Offshore Wind Power and Massachusetts's Transition to Renewable Energy

Teacher Manual: Lesson 7

Essential Question
How will large-scale offshore wind projects transform Massachusetts's energy sources?

Learning objectives. Students will be able to:

1. Describe how wind turbines capture energy and convert it into electricity
2. Identify examples of climate-critical professionals who work to design, build, and maintain offshore wind farms
3. Discuss how Massachusetts's ports and other infrastructure contribute to the offshore wind industry.

Lesson Summary
Students will learn the basics of wind turbine technology and how offshore wind power factors into MA's climate and clean energy goals. They will also examine our ports and what makes a port suitable for inclusion in the offshore wind industry.

Technology referenced in this lesson:

- Offshore wind power

Careers referenced in this lesson:

- Engineering and design
- Construction and installation
- Operations and maintenance
- Environmental science
- Project management and logistics

Agenda	Timing	PPT Slide
Opening Activity	5 minutes	2
Present agenda & learning objectives	5 minutes	3–5
Direct Instruction Video Technology introduced Careers introduced	20 minutes	6–14
Primary Learning Activity Partner or small group work Reinforce what was learned	20 minutes	15–16
Closing Review learning objectives Closing activity Reflection	5 minutes	17–19
Extension		
Handouts		
TOTAL TIME	**55 minutes**	

Pre-lesson preparation:

- Read student presentation deck (PPT)
- Watch video(s) included in the student presentation deck (most are available on the MassCEC YouTube channel).
- Print worksheets prior to class.
- Verify that the computer hosting the presentation deck is connected to the internet for video and hyperlink viewing.
- Check any links in the slide deck to make sure they work as intended, and then review the content below.

Where to learn more about the lesson's content

If additional preparation time is available, these resources will provide additional background on the topics covered in this lesson.

1. Greater New Bedford Regional Vocational Technical High School. Marine Technology Program https://www.gnbvt.edu/parents-students/program-of-studies/academy-c/marine-technology/
2. Mass Maritime Academy - Offshore wind training
3. Offshore Wind Myths vs Facts - American Clean Power

Overview and Opening Activity (10 minutes)

Materials & Resources

- Slide deck
- Student worksheets

Opening activity: Get students thinking and talking right away.
Activity objective: Have students connect the identification of certain criteria to decision-making about space and use.

Instructions:

- This activity can be done as a large group (as written) or in smaller groups with students debriefing together.
- Ask students to suggest ideas for a new space in town: sports stadium, amusement park, movie theater, water park, etc.
- Ask students to identify the criteria they would use to determine the best location for this space. For example,
  - accessibility
  - size of space
  - nearby amenities
  - environmental impact
  - convenience
- Introduce the idea that large energy projects have specific criteria for where they can be successful. For example,
  - infrastructure
  - environmental impact
  - proximity to resources
  - community impact
  - efficiency
  - Location selection is incredibly strategic. Otherwise, offshore wind farms wouldn't be successful.
- Thankfully, because of where we're located here in Massachusetts, offshore wind power is a big part of our plan to achieve net zero emissions by 2050.

Present the agenda. Students should be gaining familiarity with the format.

- After the opening activity, they will learn new information. The main activity is intended to put them in the role of a lineman. The closing activity helps them synthesize what they learned and facilitates knowledge transfer.

Present the big question and lesson objectives

- How will large-scale offshore wind projects transform Massachusetts's energy sources?
- Describe how wind turbines capture energy and convert it into electricity.
- Identify examples of climate-critical professionals who work to design, build, and maintain offshore wind farms.
- Discuss how Massachusetts's ports and other infrastructure contribute to the offshore wind industry.

Direct Instruction (20 minutes)

Provide information to help the students achieve the learning objectives and prepare them to actively engage with the activity.

- Use inquiry-based learning strategies to engage learners where possible.
- Highlight technology-related careers.
- Help learners in applying what they have learned to themselves and their communities.

MA Climate Goals. Vision for 2050—*Review*

Discussion guidance:

- By now, students are familiar with MA's ambitious goals for climate action and energy resilience.
- These goals rely heavily on electrification, and to do that, we need to secure multiple reliable long-term sources of renewable power.
- Offshore wind power is an important part of achieving such goals.

Wind-related Climate Occupations

Different climate-critical professionals work together to design, build, and maintain offshore wind farms.

- Engineering and design: Engineers design, optimize, and build wind turbines and the infrastructure that supports them.
- Construction and installation: Construction workers, welders, and crane operators help assemble, transport, and install turbines in offshore locations.
- Operations and maintenance: Wind turbine technicians, plant operators, and marine scientists all monitor and maintain the equipment to ensure its safety and efficiency. These workers will work on site or on ships to do this.
- Environmental science: Marine biologists and ecologists assess and protect ocean ecosystems surrounding wind farms. They also address any community concerns about the ocean ecosystems.
- Project management and logistics: Project managers and logistics specialists oversee project timelines, budgets, and team coordination.

Introduction to Offshore Wind Power

- Offshore wind power is a clean, sustainable energy source crucial to Massachusetts meeting its renewable energy goals.
- Offshore wind energy has significant potential due to the strong, consistent winds over ocean waters, especially compared to the winds over land.
- Massachusetts aims to provide 5,600 megawatts from offshore wind farms by 2027—that's right around the corner!
- So how does it work?
- Through spinning blades connected to a generator, wind turbines capture energy and produce electricity.
- Each turbine sends its power through cables down the tower and under the seabed to an offshore substation, where the energy is adjusted to a higher voltage and sent to shore through high-voltage cables.
- Once it reaches shore, it is adjusted to an even higher voltage so it can be fed into the grid and then distributed to homes and other buildings via power lines.

Environmental Benefits

- Offshore wind power reduces reliance on fossil fuels, resulting in cleaner air and reduced greenhouse gas emissions.
- Lowers GHG: Wind energy produces no carbon dioxide or other greenhouse gases, helping to combat climate change.
- Decreased air pollution: Wind turbines generate electricity without emitting any pollutants, leading to cleaner air, which contributes to improved public health.
- Sustainable resource: Wind is abundant, especially offshore. Offshore wind power is, therefore, a sustainable solution for long-term energy needs.
- Energy storage systems allow a more stable and reliable energy supply from renewable sources, further lowering reliance on fossil fuels.

Community Benefits

There are many benefits for communities, including economic and security gains.

- Job creation: The wind energy industry creates jobs in manufacturing, installation, maintenance, and support services, benefiting both local and national economies.
- Wind energy helps stabilize energy prices by reducing reliance on fossil fuels, which are subject to market volatility and the actions or priorities of other nations.
- Wind energy projects attract investments in infrastructure, technology, and local economies, resulting in growth and development. Locally, this can lead to more benefits, such as land lease payments, tax revenue, or further community investments.

- Wind energy systems can be built in a decentralized manner, spreading out over a larger area. This makes the grid more resilient against disruptions and helps reduce the risk of large-scale power outages.

Wind Testing Technology Center

- The Wind Testing Technology Center (WTTC) in Boston is a world-class facility where engineers test and improve wind turbine blade technology, especially for offshore wind farms.
- Turbine blades capture wind energy through aerodynamics. Their curved design causes air to move faster over one side than the other. This creates lift—similar to an airplane wing.
- This lift spins the blades, converting kinetic energy (the power of movement) into mechanical energy. A generator connected to the blades then turns mechanical energy into electricity.
- At the WTTC, engineers work to build larger, stronger, and more efficient blades.
- Larger blades can capture more wind and create more electricity, even in low-wind conditions.
- They also test new materials. Compared to older materials, carbon fiber is both lightweight and robust, potentially offering superior durability in offshore conditions.

Show the video (3–5 minutes) and follow it with a brief check-in to hear what students took away.

A visit to the New Bedford Wind Terminal. (Video coming soon)

Video debriefing

- We have one of the world's leading offshore wind farms right in our backyard. What impact do you think the wind terminal will have on nearby residents?

MA Ports and Wind Energy

- Massachusetts is a coastal state, and we have a lot of coastline.
- However, not all ports along the coast work well for the offshore wind industry.
- Recent upgrades to both New Bedford and Salem allow them to support offshore wind projects nearby, so they have both been selected to be part of the Vineyard Wind 1 Project.
- They both have features that allow wind farm components to be manufactured and transported through their wharves.

Ask students why these features are important when selecting a site for offshore wind farms.

- Heavy-duty wharves are capable of handling heavy equipment and large components, such as tower racks or turbine foundations.
- Lay-down areas are essential for storing and assembling large turbine components that can weigh over 2,800 tons. These spaces must be reinforced in order to support such weight.
- Dredging allows access for specialized construction or maintenance boats.

The two ports will not be used in the same way.

- The New Bedford Marine Commerce Terminal will support the construction, assembly, and deployment of offshore wind projects, as well as handle bulk, break-bulk, container shipping, and large specialty marine cargo.
- The Salem Marine Terminal is under construction and will serve as a logistics and operations center for turbine pre-assembly, transportation, staging activities, and assembly component storage.

Differentiations & Adaptations—Direct Instruction

Primary Learning Activity (20 minutes)

Materials

- Worksheets

Activity objective: Analyze several Boston ports and determine their feasibility for supporting future offshore wind projects. Reinforce students' understanding of key infrastructure needs and the role of strategic planning in renewable energy development.

Instructions:

- Divide students into groups and assign each group one of the four ports listed on their worksheets: Charlestown Navy Yard, Mystic River Terminal, Conley Terminal, or East Boston Terminal.
- Briefly review the criteria for offshore wind projects included in the student worksheets (depth, heavy-duty wharves, lay-down areas, proximity, and environmental impact).
- In groups, students will review the details provided about their assigned port and determine the following:
    - How well does the port meet the provided criteria for offshore wind project support?

    - What upgrades or improvements would be necessary to make the port more suitable?
    - Are there additional ways the port could support clean energy projects (e.g., energy storage, solar, or workforce development hubs)?
- During the debrief discussion, each group will give a brief (1 minute) presentation on their assigned port and share their findings with the class.

Debrief discussion:
- How will large-scale offshore wind projects transform Massachusetts's energy sources?
- Which port do you think has the most potential for supporting offshore wind projects, and why?
- What are some of the common challenges that ports face in becoming suitable for offshore wind infrastructure? How might these challenges be overcome?
- How can ports like the ones we evaluated contribute to Massachusetts's broader clean energy goals?

Key takeaways:
1. Wind turbines convert wind energy into electricity.
2. Offshore wind projects support Massachusetts's clean energy and economic goals.
3. Ports such as New Bedford and Salem are vital to the offshore wind industry.

Differentiations & Adaptations—Learning Activity

For students who struggle with group discussions: Use structured roles
Adaptation: Assign specific roles to each group member (e.g., researcher, presenter, recorder, evaluator). This structure ensures that every student has a clear and manageable task, reducing stress for those who may struggle with open-ended group discussions.
Goal: Encourage participation by breaking the activity into smaller, more focused responsibilities tailored to individual strengths.

For students who prefer hands-on activities: Create a physical port model
Adaptation: Provide students with materials such as poster boards, markers, and 3D modeling tools (e.g., building blocks, clay) to create a simple model of their assigned port. During their presentation, they can use the model to showcase their recommended upgrades and adaptations.
Goal: Engage tactile students and encourage creative problem-solving by allowing them to represent their ideas physically.

Closing Activity (5 minutes)

Materials

- Presentation/slide deck, slides
- Reflection journal

Activity objective: Encourage students to reflect on key takeaways and identify areas of interest for further exploration.

Ask students to respond to these questions:

- What did you learn about offshore wind power today that surprised you?
- Why are Massachusetts's ports vital to the offshore wind industry?

Check individual understanding of learning objectives.

Extensions–If learners are loving this topic and want more

Research offshore wind projects around the world

Prompt: Choose an offshore wind project from anywhere in the world (e.g., Hornsea Project or Walney Extension Offshore Wind Farm in the UK). Research its location, size, infrastructure, and challenges during development. Compare it to the ports in Boston and produce a short report or presentation outlining the lessons Massachusetts could learn from such a project.

Goal: Encourage students to explore global offshore wind efforts and connect their classroom learning to international clean energy advancements.

Design an ideal offshore wind support hub

Prompt: Imagine you are designing a brand-new port optimized for supporting offshore wind projects. Consider the following: space, infrastructure, environmental impact, and community benefits. Create a blueprint or diagram of your port and write a description of its features and potential support for offshore wind energy farms and other clean energy projects.

Goal: Challenge students to apply their knowledge creatively while critically considering the infrastructure and design elements needed to support clean energy innovation.

Handouts—Group Activity (below)

Massachusetts Port Evaluation

Instructions

Analyze your assigned port's current features to determine its suitability for supporting future offshore wind projects. If the port does not meet the criteria, identify specific upgrades that would allow it to be used in future offshore wind projects. Alternatively, identify other ways your port could support offshore wind project infrastructure.

Criteria	Minimum Required
Water depth	35 feet; ability to reach 35 feet through dredging
Heavy-duty wharves	Support up to 2,800 tons
Lay-down areas	10 acres available
Proximity to project sites	Within 100 miles of proposed offshore wind sites
Environmental impact	Able to undergo upgrades with minimal disruption to surrounding marine ecosystems

Evaluation Prompts

Based on your evaluation, could this port support offshore wind projects?

What upgrades would you recommend?

In what other ways could this port support MA's clean energy goals?

How might investing in port infrastructure contribute to MA's clean energy goals?

Notes for presentation:

Charleston Navy Yard

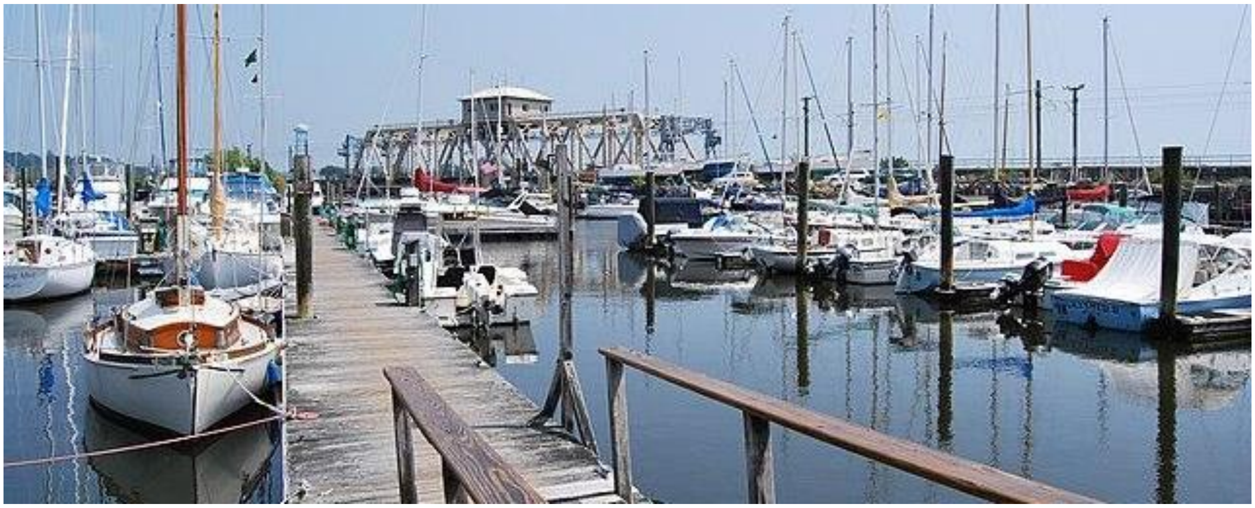
Overview: The Charlestown Navy Yard, located in Boston's Charlestown neighborhood, is a historic port. It was first used for building and repairing navy ships, but now it houses museums, businesses, and docks. Some parts of the yard have been upgraded for visitors, but the infrastructure remains old and unsuitable for industrial projects like offshore wind energy farms.

Details:

- The water depth is 32 feet, but sediment buildup has made some areas shallower.
- The wharves can hold loads weighing up to 1,500 tons.
- It has six acres of open space, which is mainly used for seasonal shops, parking, and events.
- The navy yard is 90 miles from the proposed offshore wind project sites.
- The area is busy with ferries and tourist boats.
- The navy yard is a historic site with limits on construction changes.
- There's a neighborhood nearby, and residents might oppose industrial projects.

Notes:

Mystic River Terminal



Overview: The Mystic River Terminal is an industrial port in Everett, MA. It is very active and mainly used for transporting bulk cargo such as petroleum and chemicals. It has modern facilities but was designed for bulk cargo rather than large construction projects.

Details:

- The water depth is 37 feet, with some areas being shallower due to sediment.
- The wharves can support loads weighing up to 2,000 tons.
- The terminal has eight acres of open space, which is mostly used for shipping containers and bulk materials.
- The Mystic River Terminal is 95 miles from the wind project sites.
- The river's narrow channels may limit access.
- The terminal is near protected marshlands.
- Local residents have voiced concerns about pollution from current operations.

Notes:

Conley Terminal

Overview: Conley Terminal in South Boston is a container port that handles many international shipments. It recently received upgrades, making it one of the most modern ports in the area. The port primarily handles container shipments, with limited space for non-container activities.

Details:

- Conley Terminal's water depth is 40 feet.
- The wharves can hold 3,000 tons.
- There are four acres of lay-down area available.
- Conley Terminal is 75 miles from the offshore wind project sites.
- Major shipping lanes make transport to wind farm sites relatively easy.
- The high volume of container operations limits flexibility for new uses, as reducing container space would impact port business.
- The port is near a busy highway, which helps overland access but can cause traffic delays.

Notes:

East Boston Terminal

Overview: East Boston Terminal is located across the harbor from downtown Boston. This port mainly supports smaller shipments and local businesses. As the area around the port grows with new homes and businesses, expansions are limited.

Details:

- The depth is about 30 feet.
- The wharves can handle loads of up to 1,500 tons.
- There are three acres of open area primarily used by local businesses.
- The port is 85 miles from the proposed wind energy project sites.
- The route between this port and the project sites crosses high-traffic areas.
- The port is close to a neighborhood that may oppose significant expansions.
- East Boston is growing, which could make large industrial projects less desirable.

Notes: