NREL Transforming ENERGY

Tribal Nation Offshore Wind Transmission Technical Assistance Program: Introduction to Technology and Tribal Nation Support

Technical Assistance Program Webinar
April 10, 2024

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National Renewable Energy Laboratory

GDO GRID DEPLOYMENT OFFICE

Photo by Dennis Schroeder, NREL 40682

Goals for Today

- Provide a high-level overview of offshore wind transmission technologies, planning, and decision-making processes.
- Create space for participants to share their Tribe's experiences with offshore wind and a time for knowledge sharing.
- Introduce the Offshore Wind Transmission Tribal Technical Assistance Program.

Agenda

1. Introduction to Project Team
2. Introduction to Offshore Wind Energy
3. Introduction to Offshore Wind Transmission
4. Group Discussion
5. Introduction to Technical Assistance Program

Housekeeping

- No recording.
- **Use the information** shared during the discussion, but **do not reveal the identity** or affiliation of participants.
- Consider **speaking up** if you have been quiet and **stepping back** if you have already shared – we want to make space for all perspectives.

Introductions

Jordan Meehan
Policy Advisor, GDO, U.S. Department of Energy (DOE)

Liz Weber
Senior Program Manager and Tribal Program Lead, NREL

Walter Musial
Offshore Wind Platform Lead, NREL

Suzanne MacDonald
Researcher, National Wind Technology Center, NREL

Greg Brinkman
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Introduction to the Grid Deployment Office (GDO) and the National Renewable Energy Laboratory (NREL)

Introduction to Offshore Wind Energy

DOE's Role

- DOE does NOT:
  - **Build, own, or maintain** offshore wind generation or transmission.
  - **Pay for** offshore wind generation or transmission.
  - **Decide locations** for offshore wind generation or transmission.
- DOE's role is to:
  - Advance research and conversation.
  - Support planning efforts—creating recommendations that everyone can use.
  - Convene governments (Tribal, federal, state, local), stakeholders, etc.
  - Grant competitive funding for future transmission projects. Future offshore wind transmission may be eligible to apply for competitive funding.

What Will We Cover in This Section?

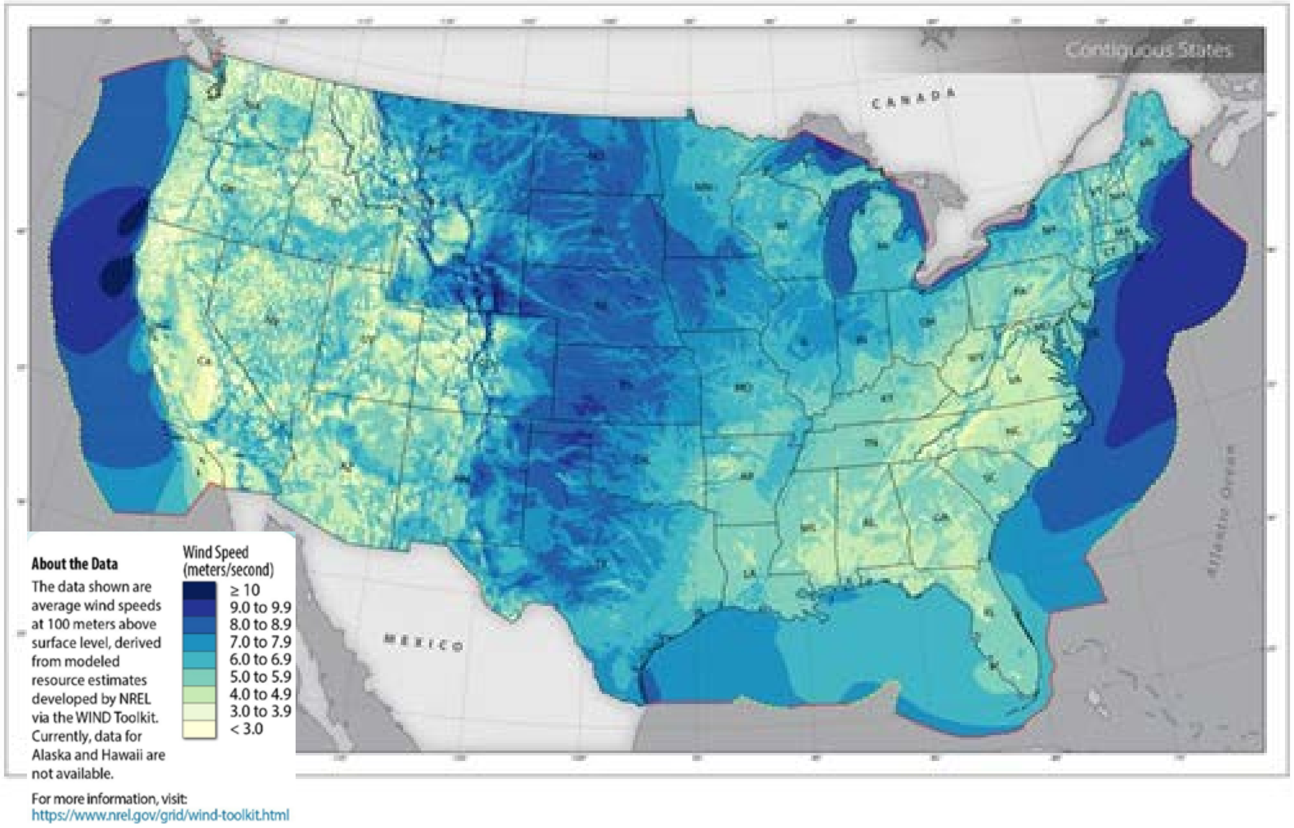
1. What is Offshore Wind Energy?
2. Offshore Wind Components
3. Why Pursue Offshore Wind Energy?
4. Industry Status
5. Development Process and Status

What Is Offshore Wind Energy?

- Offshore wind energy projects harness offshore wind resources to generate electricity.
- Wind turbines and transmission infrastructure (e.g., cables, substations) are installed in large bodies of water.
- The electricity generated by turbines is transmitted onshore and integrated into the grid, where it helps power homes, businesses, and more.

Turbines in the Block Island Wind Farm off of Rhode Island.
Photo by Dennis Schroeder, NREL 40466

Why Pursue Offshore Wind Energy?



Graphic by NREL

Benefits of offshore:

✓Generation close to the load (80% of the U.S. population lives in coastal states).

✓ Stronger, more consistent wind resources.

✓Larger-scale projects are possible.

✓Economic benefits and workforce development.

✓ Revitalization of ports and domestic manufacturing.

Biden Administration Offshore Wind Goals

- In March 2021, the Biden administration set a national target of installing **30 gigawatts (GW) of offshore wind energy by 2030.**[1]
- Achieving this goal will require:
  - Advancing U.S. wind energy projects to create well-paying, unionized jobs.
  - Investing in American infrastructure to strengthen the domestic supply chain.
  - Supporting critical research and development and data sharing.[1]

Turbines in the Block Island Wind Farm.
Photo by Suzanne Tegen, NREL 49716

[1] The White House. 2021. FACT SHEET: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs. March 29, 2021. https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/.

Offshore Wind Turbines

- Typically, offshore wind turbines differ from land-based wind turbines in several ways. They:
  - Are bigger.
  - Have more complex support structures.
  - Are designed to withstand the marine environment.

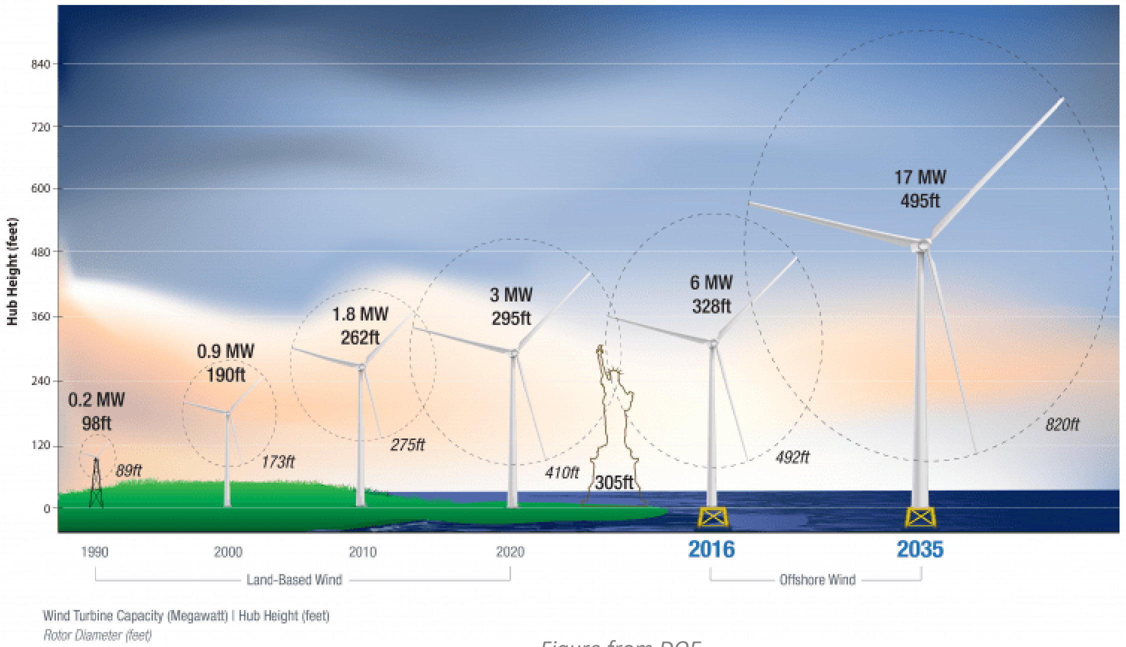
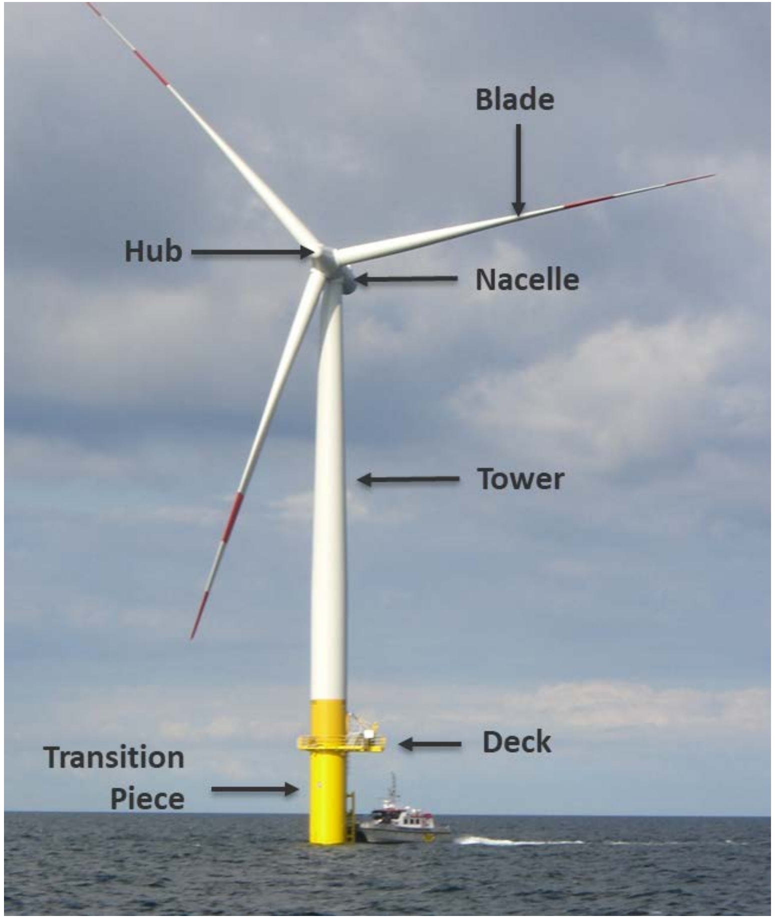


Figure from DOE

Above-the-Water Components

- Turbine components above the water include:
  - Blades, which are connected to a hub.
  - The nacelle, containing internal drive-train components (e.g., generator).
  - The tower that holds up the nacelle.
  - A transition piece connecting the tower to the substructure below water.



Siemens 2.3-megawatt (MW) offshore wind turbine, Baltic Sea, Germany.
Photo by Walt Musial, NREL

How Does a Wind Turbine Work?

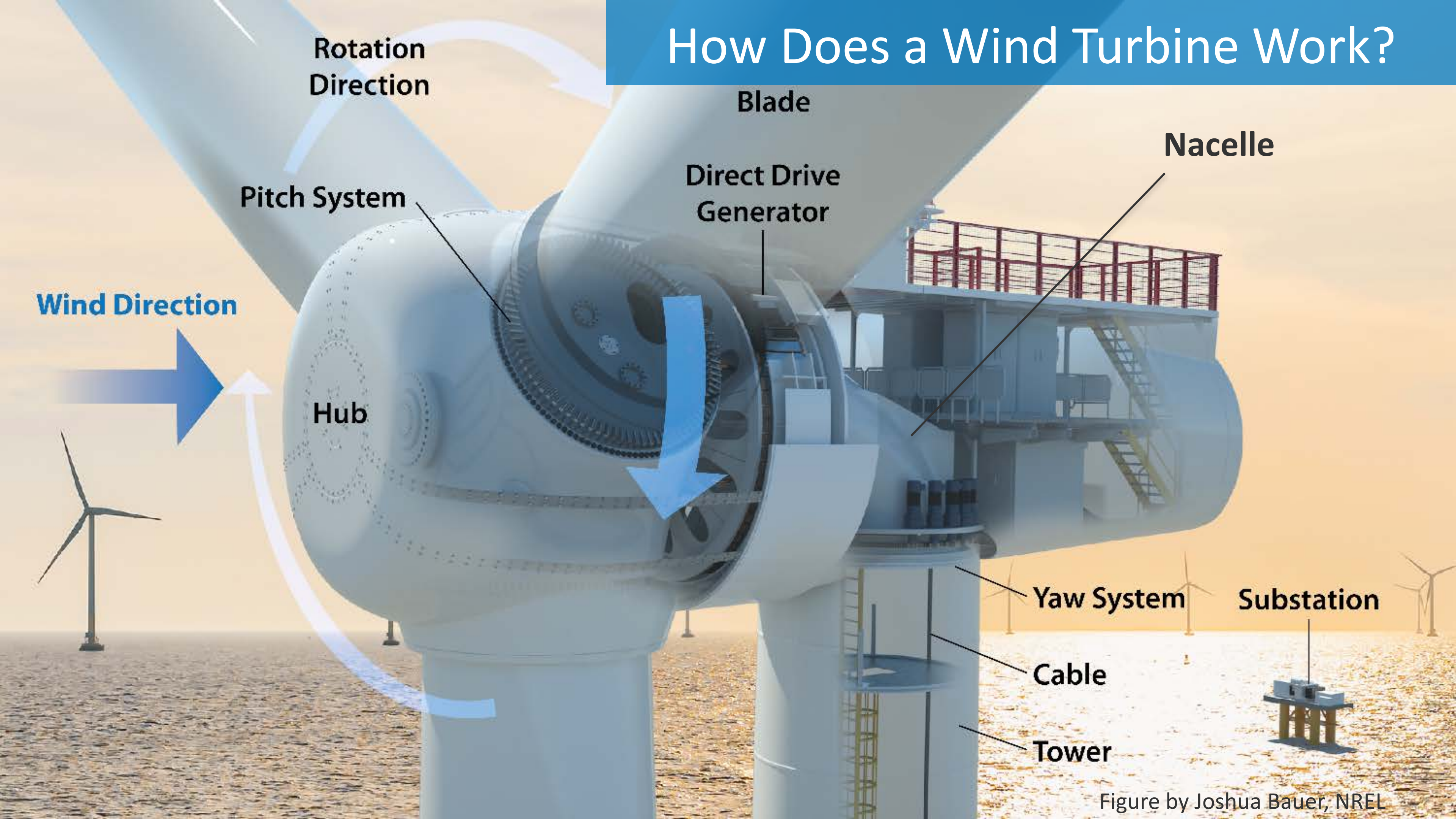


Figure by Joshua Bauer, NREL

Overview of Support Structure Types

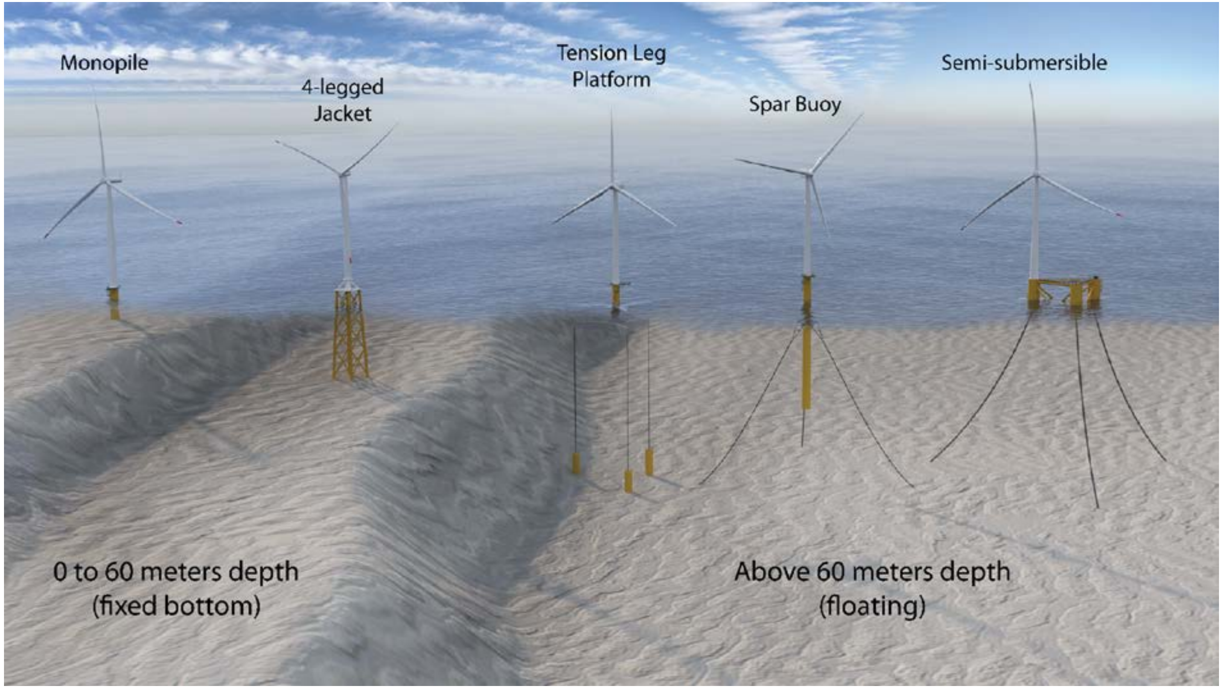
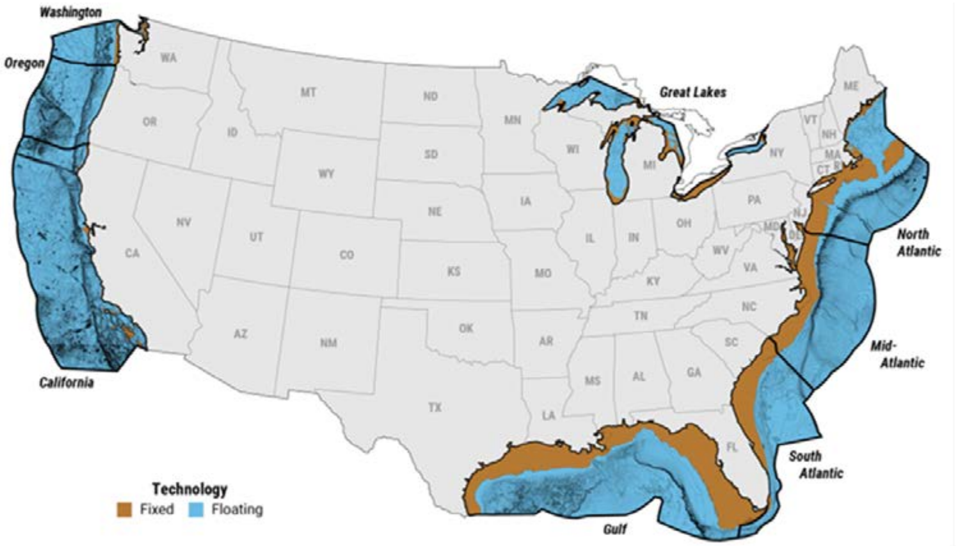


Illustration by Joshua Bauer, NREL

- In water depths 0–60 meters (0-196 feet), fixed-bottom support structures are used.

- In water depths >60 meters (>196 feet), floating support structures are used.

Below-the-Water Components



Substructure Technology Bathymetric Demarcation

60-meters ocean depth is a common delineator used to differentiate waters with either fixed or floating technology. While site specific conditions would influence ultimate technology selection, 60-meters is seen as a reasonable upper economic limit for fixed-bottom systems (Musial et al. 2016).

Figure by Billy Roberts, NREL

- Offshore wind energy technology choices depend in part on seabed and oceanographic conditions in the chosen location, such as water depth and the qualities of the seafloor.

- Offshore wind turbines can be fixed-bottom or floating, with many options for substructure designs within these broader categories.

U.S. Industry Status

- Offshore wind energy projects have been operating globally for over 30 years, and there are nearly 300 offshore wind energy projects installed around the world (mostly in Europe and Asia).
- In the United States, offshore wind call areas are being designated in all four major bodies of water: the Atlantic, the Pacific, the Gulf of Mexico, and the Great Lakes.
  - More than 18 million homes—or around 12% of all U.S. homes—could be powered by the offshore wind energy projects in the pipeline to be developed in the United States.
- Four operational projects to date:

Block Island Wind Farm (Rhode Island)

- Operating since 2016.
- Five turbines, 30 MW (enough to power 17,000 homes).

Coastal Virginia Offshore Wind (Virginia)

- Operating since 2020.
- Two turbines, 12 MW (enough to power 3,000 homes).

South Fork Wind (New York)

- Operating since late 2023.
- Twelve turbines, 132 MW (enough to power 70,000 homes).

Vineyard Wind (Massachusetts)

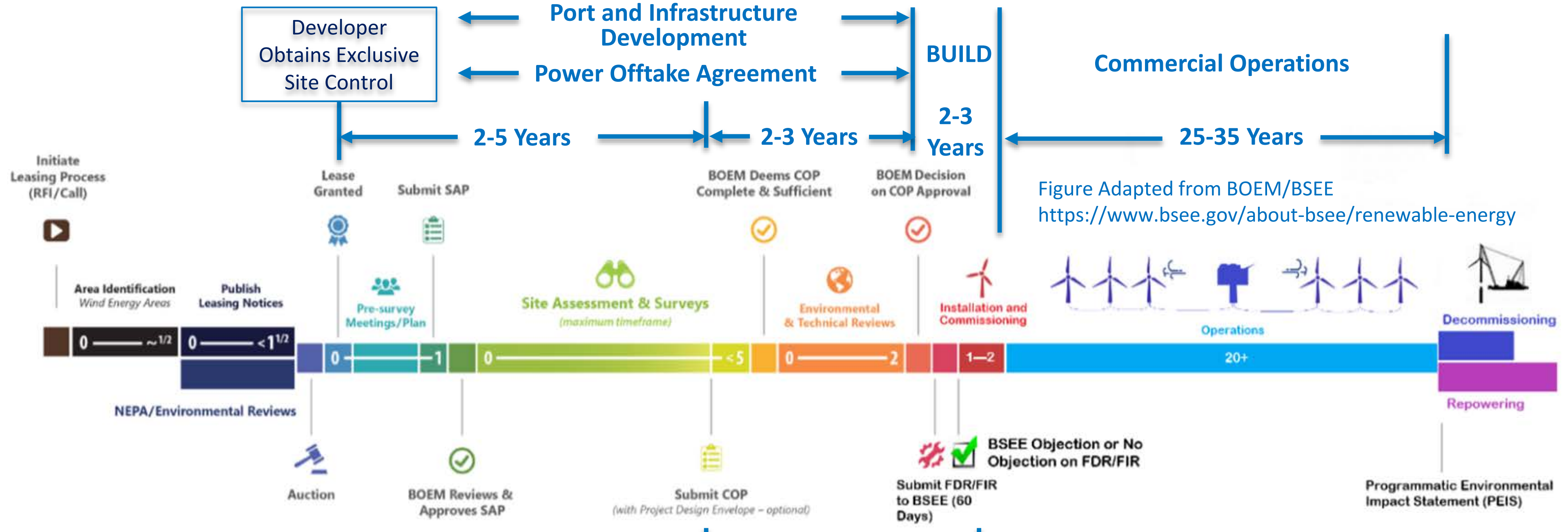
- Partially operating since early 2024.
- Sixty-two turbines, 800 MW (enough to power 400,000 homes).

Offshore Wind Energy Development Process

- Most projects will be in federal waters, where leasing and siting is overseen by the **Bureau of Ocean Energy Management (BOEM).**
  - Projects in state waters (e.g., less than three nautical miles from shore in most states, the entirety of the Great Lakes) are overseen by states.
- A single project can take **more than 10 years to develop.**
  - From early planning and analysis through construction to operations.

Maintenance is performed on a turbine at the Lillgrund Offshore Wind Farm in Sweden.
Photo from Siemens AG, 27853

Offshore Wind Leasing Process – Key Decision Points and Timelines



Construction and Operations Plan (COP) and Power Offtake contract lock in key variables like turbine size, turbine layout, projects size, foundation type, Safety Management System

FIR/FDR: Final design and installation details –: turbine type, anchor type and exact locations, installation plan. Power offtake agreement is needed to obtain financing

Engagement and Consultation

- The federal government, primarily through BOEM, and state governments have established opportunities for Tribes to communicate with offshore wind decision makers, including:
  - Formal government-to-government consultation processes.
  - Public meetings and comment periods in federal and state processes.
  - BOEM intergovernmental task forces.
  - Forums and working groups organized by BOEM, states, nongovernmental organizations, and others (e.g., BOEM's New York and New Jersey Offshore Wind Environmental Justice Forums).
- Additionally, Tribes can directly engage with offshore wind energy developers; for example:
  - Engaging with Tribal liaisons employed by developers.
  - Attending public meetings and forums convened by developers.

How Can You Engage in the BOEM Process?

- **Planning and analysis phase**
  - Wind Energy Area selection public meeting.
  - Public comment periods for Notice of Intent (NOI) and Notice of Availability (NOA) for the Environmental Assessment process.

- **Leasing phase**
  - Public comment period during the lease sale notice.

- **Construction and operations phase**
  - Public comments and meetings during the Environmental Impact Statement NOI and Notice of Record (NOR) process.

- **Ongoing engagement**
  - **Intergovernmental task forces** (mechanism to coordinate with governments and public institutions).
  - **Forums and working groups** for specific communities and/or specific topics (e.g., environmental justice, fisheries, marine industries).
  - BOEM requires companies leasing an offshore wind area to develop and follow a **Native American Tribes Communications Plan.**

States have their own processes and engagement opportunities related to power procurement and siting of infrastructure in state waters.

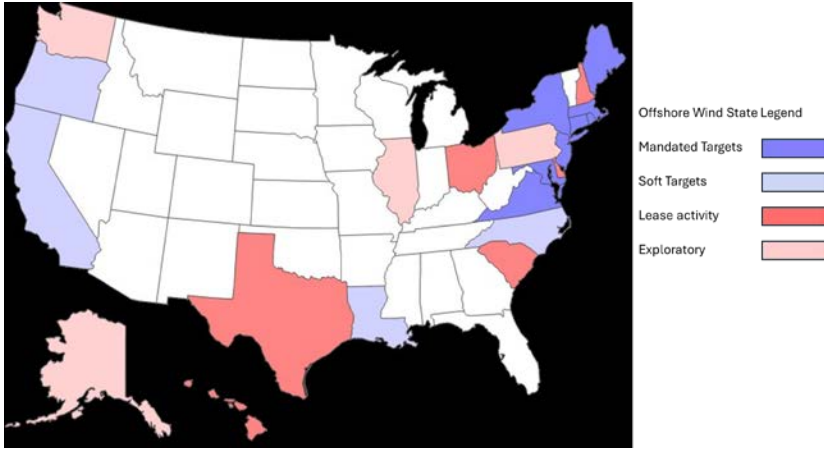


Figure from NREL

Offshore Wind Energy Transmission

What Will We Cover in This Section?

1. What is Offshore Wind Energy Transmission?
2. Cable Characteristics and Installation
3. Environmental, Cultural, and Economic Impacts
4. Transmission Topologies
5. Interconnection to Shore and Onshore Impacts
6. Transmission Decision-Making

What Is Offshore Wind Energy Transmission?

- Energy generated by offshore wind turbines is transferred onshore and connected to the grid through **transmission infrastructure** which includes:

  - **Cables**
    - Array cables
    - Offshore export cables
    - Onshore export cables
    - Cable landing areas.
  - **Substations**
    - Offshore substation
    - Onshore substation.

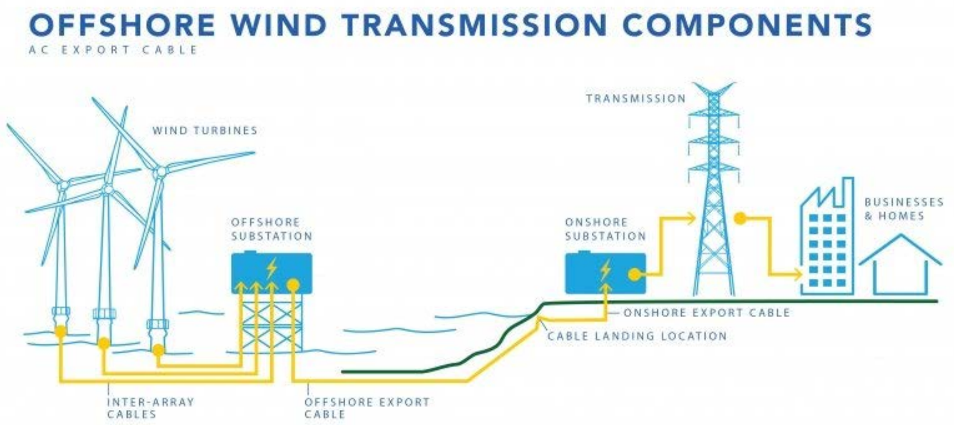


Figure from GDO

Transmission Infrastructure

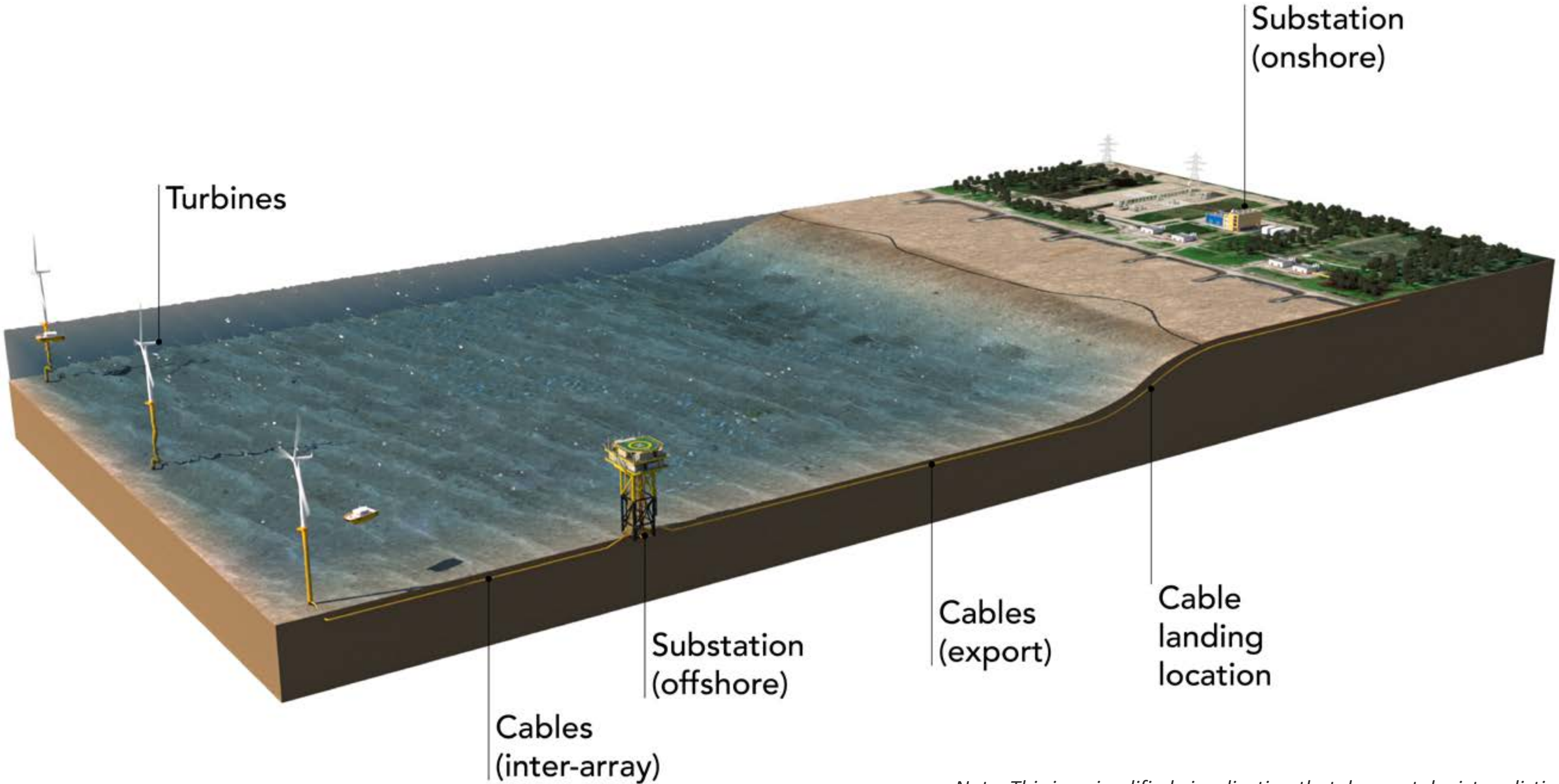


Figure by Josh Bauer, NREL

Note: This is a simplified visualization that does not depict realistic sizes or scales. Most utility-scale offshore wind projects are at least 15 miles from shore, so much farther than depicted here.

Transmission Infrastructure

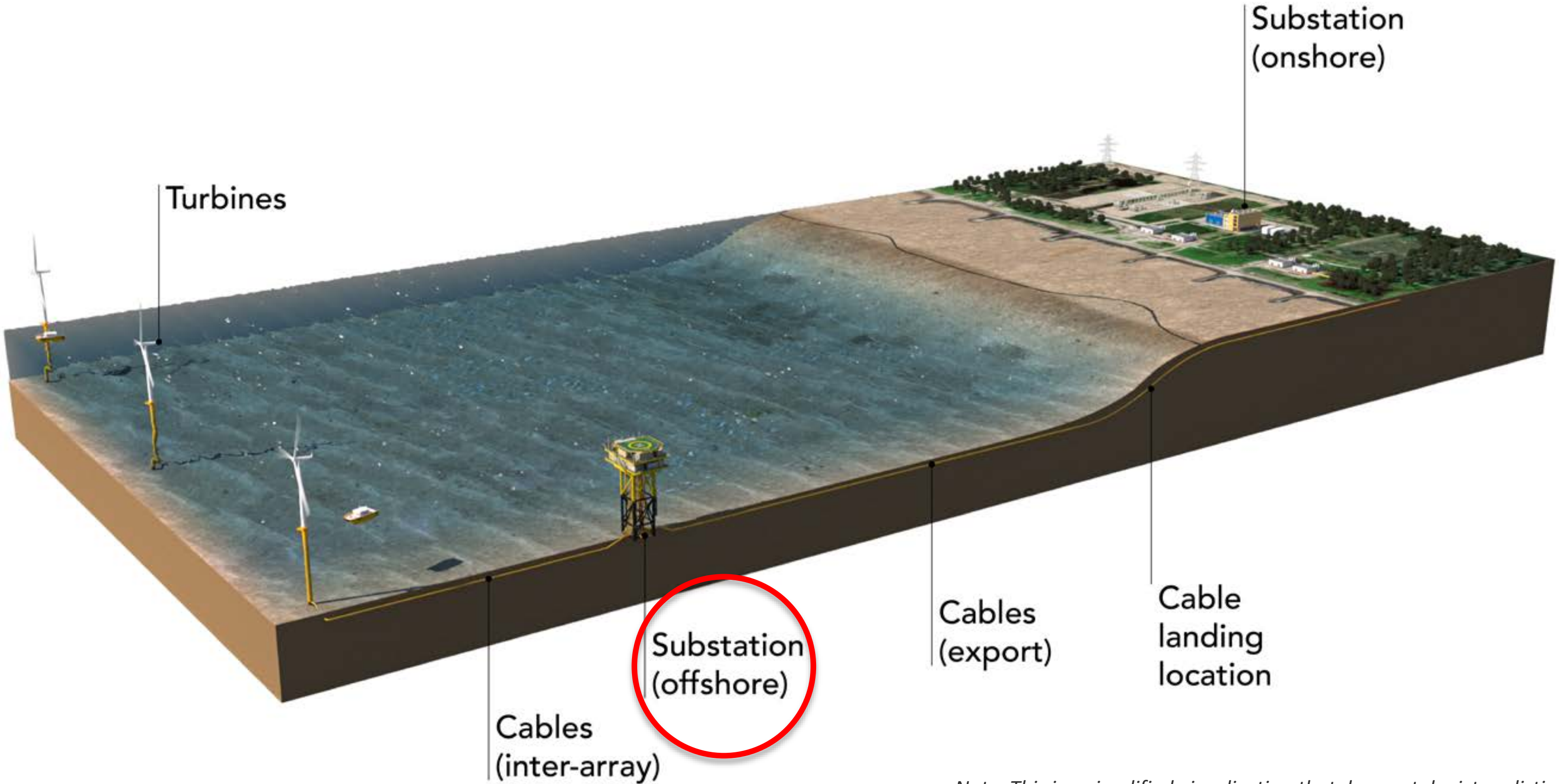


Figure by Josh Bauer, NREL

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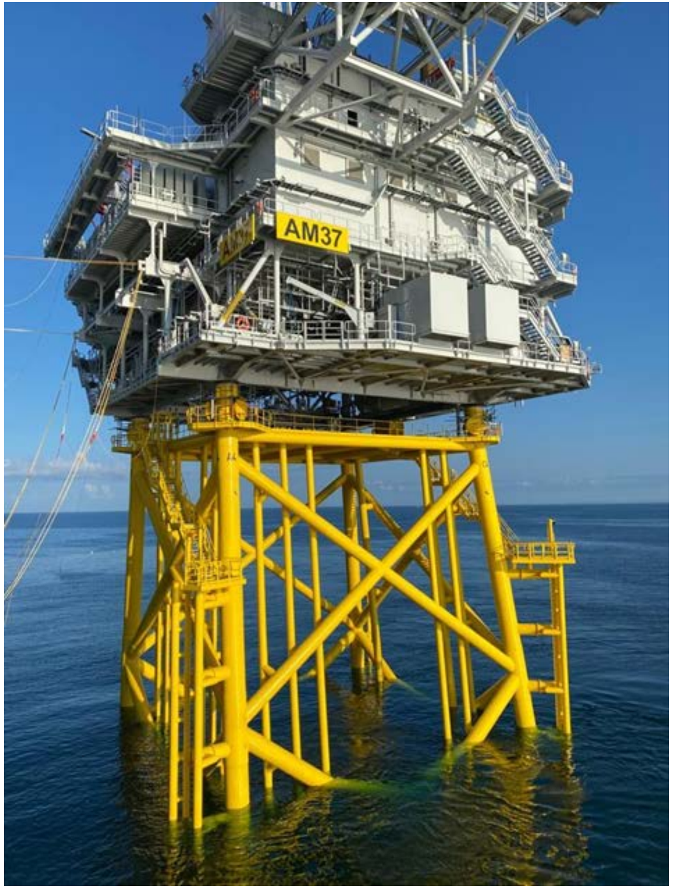
Offshore Wind Substation

- Offshore substations or electric service platforms collect AC power from turbines across a wind farm at 66 kilovolts (kV) or greater.
- High-voltage transformers step up the voltage to 220 kV and export power to shore through buried subsea cables. [1]
- Substations are attached to the seabed with substructures (e.g., monopiles or multi-leg jackets like oil rigs) or, in deeper water, substations may be floating and attached to the seabed with mooring lines.



Vineyard Wind 1 Substation
Photo Courtesy of Vineyard Wind

[1]HVDC projects require additional equipment

Transmission Infrastructure

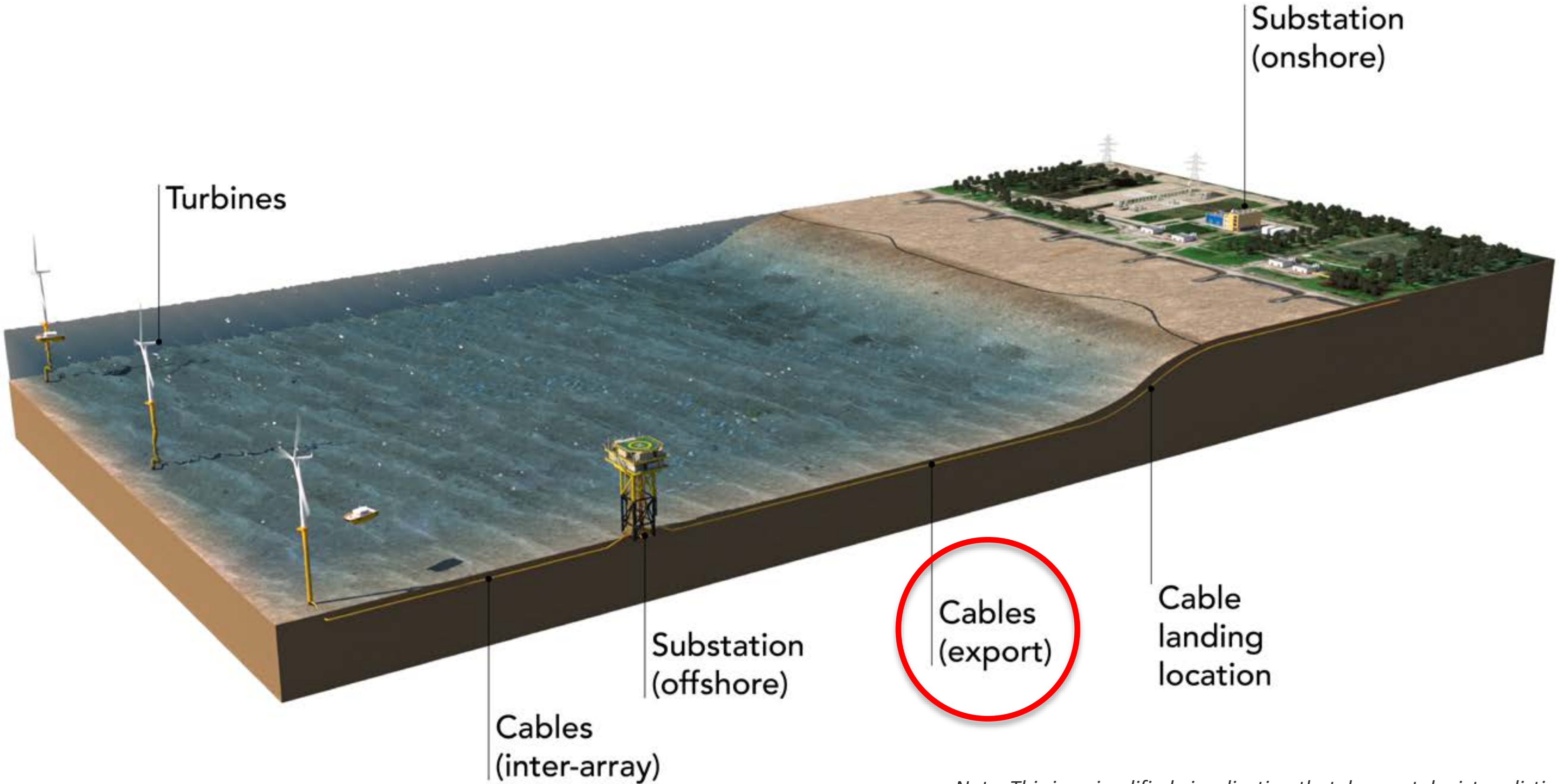


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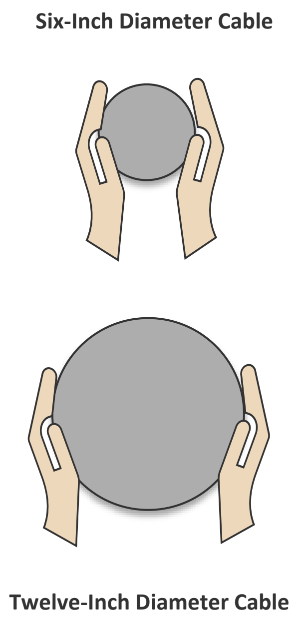
Figure by Josh Bauer, NREL

Cables

- Electricity produced by offshore wind turbines is delivered to land through a series of cables which are typically buried in the seafloor.
- **Array cables** link turbines together and deliver electricity to offshore substations.
  - Four to six inches in diameter (like a teacup saucer).[1]
- **Export cables** transmit electricity from offshore substations to land substations.
  - Six to thirteen inches in diameter (on the large end of the range, like a dinner plate).[1]
  - Existing offshore wind farms tend to use larger export cables, but smaller export cables may become more economical as projects move farther from shore due to their lower cost and lower power losses.[3]
  - Export cable distances greater than about 50 miles will use high voltage direct current systems (HVDC) to reduce losses and cost.

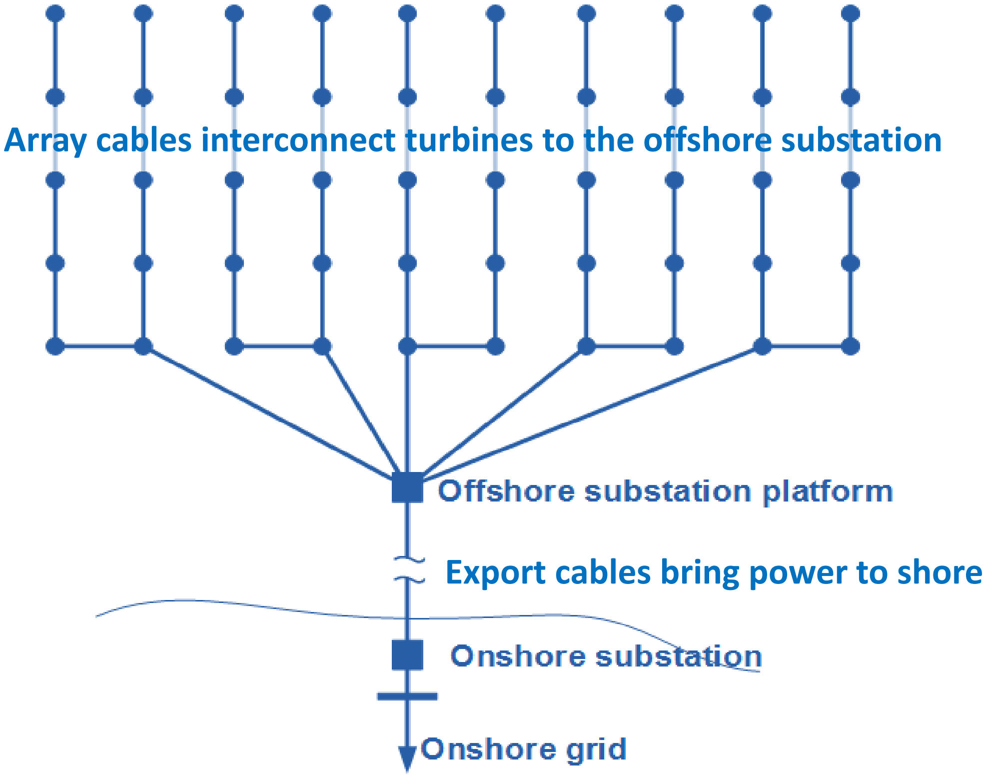


A simplified visual of human hands holding two different cables, to show the size comparison. Figure by Matilda Kreider, NREL

[1]Dresser, B. 2021. *Offshore Wind Submarine Cabling Overview*. Albany, New York: New York State Energy Research and Development Authority. NYSERDA Report 21-14. https://www.nyftwg.com/wp-content/uploads/2021/05/Offshore-Wind-Submarine-Cable-Report.pdf

[2]Van Eeckhout, B., D. Van Hertem., M. Reza, K. Srivastava, and R. Belmans. 2010. "Economic Comparison of VSC HVDC and HVAC as Transmission System for a 300 MW Offshore Wind Farm." *European Transactions on Electrical Power* 20(5), pp.661-671. https://doi.org/10.1002/etep.359.

Typical Array and Export Cable Layout



- Electrical array cable cost increases with turbine spacing but decreases with wind turbine size (fewer cables needed)
- Exact turbine spacing is largely a trade-off between wake losses and array cable costs
- Navigational concerns and array cable voltage also influence turbine spacing

Dynamic Array Collection Cables

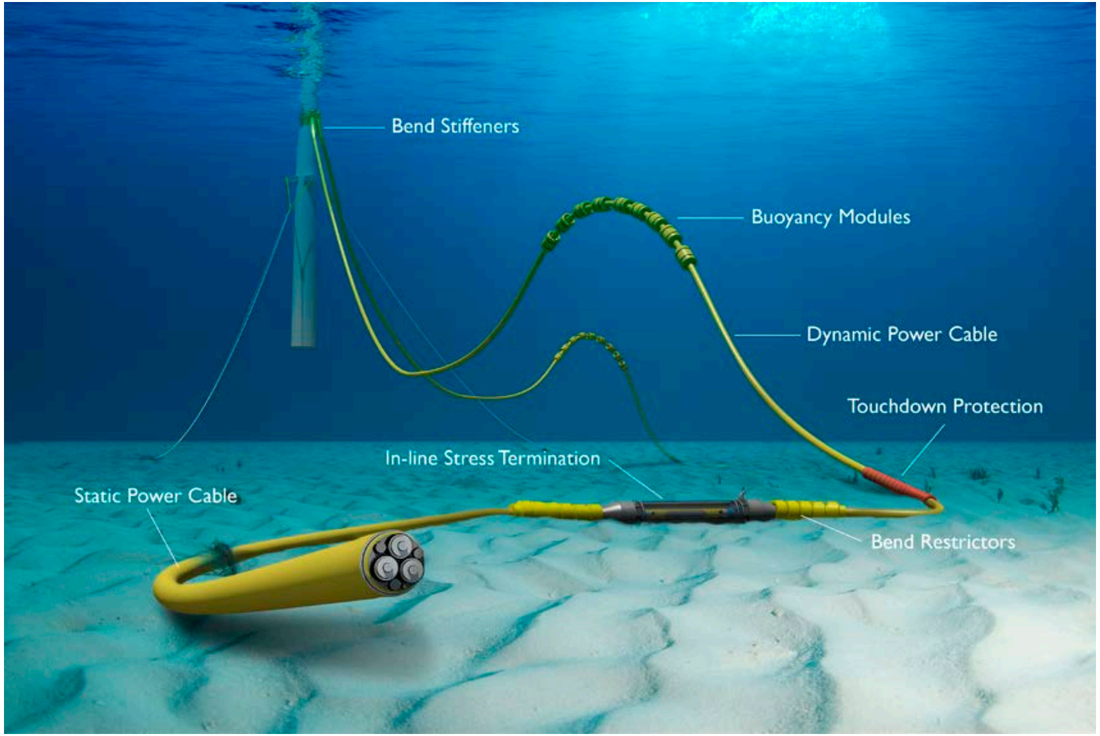
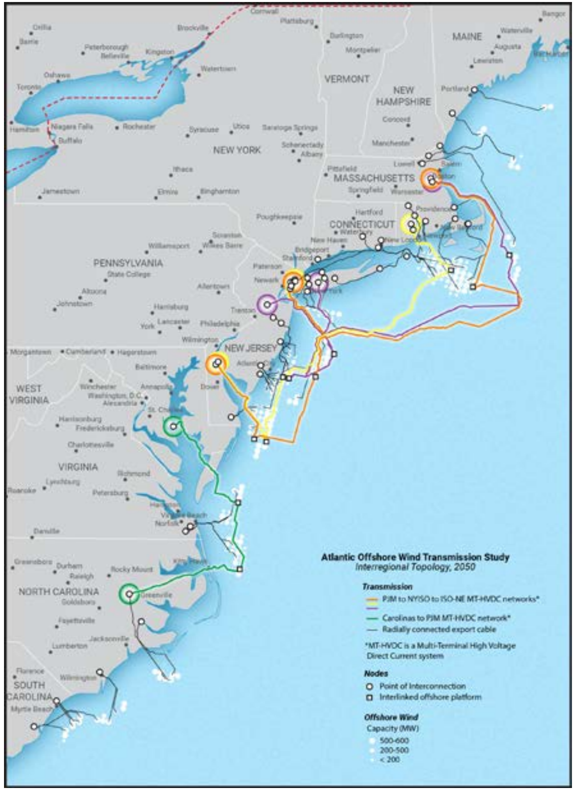


Illustration by Joshua Bauer, NREL 66313

- For floating wind turbines, dynamic array cables may be used because they allow for movement in the water.
- Buoyancy modules can suspend cables in the water column for very deep sites.

Protecting Cables and the Surrounding Environment

- Careful route planning occurs early in the development processes and is intended to avoid areas with high environmental or cultural sensitivity, such as:
    - Cultural resources
    - Fishing grounds
    - Fish-spawning areas
    - Seismic activity
    - Shipping lanes
    - Anchorages
    - Seabed assets (such as pipelines or other cables).[1]



DOE and BOEM-recommended offshore wind transmission topology scenario in the Northeast.
Figure from DOE and BOEM

[1]Dresser. *Offshore Wind Submarine Cabling Overview*.

Protecting Cables and the Surrounding Environment

- Cables can be buried for protection.
- Burial depth is driven by guidance from the industry and federal and state agencies.
    - Too shallow = at risk of damage.
    - Too deep = expensive, environmental impact, issues with the cable's capacity for carrying power.[1]
- Cable burial risk assessment is used to determine how deep cables should be buried to reduce risk "as low as is reasonably practical."[1]

Illustration of a cable-laying vessel.
Illustration by Joshua Bauer, NREL

[1]Dresser. *Offshore Wind Submarine Cabling Overview*.

Cable Installation

- Cables are covered with protective material where cable burial is not practical, such as bedrock or points where cables must cross other seabed assets like other cables.[1]
- Some protection options:
  - Rock dumping
  - Bags of rocks or grout
  - Concrete mattresses
  - Frond mats.

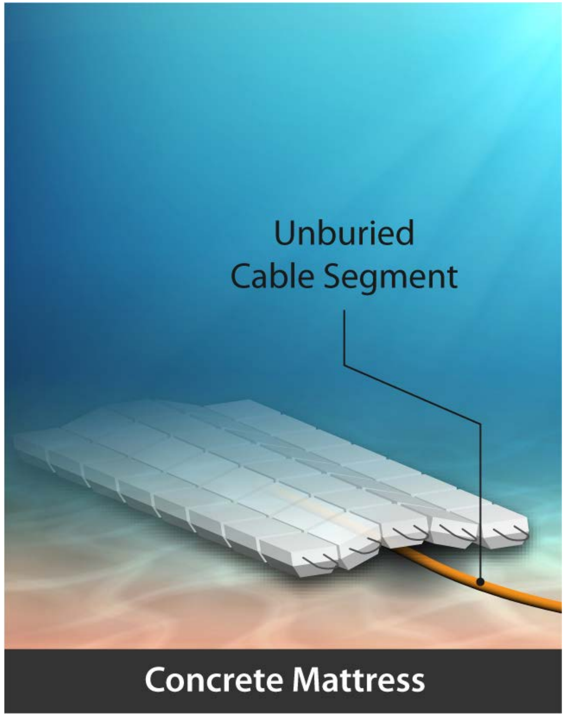
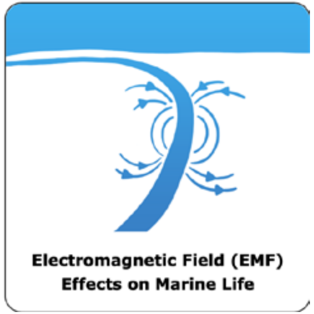


Illustration by Alfred Hicks, NREL 84462

[1]Dresser. *Offshore Wind Submarine Cabling Overview*.

Environmental Impacts

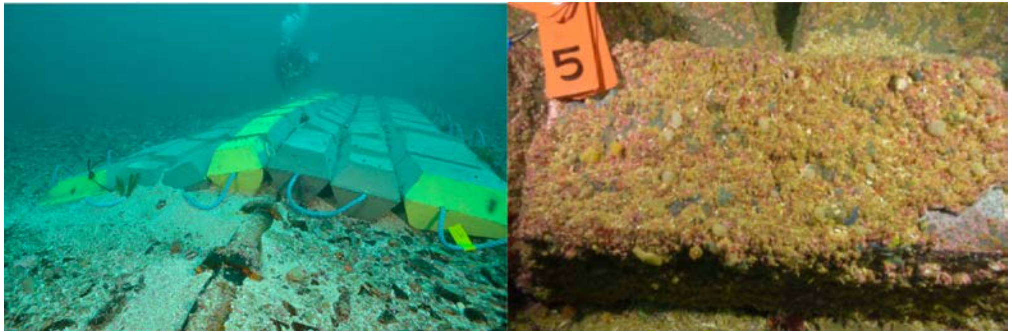
- Some potential environmental impacts from offshore transmission infrastructure:
  - Disturbance to the seafloor environment (“benthic”).
  - Electromagnetic field (EMF) effects on marine life.
- Ongoing research to understand how transmission infrastructure may impact species and ecosystems:
  - U.S. Offshore Wind Synthesis of Environmental Effects Research (SEER).
  - National Oceanic and Atmospheric Administration (NOAA).
  - Regional Wildlife Science Collaborative for Offshore Wind.
  - National laboratories and universities.
- Transmission route planning considers ways to avoid, minimize, or mitigate conflicts with species and sensitive habitats on the seafloor.
- Tribal consultation during transmission route planning can address impacts to Tribal environmental resources.



Figures from U.S. Offshore Wind Synthesis of Environmental Effects Research

Disturbance to Benthic Environment

- Transmission infrastructure may alter the seafloor environment during and after construction, with potential effects like:
  - Alteration of habitat that **displaces some species.**
  - Creation of new habitat that may **increase species abundance** and biodiversity.
  - Physical and chemical changes to **sediment structure, which can temporarily disturb organisms and habitats on the seabed.**[1]
- Most physical effects are in areas closest to the infrastructure, not spread across the entire wind farm area.[1]
- Many impacts will be temporary during project construction—like impacts on sediment—while others will be longer term—like creation of new habitats.[1]



Newly installed concrete mattress over a partially exposed cable (left) and concrete mattress after it has been colonized by organisms after installation (right). Images from [Taormina et. al (2020)](#)

[1]U.S. Offshore Wind Synthesis of Environmental Effects Research. 2022. *Benthic Disturbance from Offshore Wind Foundations, Anchors, and Cables*. Report by National Renewable Energy Laboratory and Pacific Northwest National Laboratory for the U.S. Department of Energy, Wind Energy Technologies Office. https://tethys.pnnl.gov/sites/default/files/summaries/SEER-Educational-Research-Brief-Benthic-Disturbance.pdf.

EMF Effects on Marine Life

- Subsea cables are sources of EMFs.
- Natural sources also create EMFs in the marine environment, and some species can detect and use EMFs for essential life functions like searching for prey.[1]
- Thus far, EMFs from subsea cables have not been determined to negatively affect species.[1]

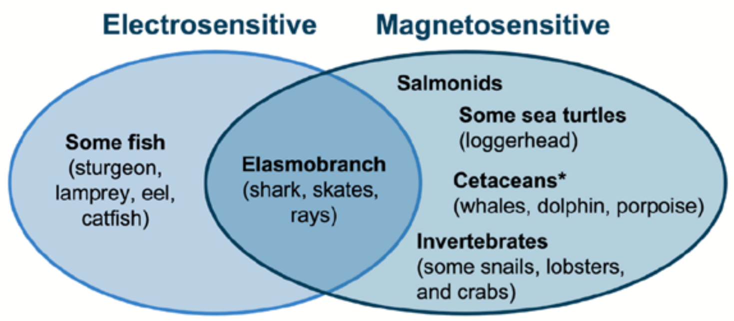


***Figure 6.** Examples of marine wildlife with the ability to sense EMFs. This diagram does not include all electrosensitive and magnetosensitive marine life. *Note that the hypothesis of magnetosensitivity in cetaceans is primarily based on indirect, theoretical, anatomical, and limited observational evidence based on migratory behaviors.*

Figure from U.S. Offshore Wind Synthesis of Environmental Effects Research

[1]U.S. Offshore Wind Synthesis of Environmental Effects Research. 2022. *Electromagnetic Field Effects on Marine Life*. Report by National Renewable Energy Laboratory and Pacific Northwest National Laboratory for the U.S. Department of Energy, Wind Energy Technologies Office. https://tethys.pnnl.gov/sites/default/files/summaries/SEER-Educational-Research-Brief-Electromagnetic-Field-Effects-on-Marine-Life.pdf.

Impacts on Cultural and Historical Resources

- Cultural and historical resources and areas of significance to Tribes—particularly those on or near the seafloor and in coastal areas where transmission infrastructure will be routed—may be impacted by transmission infrastructure.
- Visual impacts from cables are minimal, but substations may be more visible in areas of importance to Tribes.
- Tribal consultation and engagement during transmission route planning can address impacts to Tribal cultural resources.

People stand on the beach near the Block Island Wind Farm cable landing site. Photo by Dennis Schroeder, NREL, 40399

Economic Impacts

People aboard a boat near the Block Island Wind Farm.
Photo by Dennis Schroeder, NREL 40453

- Transmission infrastructure can impact ocean-based cultural and economic activities like fishing, as well as tourism.
  - Fishing techniques like dredging and trawling may be restricted because they can damage cables.
  - Transmission infrastructure may impact ecosystems and fish ecology, which could affect fishing and recreational activities.
- Minimizing or avoiding conflicts with fisheries and fishing activities is part of transmission planning, and Tribal consultation and engagement can address impacts to Tribal fishing practices.

Transmission Topologies

- There are different ways to lay out and design transmission lines to transmit power to shore; these are often referred to as **topologies.**
- Currently, the most common topology is the **generation lead line**, in which an individual offshore wind project connects to shore directly.[1]
- However, more coordinated approaches, like connecting multiple offshore wind projects through a single path to shore, are being considered.

Lillgrund Offshore Wind Farm turbines and substation in Sweden.
Photo from Siemens AG, 27852

[1]U.S. Department of Energy and Bureau of Ocean Energy Management. 2023. *An Action Plan for Offshore Wind Transmission Development in the U.S. Atlantic Region*. https://www.energy.gov/sites/default/files/2023-10/Atlantic-Offshore-Wind-Transmission-Plan-Report_October-2023.pdf.

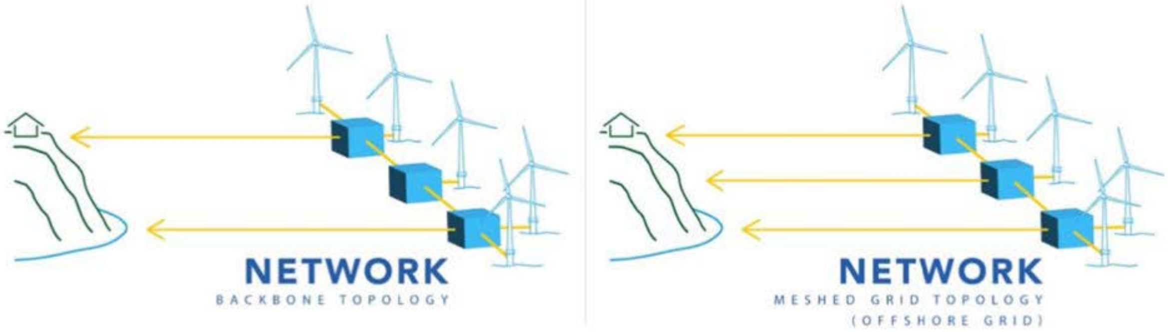
Topologies

Figure 7. Radial transmission topologies (offshore wind plants represented as single turbines).

Note: The wind turbines in these figures each represent an entire offshore wind energy project.

Figures from DOE and BOEM

Figure 8. Network transmission topologies (offshore wind plants are represented as single turbines).



Transmission Infrastructure

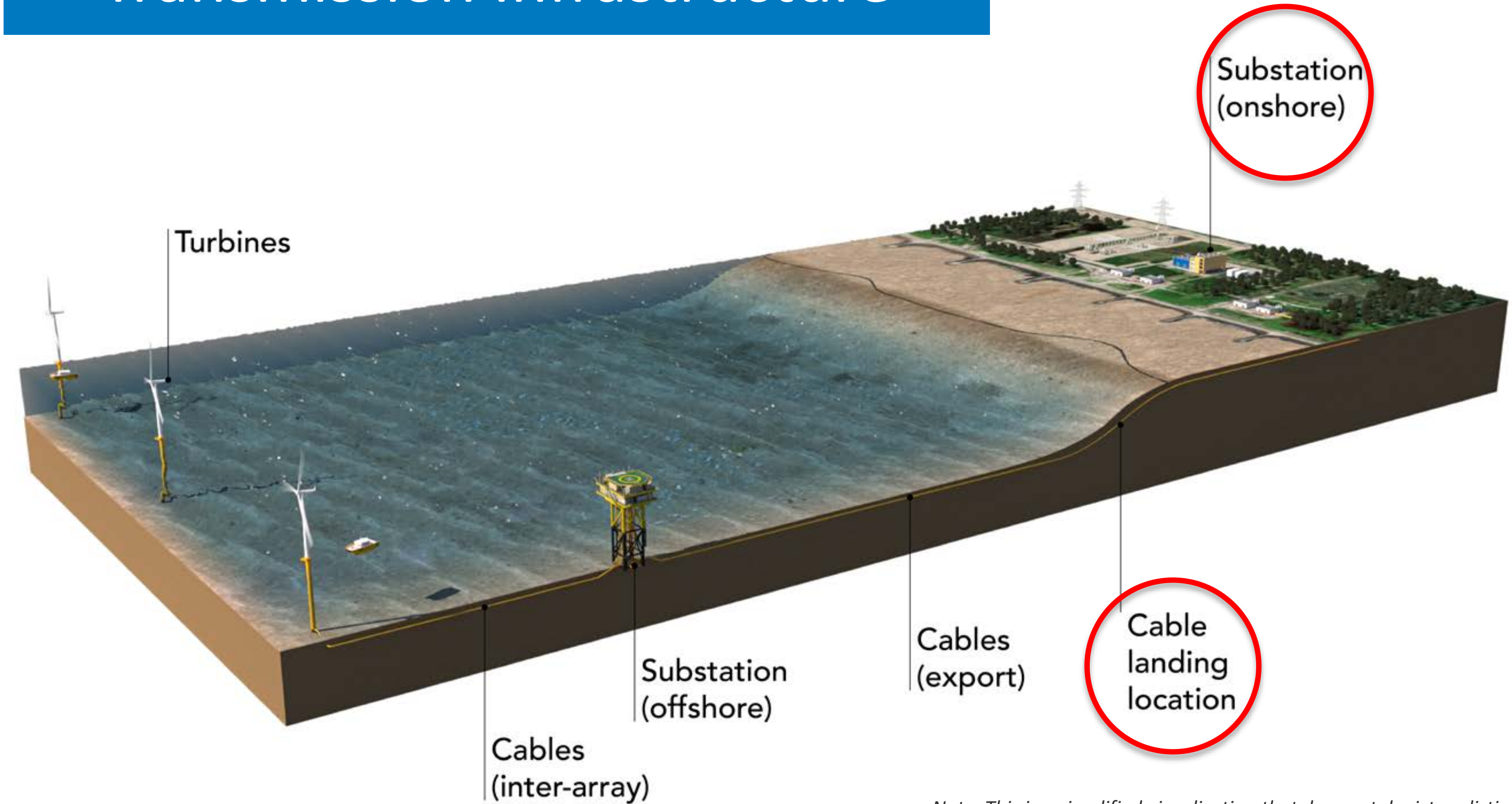


Figure by Josh Bauer, NREL

Note: This is a simplified visualization that does not depict realistic sizes or scales. Most utility-scale offshore wind projects are at least 15 miles from shore, so much farther than depicted here.

Cable Landfall

- The cable landing or landfall site is the point at which the export cable comes onshore.
  - Typically at a beach but could be another coastal area.
  - Cable passes underground.
  - Construction may require digging an open trench in the land that will later be covered, or it may be done with other methods that do not require creating an open trench.
- Cables continue underground to an onshore substation, transmitting electricity to the onshore grid.

Block Island Wind Farm cable landing site. Photo by Dennis Schroeder, NREL 40394

Economic Impacts

- Once onshore, transmission infrastructure can bring financial benefits to the communities and governments involved.
  - Property and sales tax revenue.
  - Tax agreements.
  - Tribal benefit agreements, community benefit agreements, or host community agreements.

Long Island Business News

Wind power deal yields $170M in community benefits

The agreement enables 18 miles of real estate access for a cable to carry electricity from Sunrise Wind's planned offshore wind power...

Mar 20, 2023

The East Hampton Star

Wind Farm Benefits Package Totals $29 Million for East Hampton Town

The Town of East Hampton and the town trustees will share a community benefits package worth almost $29 million in exchange for easements...

Sep 10, 2020

Barnstable Patriot

Barnstable enters host agreement with Vineyard Wind

Vineyard Wind has agreed to pay the Town of Barnstable up to $16 million plus taxes over the next 25 years for the rights to land...

Oct 5, 2018

Construction Impacts

- Construction of transmission infrastructure may have impacts such as:
  - Noise.
  - Traffic impacts.
  - Disruptions to access to beach or other land while construction is occurring.
  - Environmental impacts (e.g., impact from digging a trench on beach or other coastal land) or impacts to cultural resources.
- Most of these impacts will occur only during construction.

Upgraded grid infrastructure on Block Island.
Photo by Dennis Schroeder, NREL, 40394

Grid and Electricity Impacts

- Grid infrastructure upgrades may be necessary to accommodate power entering the grid from offshore wind energy.
- Offshore wind can add diversity to the system and offset the decline in generation from solar photovoltaics in afternoon hours (commonly described as the duck curve effect).
- Increased electricity generation from renewable energy can displace fossil fuel power generation in the region, helping to:
  - Reduce air pollutant emissions.
  - Mitigate climate change.

The old diesel power plant, left, was later replaced by the new switching station, right, for Block Island. Photo by Dennis Schroeder, NREL 40458

Transmission Siting Authority

- Authority over siting of **offshore** cables and substations can be federal, state, or Tribal depending on the type of infrastructure and who has authority over the waters where infrastructure would be installed.
- Authority over siting of **onshore** cables and substations is typically held by whoever has authority over the land on which the infrastructure is installed.
    - Could be a local government, the state government, a Tribe, the federal government, or a private landowner.

Transmission infrastructure on Block Island.
Photo by Dennis Schroeder, NREL 40488

Transmission Decision-Making

- A variety of entities may be involved in decisions, research, and planning related to transmission and the grid:
    - Tribal governments.
    - Offshore wind developers.
    - Federal government (e.g., DOE, BOEM, Federal Energy Regulatory Commission, Federal Communications Commission, National Oceanic and Atmospheric Administration).
    - State governments.
    - Local governments.
    - Grid operators.
    - Utility companies and public utilities.
    - Universities, national laboratories, and other research institutions.

Panelists at a session on Tribal perspectives on offshore wind energy at DOE's 2024 Tribal Clean Energy Summit.
Photo credit: DOE Office of Indian Energy

GRID DEPLOYMENT OFFICE

Tribal Nation Offshore Wind Transmission Technical Assistance Program

Photo by Lyfted Media for Dominion Energy

Program Overview

- DOE's Tribal Nation Offshore Wind Transmission Technical Assistance Program supports federally recognized American Indian and Alaska Native Tribes and Villages in activities related to the planning and development of U.S. offshore wind transmission projects.

- Through the program, DOE will offer educational resources, training, and on-call assistance from technical experts and researchers at NREL. **Funds for Tribal member and staff participation in key offshore wind transmission forums are also available through the program.**

Photo from Getty Images 1493565700

Educational Resources

Educational events for Tribal members and staff will cover topics such as transmission designs, technologies and supply chains, siting and permitting, interconnection processes, offshore wind development updates, and related cultural and environmental impacts.

We are also open to your feedback on what is the most helpful to you!

Photo from DOE Office of Indian Energy

On-Call and In-Depth Technical Assistance

Planning and permitting for offshore wind transmission is a complex, multi-year process. This program allows Tribal members and staff to consult with national laboratory experts to better understand and respond to offshore wind transmission proposals. Following an initial consultation, Tribes receive customized information in the form of data, modeling and analysis support, policy and regulatory review, and more.

Photo from DOE Office of Indian Energy

What is Technical Assistance?

Technical assistance is the provision of direct support—one-on-one to communities, in cohorts, or to coalitions—to identify and address knowledge gaps, challenges, decision-making considerations, and implementation strategies related to energy system planning.

What questions can be answered with technical assistance support?

- What are optimal locations for offshore wind?
- How much of my community's energy consumption could be met by locally generated offshore wind?
- How do offshore wind costs and generation compare with other technologies?
- How many jobs might offshore wind development bring to my community?
- How can impacts be mitigated and community benefits ensured?

Participation Support

It is **critical** that Tribal perspectives are **represented** and **understood** in offshore wind planning efforts, but inadequate financial resources can be a barrier to Tribal participation.

This program enables Tribal members and staff to request funding to participate in discussions and events related to offshore wind transmission.

Eligible events may include those hosted by federal or state agencies and/or national laboratories, such as BOEM task force meetings and federal permitting, siting, and environmental review forums. Events must have an offshore wind transmission component.

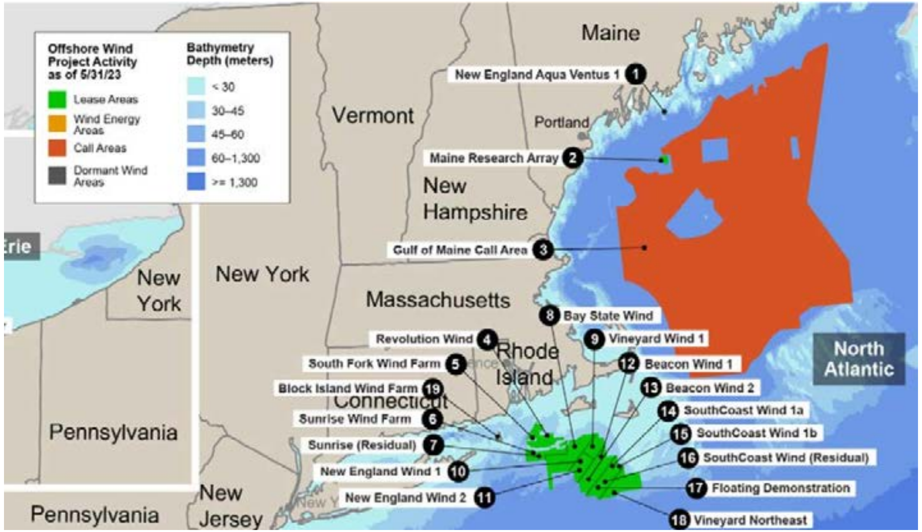
Photo from DOE Office of Indian Energy

Appendix

North Atlantic Region

- Red areas are “Call Areas”—areas where BOEM is exploring potential development.
    - Boundaries are likely to change.
- Green areas are lease areas held by developers.

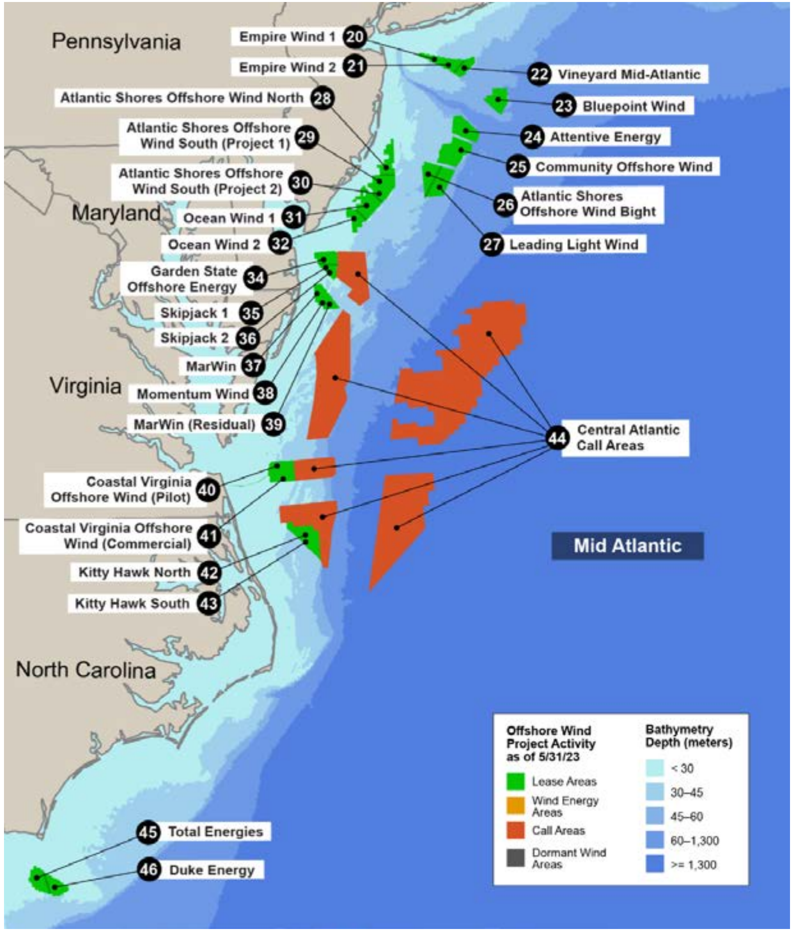
Offshore wind project activity in the North Atlantic as of May 2023



Graphic by John Frenzl, NREL

Mid- and South Atlantic Regions

Offshore wind project activity in the Mid- and South Atlantic as of May 2023



Graphic by John Frenzl, NREL

Gulf of Mexico Region

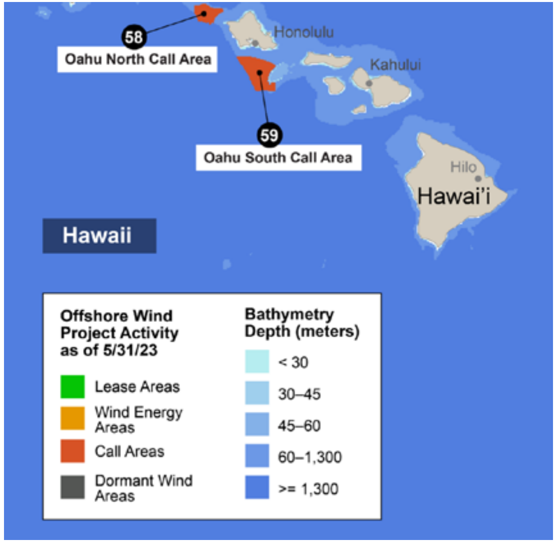
- Orange areas are Wind Energy Areas (WEAs), designated for potential development at the start of BOEM's leasing process.
    - Since this graphic was created, BOEM held a lease auction and granted one lease in the Lake Charles WEA.
    - Additionally, the state of Louisiana has granted two leases for offshore wind energy development in state waters.

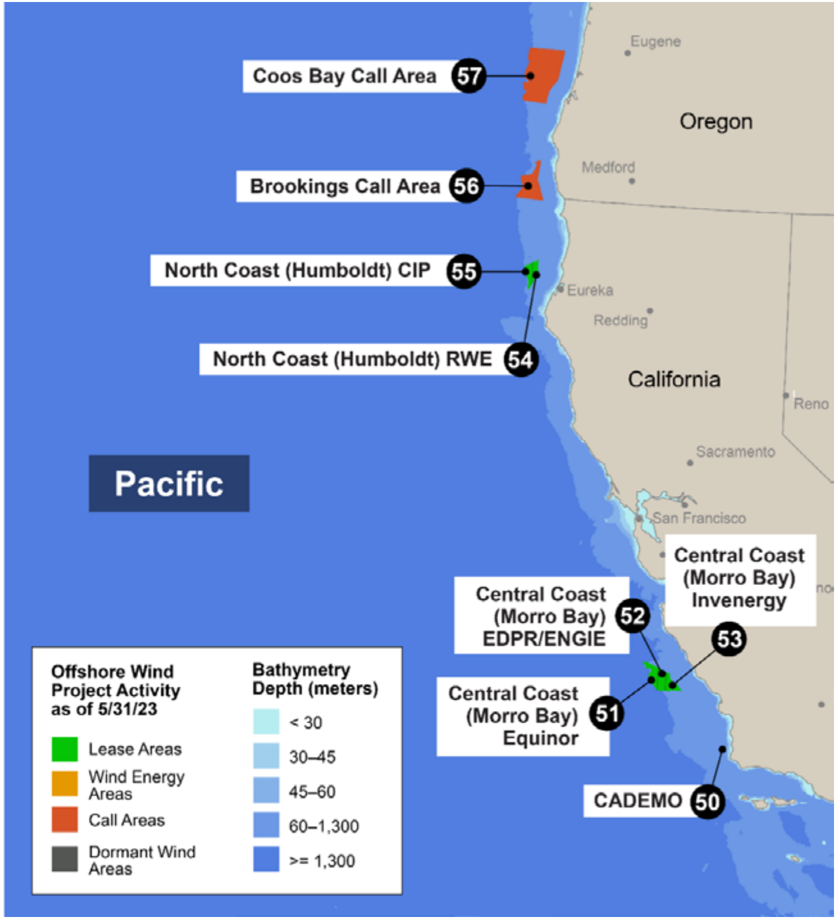
Offshore wind project activity in the Gulf of Mexico as of May 2023

Graphic by John Frenzl, NREL

Pacific and Hawaii Regions

Offshore wind project activity in the Pacific and Hawaii as of May 2023





Graphic by John Frenzl, NREL

Cable Monitoring

- Cable monitoring occurs throughout the life of a wind farm.
  - Cable surveys are conducted periodically to ensure the cable isn't shifting too far from its burial position.[1]
  - Cable sensing can be done with distributed temperature or vibration sensing.[1]

Maintenance is performed on a substation that is part of the Lillgrund Offshore Wind Farm in Sweden. Photo from Siemens AG NREL 27854.

[1]Dresser. *Offshore Wind Submarine Cabling Overview*.

Thank You!

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