with floating offshore wind is still a relatively nascent area of RDD&D activities, so there is less stakeholder feedback in this pillar.


H2
H2

Co-Generation

# ACCOMPLISHMENTS

Building on the major areas of need identified for co-generation opportunities in the *Advancing Offshore Wind Energy in the United States* strategy, the Floating Offshore Wind Shot partner agencies executed a variety of funding opportunities and new projects in the first year of this Energy Earthshot.

## Wind Storage Solutions Advancement

### Small Business Awards for Energy Storage

DOE announced funding for Small Business Innovation Research/Small Business Technology Transfer projects associated with compact, long-duration storage for wind energy, including innovative R&D applications that can store energy. This funding will support applications that will address challenges associated with wind intermittency and ensure a stable and reliable energy supply.[84]

- Supporting Office: DOE WETO and DOE OE


Image caption. Wind energy and hydrogen storage. *Image from NREL*

## Wind-to-X Solutions Advancement

### Offshore Wind to Hydrogen Feasibility Analysis

DOE funded a preliminary use-case analysis and calculated costs for hydrogen production at four different U.S. offshore wind sites, including a floating offshore wind site in California. This analysis will help inform future hydrogen co-generation applications to maximize our nation's clean energy goals.[85]

- Performer: NREL
- Supporting Offices: DOE WETO and DOE HFTO

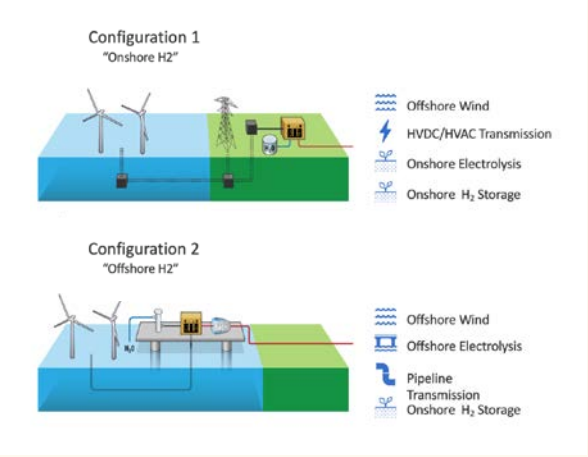



*Image caption.* A graphical representation of two potential wind-hydrogen co-generation configurations. *Image from NREL*

## Wind-to-X Solutions Advancement

### Offshore-Wind-To-Hydrogen Systems International Collaboration

DOE funded a collaborative effort between NREL and The Netherlands Organization to examine the differences in offshore-wind-to-hydrogen systems deployed off the coasts of the United States and the Netherlands. The results pointed to cost differences arising from the developing U.S. supply chain and varied national priorities regarding electrolyzer cost targets. Three system configurations were discussed that could be deployed in both countries (HFTO).[86]

### Offshore-Wind-To-Hydrogen Feasibility Analysis

DOE worked with industry and the national labs (NREL, Giner Inc.) to model and analyze the levelized cost of hydrogen for de-centralized offshore-wind-to-hydrogen systems, determine seawater impurity effects on electrolyzer performance, and test dynamic electrolyzer operation simulating offshore-wind-to-hydrogen operations (HFTO).[87]

### International Energy Agency Taskforce on Co-Generation

DOE helped lead the International Energy Agency Topical Expert Meeting #106 in September 2023. The meeting resulted in the creation of a joint task between DOE's wind, solar, and hydrogen offices to advance integrated energy systems including offshore wind to hydrogen (WETO, HFTO, and SETO).[88]

### BOEM Offshore-Wind-To-Hydrogen Feasibility Study

BOEM contracted a report titled, *Assessment of BOEM's Role in Reviewing Hydrogen Production as a Complement to Offshore Wind*, which was released in June 2022. This report provides BOEM with necessary background, technical analysis, and recommendations to update existing regulatory guidance for offshore wind development on the Outer Continental Shelf, and to identify existing gaps in technical review expertise required for administering hydrogen-to-offshore-wind permitting and for safety enforcement under BSEE (BOEM).[89]

## Offshore Energy Hubs Evaluation

While this has been identified as an opportunity for R&D activities, no significant actions have taken place since the Floating Offshore Wind Shot was established.

## Near-Term Priorities

Through the development of the *Advancing Offshore Wind Energy in the United States* strategy and feedback from stakeholder engagement, the Floating Offshore Wind Shot partner agencies identified the following near-term priorities to promote co-generation opportunities:

- Complete techno-economic analyses of opportunities and cost-effective methods to generate hydrogen from floating offshore wind to determine the best path forward for future RDD&D efforts.
- Develop reference designs and demonstrations within controlled (laboratory) environments to validate assumptions and performance and accelerate industry adoption.
- Explore innovative offshore wind energy storage opportunities to advance energy reliability and resiliency.

# Looking Forward

The Floating Offshore Wind Shot sets an ambitious target for cost reduction that reflects government support for this growing industry, and the potential to unlock a major renewable source of energy, while creating a strong economy and good, family-supporting jobs. Through DOE and partner agency investments we are creating new opportunities to develop a sustainable, clean energy industry within the United States. Realizing the full potential of this Energy Earthshot will take strong collaboration across government and with a range of stakeholders.

The five pillars enable multiple approaches to reducing costs and building the capabilities to advance the industry, and this report highlights how much has already been done since the Floating Offshore Wind Shot launched in 2022. More is needed, and a continued focus on working collaboratively and addressing challenges together, so the right expertise and resources can be identified, is critical.

The Floating Offshore Wind Shot team will continue to engage with stakeholders through virtual meetings and in-person events, particularly annual conferences. Feedback on the identified priorities is encouraged and will continue to inform how this Energy Earthshot evolves to reach the cost reduction target. There will be regular summits to communicate the progress and guiding priorities, with this summary report being updated periodically, as appropriate.

Advancing floating offshore wind helps tackle the rapidly growing global demand for clean energy while strengthening the U.S. economy and future energy security. Through the ongoing and forthcoming work of this Energy Earthshot, the United States is well-positioned to become a leader in this rapidly growing global industry by seizing the opportunity now.

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