THE UNIVERSITY OF MAINE

The 10th Annual Matthew R. Simmons

WINDSTORM CHALLENGE

2025 Curriculum

ADVANCED STRUCTURES & COMPOSITES CENTER

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WHAT IS SUSTAINABILITY?

The United Nations defines sustainability as "meeting the needs of the present without compromising the ability of the future generations to meet their own needs."

The Four Pillars of Sustainability

I. Human - Human sustainability focuses on maintaining and improving human capital in society. Human capital refers to the knowledge, skills, and health that people need to become productive members of society. Therefore, investments in healthcare, education, and access to services are all part of human sustainability. Improving human capital leads to growth, and as natural resources and space are limited, achieving health and economic wellbeing for all humans will require balance and certain trade-offs.

II. Social - Social sustainability focuses on preserving social capital, or the values and resources that enable people to work together in groups to achieve a common goal. This includes investing in and creating services that form the framework for our society. Social sustainability can be considered on a global scale, in relation to communities, cultures, and globalization. Social sustainability is centered on the relationships among people, and improving social quality. As a framework for our society, social sustainability can be supported by laws, information and idea sharing, and the concepts of equality and rights.

III. Economic - Economic sustainability focuses on improving the standard of living, by balancing economic growth with sustainable development.

IV. Environmental - Environmental sustainability focuses on improving human welfare by protecting natural resources. These resources include land, air, water, and minerals. Programs are considered environmentally sustainable when they meet the needs of present populations without compromising the needs of future generations.

OPTIONAL ACTIVITY!

Sustainability Explained

10 Minute Video

https://www.youtube.com/watch?v=_5r4loXPyx8

Renewable VS. Non-Renewable Energy

Renewable energy includes all sources of energy that are able to naturally replenish themselves. Renewable energy resources will never run out!

Sources: Bio, Geothermal, Hydropower, Marine, Solar and Wind Energy.

Nonrenewable energy includes sources of energy that do not naturally replenish themselves faster than we consume them. When we use nonrenewable energy, we are using it up.

Sources: Oil, Natural Gas, Petroleum, Coal, and Gasoline.

Renewable	Benefits	Non-Renewable
✓	Job Creation	✓
✓	Reduced Carbon Emmisions and Air Pollution	✓
✓	Increased U.S. Energy Independence	✓
✓	Lower Overall Maintenance	✓
✓	Will Never Run Out	✓
✓	Long-Term Economic Savings	✓
	Easy to use and store within existing infrastructure	
	Storage and on-demand use	

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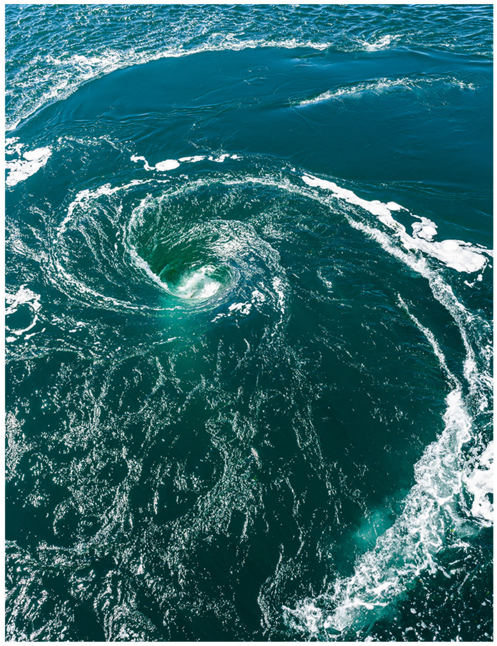
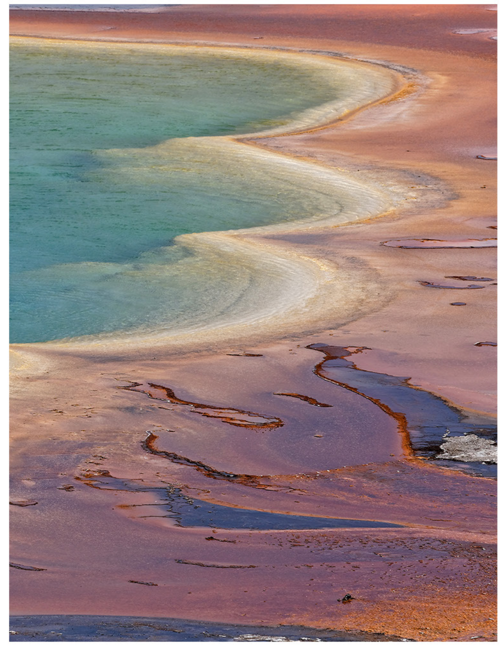

CLEAN ENERGY SOURCES




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CLEAN ENERGY SOURCES

HYDRO

Hydropower, one of the oldest sources of renewable energy, uses the flow and elevation difference of water to generate power. Dams, watermills, and other diversion structures are all common examples of means to harness kinetic energy to convert into hydropower.

Today, hydropower accounts for 31.5% of U.S. renewable energy generation and about 6.3% of general electricity generation. Hydropower is more cost-effective than most energy sources with low maintenance, operations, and fuel costs that all result in a lower energy bill for states and individuals. Hydropower equipment is known to be much more reliable for a longer period of time without needing replacement or repair. Outside of low-cost sustainable energy benefits, hydropower also helps regulate natural elements such as flood control, irrigation support, and water supply.

SOLAR

Solar or electromagnetic radiation power is sunlight, and solar technologies are able to convert the light into electric energy, through photovoltaic (PV) panels or concentrating solar-thermal power (CSP) systems like mirrors. Despite the varying levels of sunlight different locations on Earth receive, energy.gov states “The amount of sunlight that strikes on earth’s surface in an hour and a half is enough to handle the entire world’s energy consumption for a full year.”

Switching to solar energy provides many environmental and economic impacts; solar power reduces energy costs, creates jobs, and contributes to a resilient electrical grid that is able to generate and store back-up power. Solar energy plants can operate at similar efficiencies as nonrenewable energy, at both small and large scales.

NUCLEAR ENERGY

Nuclear energy is an example of potential energy, or when energy is stored or positioned. Nuclear energy is found in the nucleus of atoms and the energy is harnessed either through the fusion of small nuclei or through the splitting (fission) of large nuclei, where mass is converted to energy. Typically, uranium is mined and widely-used to create nuclear power. Despite its commonality as a metal – which is 100x more common than silver – uranium is still considered a nonrenewable resource.

Despite the non-renewability of uranium, nuclear energy still provides benefits to the environment as well as to the economy. Generating 800 billion kilowatt hours of electricity each year, nuclear power is the largest source of clean energy available in the U.S. Nuclear does not create emissions, so it does not contribute to pollution – the only waste that is produced is low-level radioactive waste that is safely handled and disposed of when necessary. The nuclear industry provides ample employment opportunities in the U.S., with about half a million jobs created and an estimated $60B gross domestic product generated in the country.

WIND ENERGY

Once called windmills, the technology used to harness the power of wind has advanced significantly over the past ten years, with the United States increasing its wind power capacity 30% year over year. Wind turbines, as they are now called, collect and convert the kinetic energy that wind produces into electricity to help power the grid.

Wind energy is actually a byproduct of the sun. The sun's uneven heating of the atmosphere, the earth's irregular surfaces (mountains and valleys), and the planet's revolution around the sun all combine to create wind. Since wind is in plentiful supply, it's a sustainable resource for as long as the sun's rays heat the planet.

MARINE ENERGY

Marine energy is similar to hydropower in that they both utilize the kinetic energy of water to generate electricity. However, marine energy generates power by converting the natural energy occuring in the ocean and rivers, such as waves, tides, and currents. The technology associated with marine energy include buoys to harness wave movement and turbines to catch energy from the tides and currents.

The U.S has miles of coastline bordering the ocean (here in Maine, for example), so the supply

GEOTHERMAL ENERGY

Geothermal energy is energy from the heat inside of the earth. Garnered from reservoirs in differing depths and temperatures beneath the surface, wells are dug and the reservoir is drilled into so the hot water and steam within them can be transported to the surface. Geothermal energy can be utilized for providing electricity, heating and cooling. Unlike other sources of energy, geothermal is readily available and geothermal plants can consistently produce electricity all of the time and in any kind of weather.

Environmental benefits from using geothermal energy include the complete absence of greenhouse gasses and low green house gas (GHG) emissions (4x less than solar PV panels and 20x less than natural gas). As geothermal energy can be harnessed and produced domestically, geothermal power plants are very compact and on average use less land than solar panels, wind mills, and coal plants.

BIOENERGY

Bioenergy is produced from biomass-- materials that derive from organic matter like crop, food, and wood wastes, microalgae, and forest residues. These resources are then produced through burning, bacterial decomposition, and conversion to a liquid or gas fuel. Because it can be a liquid, biofuels can be compared to the gasoline or other fossil based-fuels that power transportation vehicles, and provide heat and electricity. Biomass creates biofuels such as ethanol, biodiesel, and renewable hydrocarbon fuels that are a sustainable replacement for petroleum-based fuels or materials like plastic.

Like other clean energy sources, bioenergy enables economic development at a lower environmental cost than fossil fuels. Bioenergy allows the U.S. to move towards domestic acquisition of energy instead of relying on oil sourced from other countries – in turn, providing more jobs for Americans and revitalizing rural communities who have the necessary resources. In fact, the U.S has such a stable supply of biomass that the U.S Dept. of Energy stated "the United States has the potential to produce 1 billion dry tons of non-food biomass resources annually by 2040 and still meet demands for food, feed, and fiber." (energy.gov). The bioenergy industry has the potential to generate 1.1 million U.S jobs and keep $260B within the country. We have the resources, manpower, and capability to shift our dependence from fossil fuels to sustainably-sourced biofuels.

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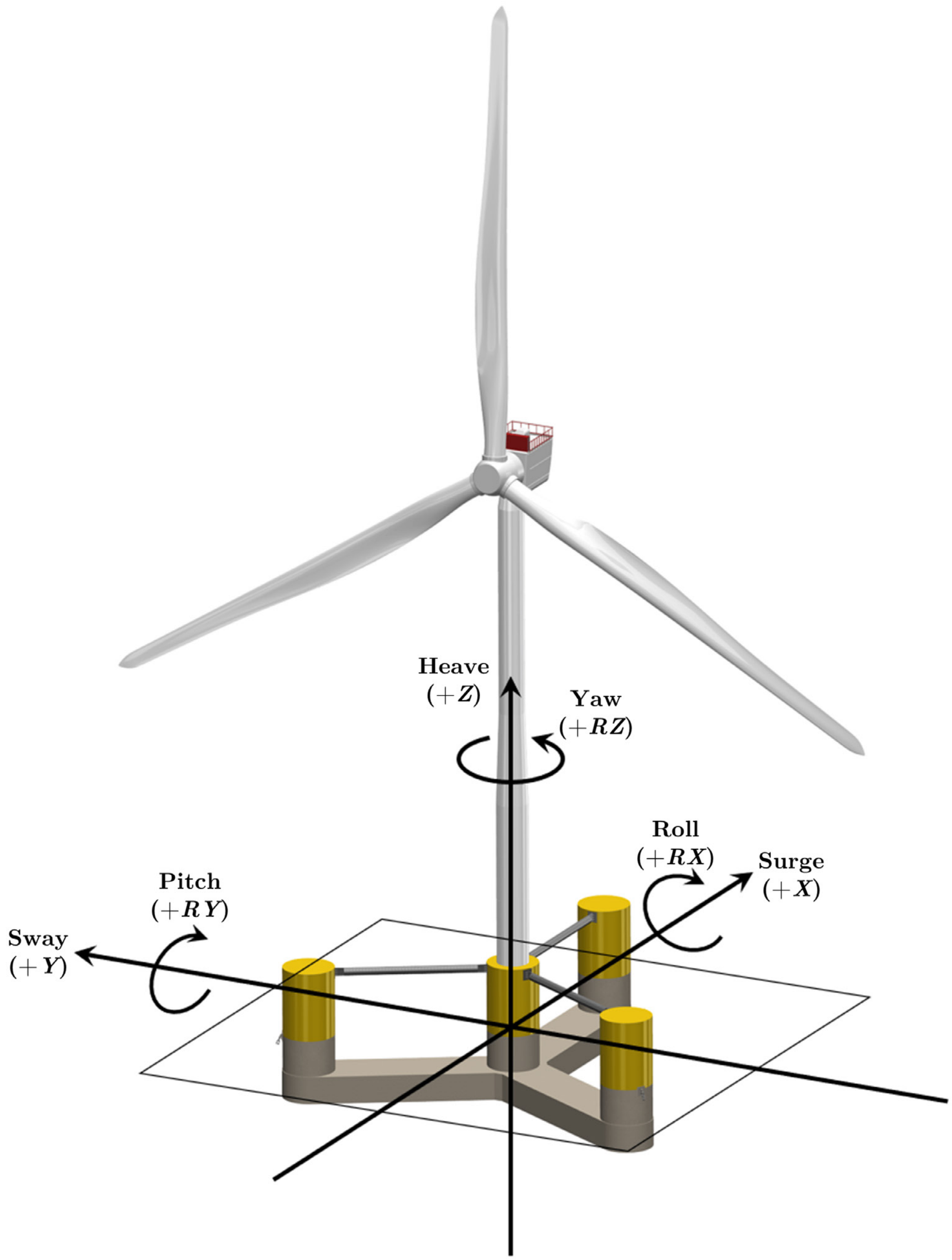
FLOATING OFFSHORE WIND TURBINE TERMINOLOGY



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FLOATING OFFSHORE WIND TURBINE TERMINOLOGY

Mooring Lines & Electrical Cables - The mooring lines are cables that come down from the platform and connect to the seabed through the anchor systems, holding the turbine in place. They can be made from many different materials; steel chains, wire and sythetic fiber ropes are some examples. They require regular maitenance to prevent damage from corrosion and marine growth. High voltage power transmission cables are made of conductive metals such as aluminum or copper, and are insulated and armored to protect from the elements. These cables transport the energy generated by the turbine and carries it over a great distance to the shore.

Hull - The hull is the foundation of the turbine and allows it to float. There are several different types of turbine platform, including semi-submersible, tension leg platform, barge, and spar. The platform pictured is a semi-submersible type, where part of the structure sits above and below the water surface. The platform includes a structure with enough buoyancy to allow the turbine to float.

Rotor Hub - The hub holds the blades in place and connects them to the main structure and the nacelle.

Blades - Turbine blades are shaped to capture the wind, similar to the wing of an airplane. They catch the force of the wind, generating energy by spinning.

Nacelle - The nacelle converts mechanical energy into electrical energy. It contains the generator, gearbox, drive train, and brakes. The shell is made from fiberglass composite materials to protect against weathering.

Tower - The tower is the structure that has to support the weight of the turbine through turbulent weather without bending or breaking.

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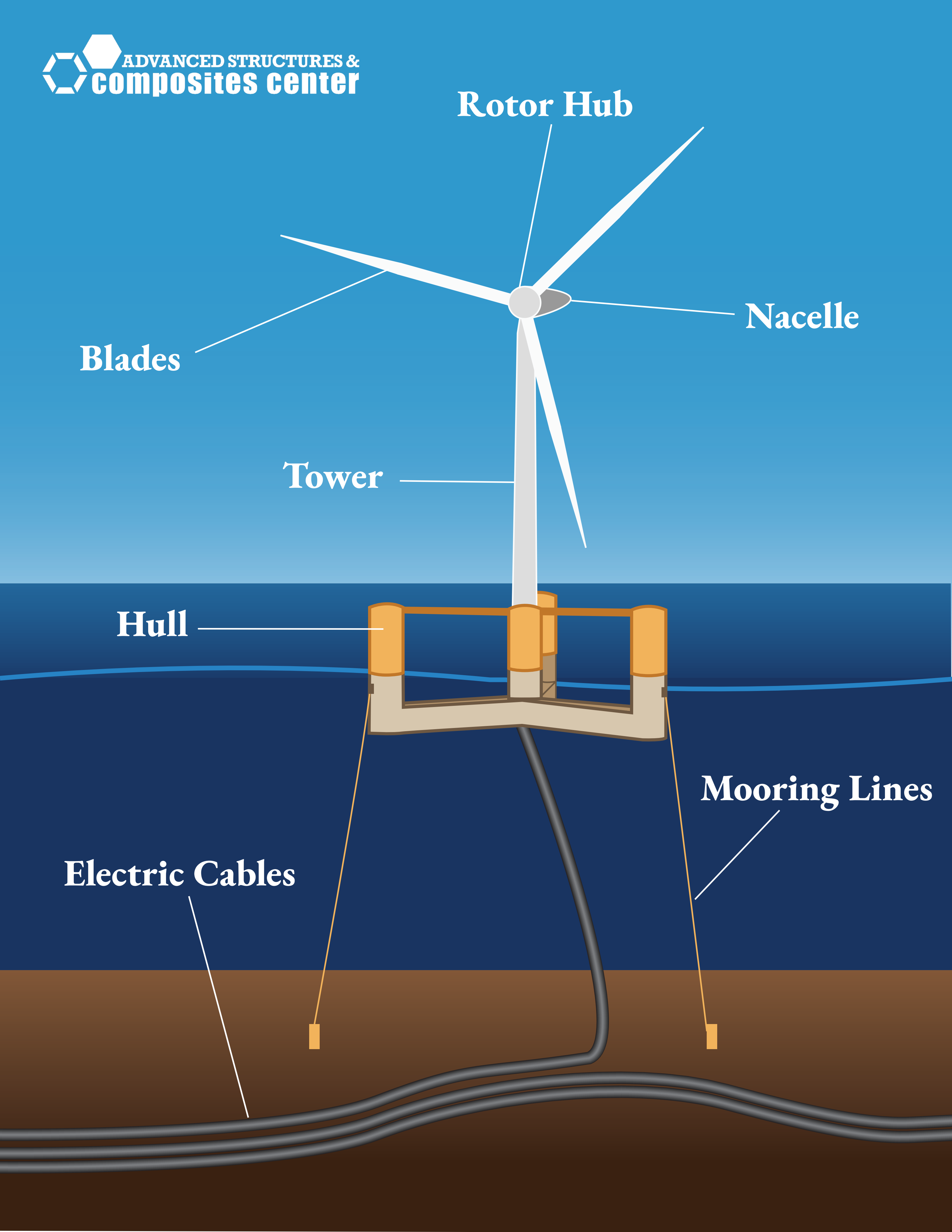
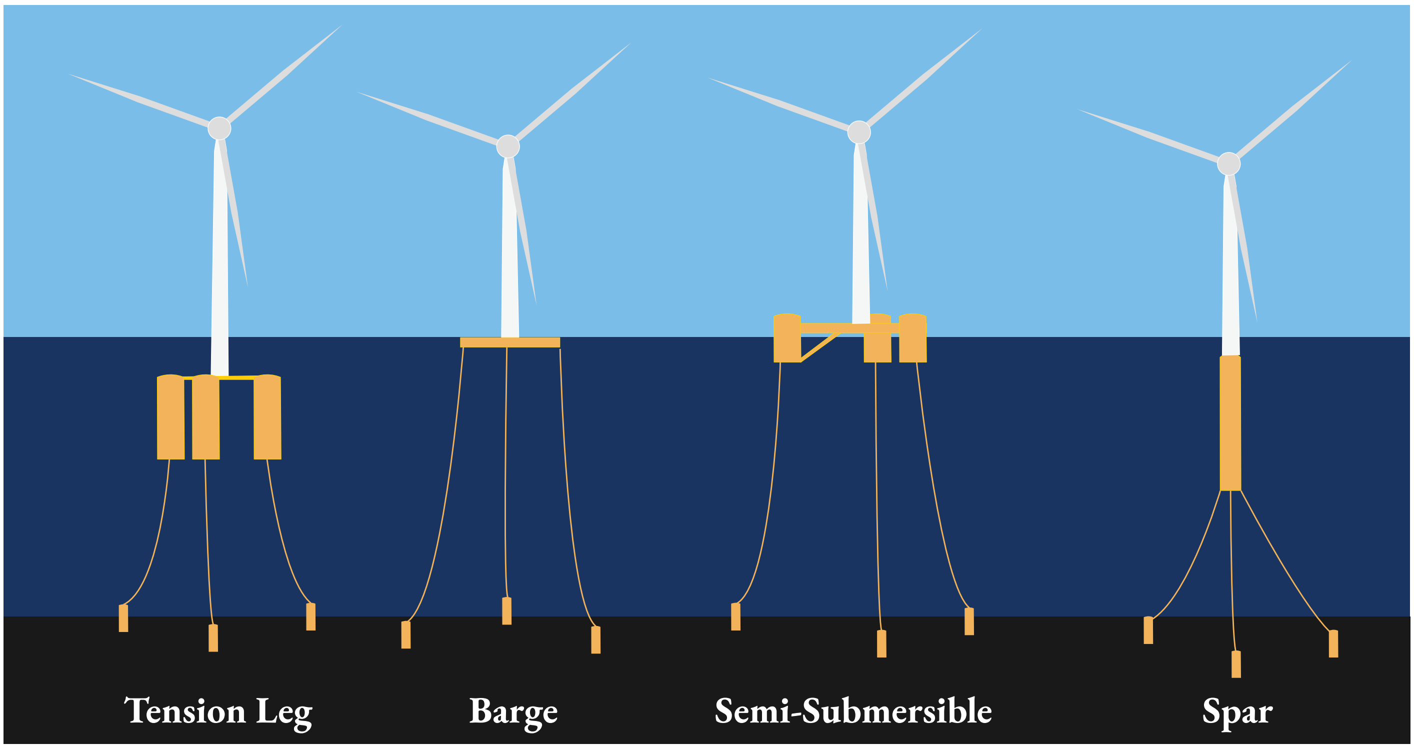

ADVANCED STRUCTURES &
composites center
Rotor Hub
Nacelle
Blades
Tower
Hull
Mooring Lines
Electric Cables

TYPES OF HULLS:
Benefits and Disadvantages



TENSION LEG

Tension Leg Platforms (TLPs): These stay in place because they are anchored to the ocean floor with strong ropes or cables that pull down. The floating part always stays tight and balanced because the cables are under constant tension, like a tightrope, keeping everything steady.

BENEFITS:

- Tendency for lower critical wave-induced motions
- Low mass
- Can be assembled onshore
- Best suited to water depths 70-200 meters deep

DISADVANTAGES:

- Harder to keep stable during transport and installation
- A special purpose vessel may be required
- Some uncertainty about impact of possible high-frequency dynamic effects on the turbine
- Higher installed mooring cost

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BARGE

Barge Hulls: These have a flat shape that sits on the surface of the water, kind of like a large raft. They are stable because they spread out across a big area, but this also means they can move around more when waves hit them.

BENEFITS:

- Advantages in weight and anchors
- Simple manufacturing
- Ease of installation
- Can be assembled in port and towed to site

DISADVANTAGES:

- More sensitivity to waves, mostly used in calm seas

SEMI-SUBMERSIBLE

Also called "Column-Stabilized." These have floating sections, usually shaped like columns, that are connected by beams or platforms. They float on the water but also have heavy weights (ballast) to help them stay steady, even when the wind or waves are strong.

BENEFITS:

- Turbines and bases can be assembled in port and towed to site for installation
- Stabilized by large waterplane area
- Best suited to most water depths

DISADVANTAGES:

- Cabling requires frequent inspection and maintenance
- Anchors and cabling can disrupt sea life
- Design more affected by waves

SPAR

Spar Hulls: These are tall, tube-like structures that float vertically in the water. They have heavy weights (ballast) at the bottom, which makes them very stable, like a weeble toy that wobbles but doesn't fall over. This design helps them stay upright, even in rough seas.

BENEFITS:

- Simple design
- Lower installed mooring cost
- Tendency for lower critical wave-induced motions
- Stabilized by low-down ballast
- Best suited for very deep waters

DISADVANTAGES:

- Offshore operations require heavy-lift vessels and currently can only be done in relatively sheltered, deep water
- Needs to be installed in deep water (>100m)

Science & Engineering Guide

This guide in conjunction with the Windstorm Curriculum and Buoyancy & Stability slides help build the knowledge and skills needed to successfully compete in the Windstorm Challenge!

The Windstorm Curriculum focuses on renewable energy, sustainability, and offshore wind in Maine. The Science & Engineering Guide contains structured guidance for tasks associated with the Windstorm Challenge micro-cre dential, but can be used by anyone to help progress through the engineering design process. The Buoyancy & Stability slides provide a closer look at the science and engineering principles directly applied to floating offshore wind platforms.

Level 1

The Windstorm Challenge Level 1 badge is about building knowledge about offshore wind, the steps in the engineering design process and the science and engineering principles that apply to floating platform design.

Building knowledge-links are provided as resources, you may use any other materials you have available to teach these topics. The outline below represents the order suggested for the material.

- ☐ Windstorm Curriculum
- ☐ Engineering design process
- ☐ Forces
    - ☐ Newton's Laws
    - ☐ Force Diagrams
        - ☐ Examples also in Buoyance & Stability slides
- ☐ Buoyancy & Stability Slides
- ☐ Activity Buoyancy - (45 minutes)
- ☐ Assesment - take the Windstorm Quiz and score 80% or better to get the Level 1 badge

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Engineering Design Process

Newton's Laws - Reading

Newton's Laws - Video

Newton's Laws - Simulation

Force Diagrams - Video

Buoyancy Activity

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Level 2

Windstorm Challenge Level 2 is about forming your team and getting started on the design process to build your platform for the Windstorm Challenge Competition. In addition to working through the design process, students build skills in collaboration and creative problem-solving. Each section below describes tasks or assignments that will count towards earning the Level 2 Windstorm badge. In addition, students will earn the Collaboration and Creative Problem Solving microbadges!

1. Team Charter

(Collaboration micro-badge requirement)

The Team Charter is a document developed by each team that provides a blueprint for team interactions. It lays out rules and processes for creating a positive team environment and addressing issues that may arise during the project. The Team Charter should be developed as a team, include input from all team members, and be signed by the whole team.

Create a Team Charter that outlines the rules and processes your team will follow to create a positive working environment. The Team Charter should start with a diversity statement that acknowledges that different perspectives strengthen teams and highlights how the team with seek out and use their own diverse perspectives during the Windstorm Challenge. Next outline rules or a process for the following scenarios: general interactions with teammates, whole team discussions, making decisions as a team, preventing conflicts from occurring, resolving conflicts that do occur, and dividing tasks or roles fairly.

Team Charter 1 **Team Charter 2**

Students should also be aware of the Teamwork Behavior Rubric criteria required to earn the Collaboration micro-badge. The behaviors outlined in the rubric demonstrate that the student is following the Team Charter and contributing to a positive team environment. Educators may choose to have students complete the Teamwork Behavior Rubric as a self-assessment and/or assess teammates to gather data on student behaviors in addition to their own observations. Only the educator assessment will be submitted as evidence for earning the Collaboration microbadge however.

2. Understanding the Problem

(Creative Problem Solving micro-badge requirement)

☐ Define the Problem (Suggest students complete individually, then combine with group to share ideas, especially priorities for Design Strategy)

Understand the Problem 1 **Understand the Problem 2**

Read the Windstorm Guidebook. Write a Problem Statement that will help guide you through the design process. The Problem Statement must include the following information:

Description of the design task objectives. What does the platform need to do? What does the team need to do? Remember physical performance of the platform is only one part of the competition.

Constraints. What are the rules that must be followed? What other criteria must you consider?

Design Strategy. Identify design priorities. What is important to your team? Explain why the priorities are important. Think about global, societal, or environmental impacts. Design drivers should vary between groups. Some ideas could include aesthetics (Does it look cool?), cost (Is it cheap?), simplicity (Is it easy to build?), and sustainability (Can it be recycled?). Make sure to include definitions of the keywords in your design strategy, don't just say "sleek and sustainable", explain what that means to you and why it is important.

☐Research the Problem

Scribbr **UMaine Library** **UMaine OSW Resource**

What types of designs are already in use? What types of designs are used for similar applications? (ex: boats, buoys, weather sensors, pool toys, etc) How do those designs work? What scientific concepts do you need to apply to your design?

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3. Design Process

(Creative Problem Solving badge requirement. Educators to assess group documents.)

This section outlines the processes used to develop the design including generating and evaluating ideas, select ing the best ideas, and developing a plan for gathering information or testing the design.

□ Ideation (Brainstorming)

Devise at least 3 models that could work for the platform design. The models should be significantly different from each other. Include sketches or CAD drawings to visualize the models. Include preliminary material ideas and cost estimates.

□ Selection (Decision Matrix)

Create a Decision Matrix based on the judging criteria and any other relevant criteria for sourcing and building the models. Weigh each criteria according to the Design Strategy outlined in the Problem Statement.

Use the Decision Matrix to assess each model. Option to build small scale models to gather additional data for assessment on performance, ease of construction, etc. Analyze the results and choose the best model for construction.

□ Testing Plan

Analyze your design features, materials, and likely construction steps to identify 3 potential trouble spots or failures. Develop a plan for collecting data about these likely trouble spots in your selected design prior to Windstorm Competition Day. This could involve building small-scale models to experiment with construction techniques, gathering feedback from others on design aesthetics, testing full scale models in a community pool or large water tank, etc. The plan should include what you will test, how you will test, and why the test will be useful.

4. Iteration: Engineering Notebook

(Creative Problem Solving badge requirement. Kept individually by each team member) Option to keep all parts of the Design Process in the Engineering Notebook too.

□ Pre-Build Troubleshooting

Collect any pre-construction data included in your Testing Plan. Record testing results and note any decisions made or alterations to your design in your Engineering Notebook. Testing may uncover a larger problem (this is good! It's why you did the test!) with one or more aspects of the design. Just use the previous Design Process steps (Ideation, Selection and Testing) again for these specific problems. Record everything in your Engineering Note book. Finalize the materials list and outline the steps in construction.

□ Building

5. Construct your platform.

Use your Engineering Notebook to record any problems that arise during construction and the solutions you chose (Remember you can use the Ideation, Selection and Testing framework to make decisions!).

□ Analysis

Carry out any remaining parts of your Testing Plan. Analyze the results to determine if design modifications are required. Refer back to the science concepts to determine causes of any design failures. Go back to the Design Process Ideation, Selection and Testing framework if needed. You may need several cycles to get the design to work the way you want, this is normal! Keep track of all changes to the design in your Engineering Notebook. Make sure you have a clear record of all the final materials and design elements.

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Level 3

Compete in the Windstorm Challenge and reflect on your learning experience!

Students will need to submit a reflection on learning that will be assessed by ASCC faculty or staff to earn the Level 3 Windstorm Badge and complete the Windstorm Challenge Micro-credential!

◻ Final Reflection: Reflect on your experience participating in the Windstorm Challenge. Limit of 750 words or 5 minutes if recorded. Include the following sections:

◻ Windstorm Debrief: What went well, what went wrong, how could you improve? Address technical performance, design, and presentation experience.

◻ Skill Assessment: What skills did you learn? Provide examples of your skill progression throughout the project.

◻ Future Goals: Discuss how the skills you developed will help you achieve success in the future, either in school or in your career.

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Offshore Wind Potential

in Maine

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OFFSHORE WIND POTENTIAL IN MAINE

Offshore wind is Maine's largest untapped energy source, with the potential to produce 150 gigawatts of energy per year.

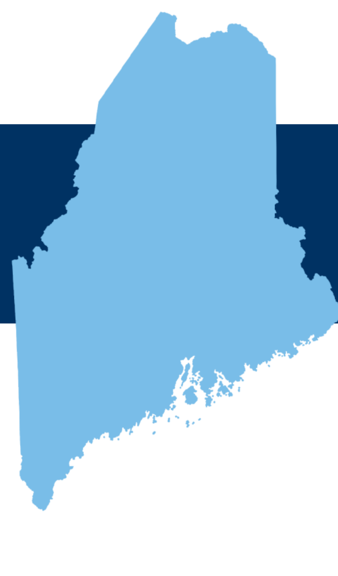
Maine is an ideal state for deepwater offshore wind development, due to its coast.

Harnessing just 3% of the Gulf of Maine's offshore wind resource would be enough to fully electrify heating and transportation in Maine.

In 2008, Governor Baldacci established the Maine Ocean Energy Task Force to recommend a strategy for developing renewable ocean energy resources in the Gulf of Maine.

$5 billion leaves the state every year in heating oil and gasoline costs; wind energy development in Maine will help keep those dollars in-state

OPTIONAL ACTIVITIES



BUILD YOU OWN OFFSHORE WIND PLATFORM

extension.umaine.edu/4h/stem-toolkits/off-shore-wind/#activity-2-platform-building

DR. HABIB DAGHER TED TALK

youtube.com/watch?v=agS-lMsiV-g

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VolturnUS+

Building on the success of UMaine's patented VolturnUS concrete hull, VolturnUS+ offers a lighter design with improved motion control.

UMaine's VolturnUS floating concrete hull, capable of supporting wind turbines in depths over 150 feet, was tested with a 1/8th scale prototype off Castine, Maine in 2013—the first grid-connected floating wind turbine in the Americas.

The project aims to showcase a full-size VolturnUS hull and collaborate with local contractors and manufacturers to support Maine jobs.

ADVANCED STRUCTURES & composites center

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OFFSHORE WIND JOB CREATION

WINDSTORM CHALLENGE
10 YEARS

Offshore Wind Job Creation

The federal government set a goal of deploying 30 gigawatts of offshore wind by 2030

- More than 44,000 workers are expected to be employed in offshore wind by 2030, and 33,000 additional jobs are expected to be created in communities supported by offshore wind activity

Governor Mills has set a goal of reaching 30,000 clean energy jobs in Maine by 2030

- Between 2016-2019, Maine's clean energy economy grew faster than the state's overall economy
- In 2021, nearly 14,000 clean energy jobs existed in Maine

Wind is the largest source of renewable energy employment in the state, and offshore wind in Maine has the potential to substantially grow the state's economy

- Maine's wind-related workforce accounted for more than 1,300 jobs in 2020
- The sector was one of few industries to grow during the pandemic

The New England Aqua Ventus floating offshore wind project is estimated to generate $200 million in economic output and support more than 1,500 Maine-based jobs

According to the U.S. Bureau of Labor Statistics, wind turbine technician is the second-fastest growing occupation in the U.S.

In the next decade, wind turbine technician employment opportunities are expected to create 2,000 new openings each year.

Career Pathways

The offshore wind industry will create jobs in many areas, including in project development, supply chain and manufacturing, ports and staging, maritime construction, and operation and maintenance. 117 additional occupations have been identified as important to the development and operation of the offshore wind industry.

Examples of jobs associated with wind energy:

Engineers: Engineers focus on the research, design, and development of the components and tools used in the wind industry, from turbines, to rotor blades, to electrical, engineering expertise is needed in many areas of wind project development.

GIS Specialists: Geographic Information System (GIS) specialists design and manage digital maps with geospatial data which are critical to site planning. These maps may consider land boundaries, wind resources, environmentally sensitive areas, and topography.

Wind Energy Analyst: Wind energy analysts help determine site locations by gathering a variety of data, such as wind and weather data.

Wind Turbine Technician: Technicians inspect turbines to perform routine maintenance and repairs on equipment.

Construction Jobs: A variety of construction jobs are involved in the manufacturing and maintenance of wind energy projects, such as project managers, crane operators, welders, and electricians. Construction work may involve building access roads, building foundations, and operating heavy equipment.

Attorney: Attorneys work within all sectors of the wind industry to represent individuals, businesses, or government agencies to support contract negotiations, patent filings, financing agreements, and regulatory processes.

Examples of occupations involved with each phase of an offshore wind project:

Planning and Development: engineers, financial analysts, lawyers.

Manufacturing and Assembly: engineers, metal workers, operators, assemblers, administrative staff.

Construction and Installation: crane operators, electricians, mechanical engineers, line workers, welders.

Operations and Maintenance: administrative staff, wind turbine technicians, marine operators, plant managers.

Support Services: meteorologists, vessel mechanics, lawyers, policy experts.

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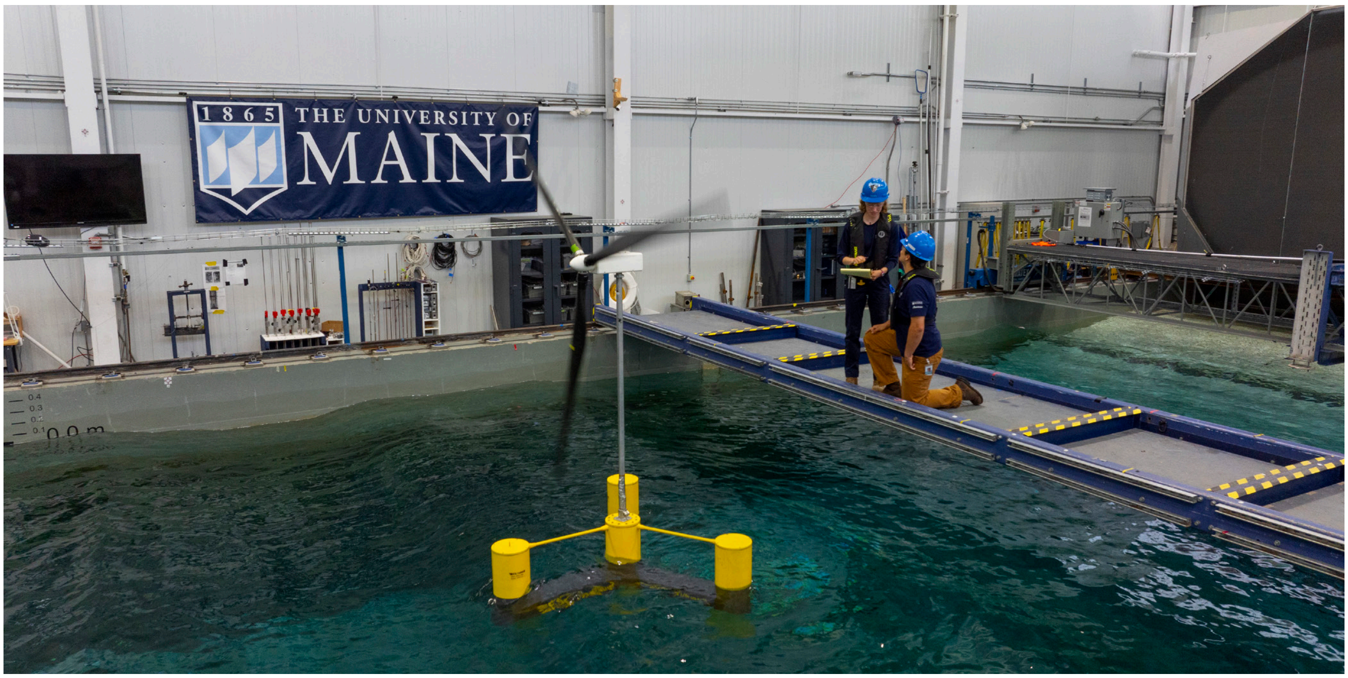
Wind Curriculum at Maine Maritime Academy & Northern Maine Community College

Northern Maine Community College is partnering with Maine Maritime Academy to develop a training facility and comprehensive curriculum to prepare wind technicians to work on offshore wind turbines.



Offshore Wind Curriculum at UMaine

The University of Maine offers pathways to careers in offshore wind classes through the Maine College of Engineering and Computing, such as: Wind Energy Engineering, Floating Offshore (Energy) System Design, and Offshore Wind Farm Engineering. Undergraduate and graduate students (M.S. and Ph.D) in Mechanical engineering can declare a concentration in Offshore Wind Energy.

The Advanced Structures and Composites Center (ASCC) at UMaine employs researchers and engineers on offshore wind projects at the undergraduate and graduate level.

See the Offshore Wind Education and Training Database for more information on institutions and programs that are training students for careers in offshore wind.

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