



The 10th Annual Matthew R. Simmons
**WINDSTORM
CHALLENGE**

2025 Curriculum

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

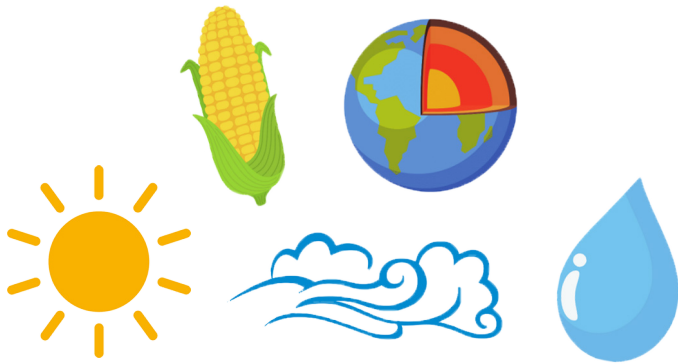
10 Minute Video

<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!



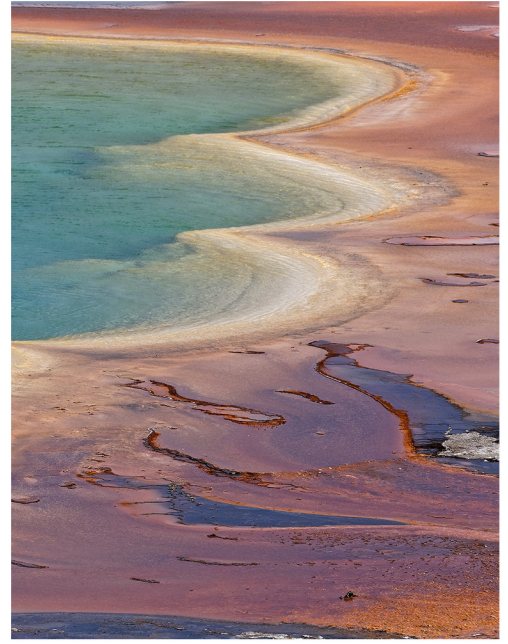
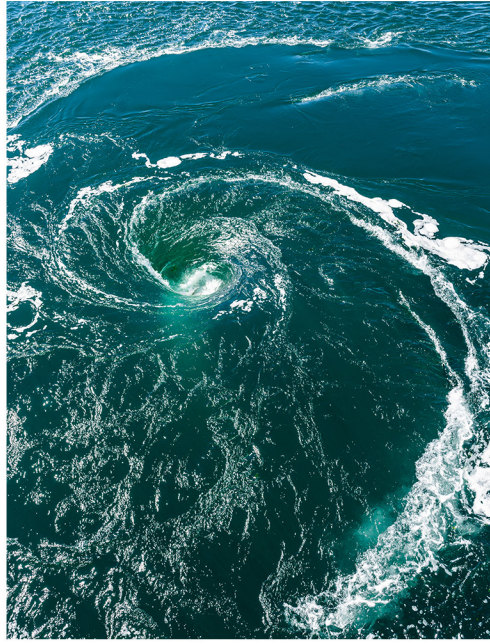
Sources: Bio, Geothermal, Hydropower, Marine, Solar and Wind Energy.

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 Emmissions 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	



CLEAN ENERGY SOURCES



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 occurring 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

GEOHERMAL 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.



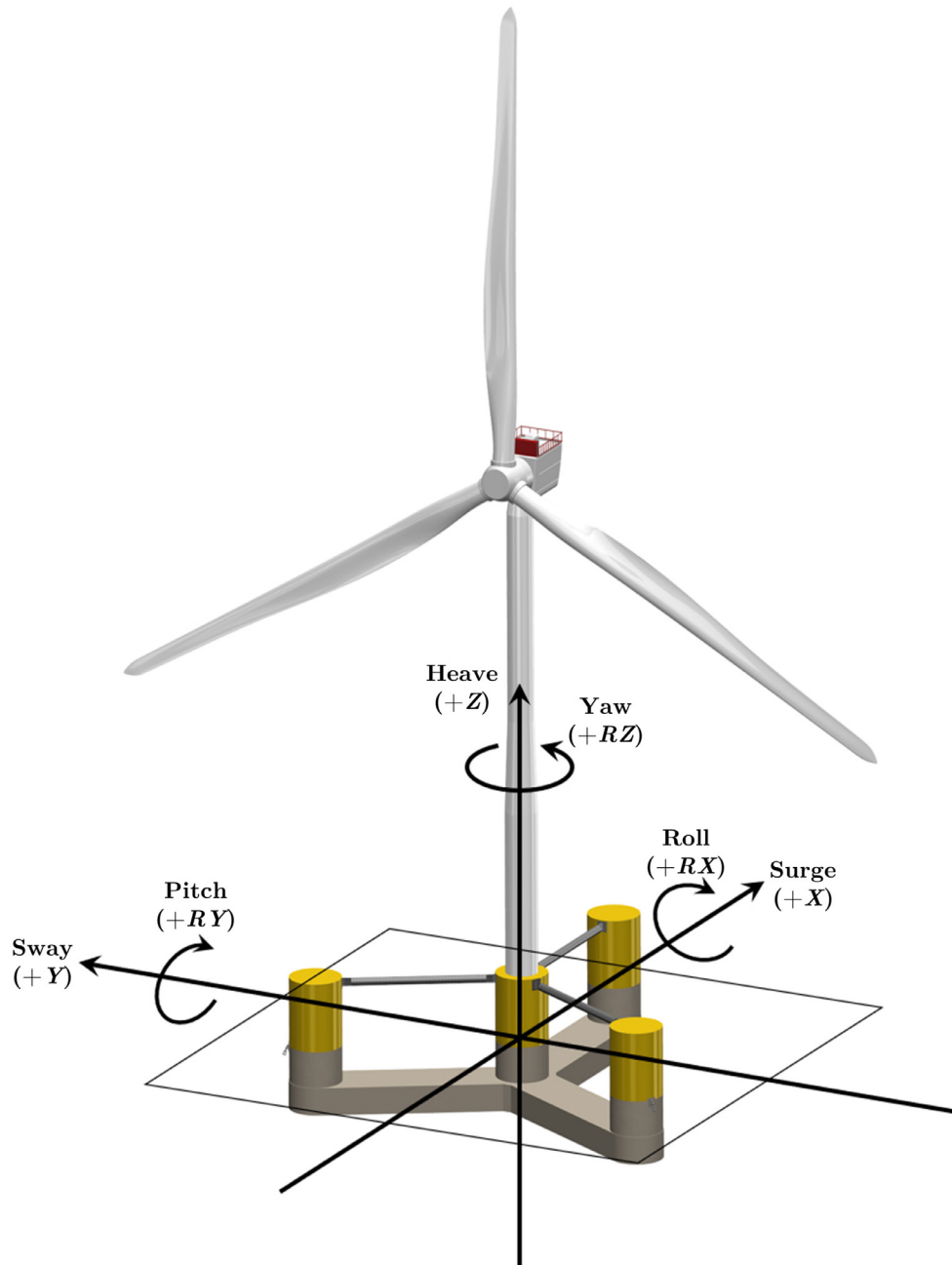
BIOENERGY

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.



FLOATING OFFSHORE WIND TURBINE TERMINOLOGY



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 synthetic fiber ropes are some examples. They require regular maintenance 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.

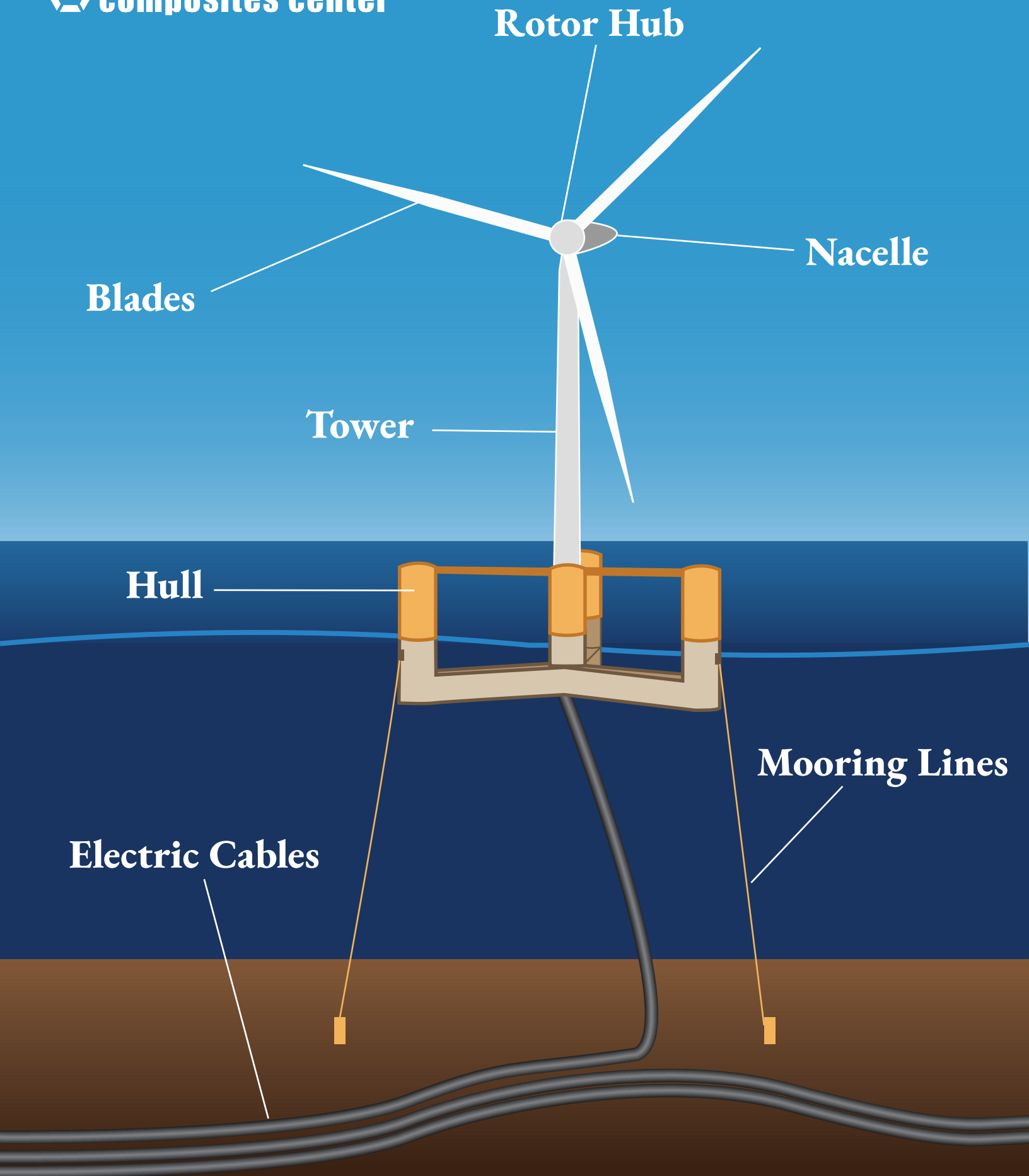
Hull - The hull is the foundation of the turbine and allows it to float. There are several different types of turbine platform, including semi-submersible, tension leg platform, barge, and spar. The platform pictured is a semi-submersible type, where part of the structure sits above and below the water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

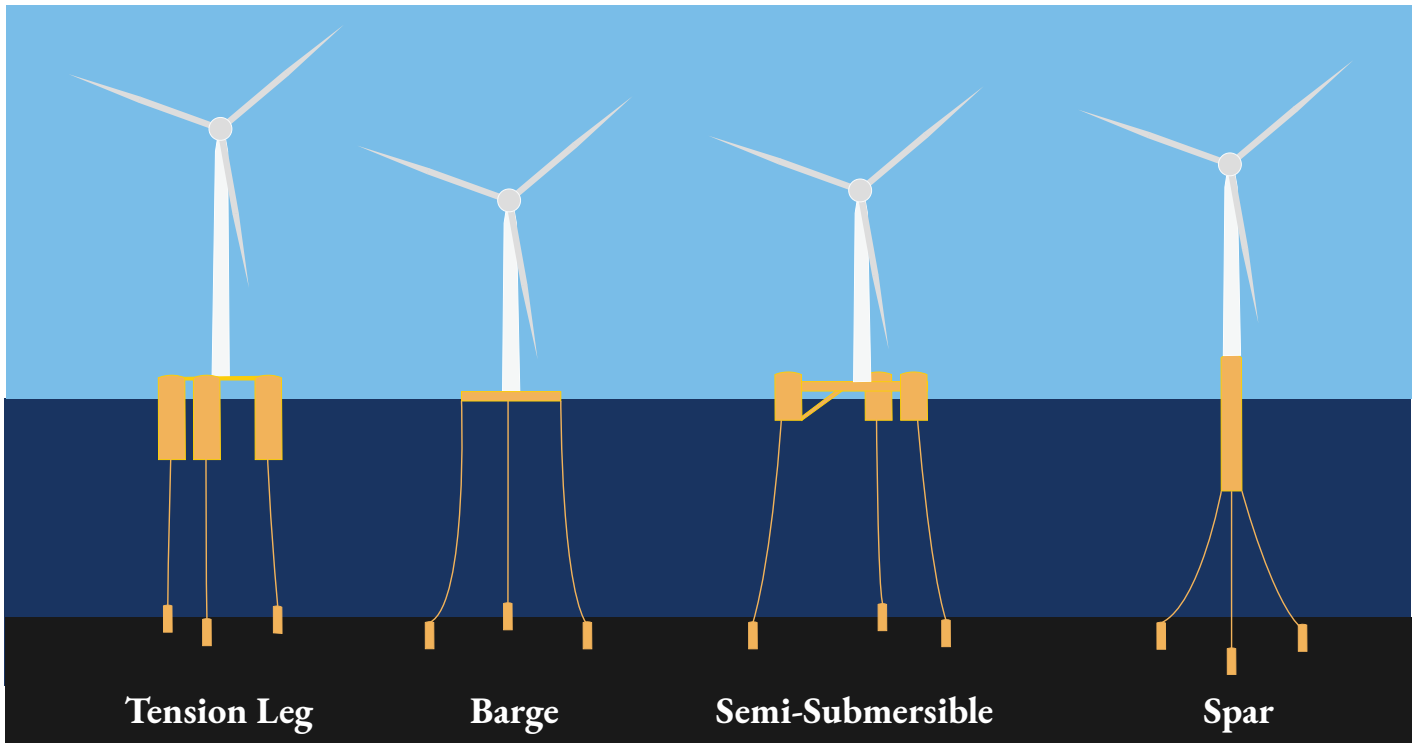
Blades - Turbine blades are shaped to capture the wind, similar to the wing of an airplane. They catch the force of the wind, generating energy by spinning.

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.



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

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.

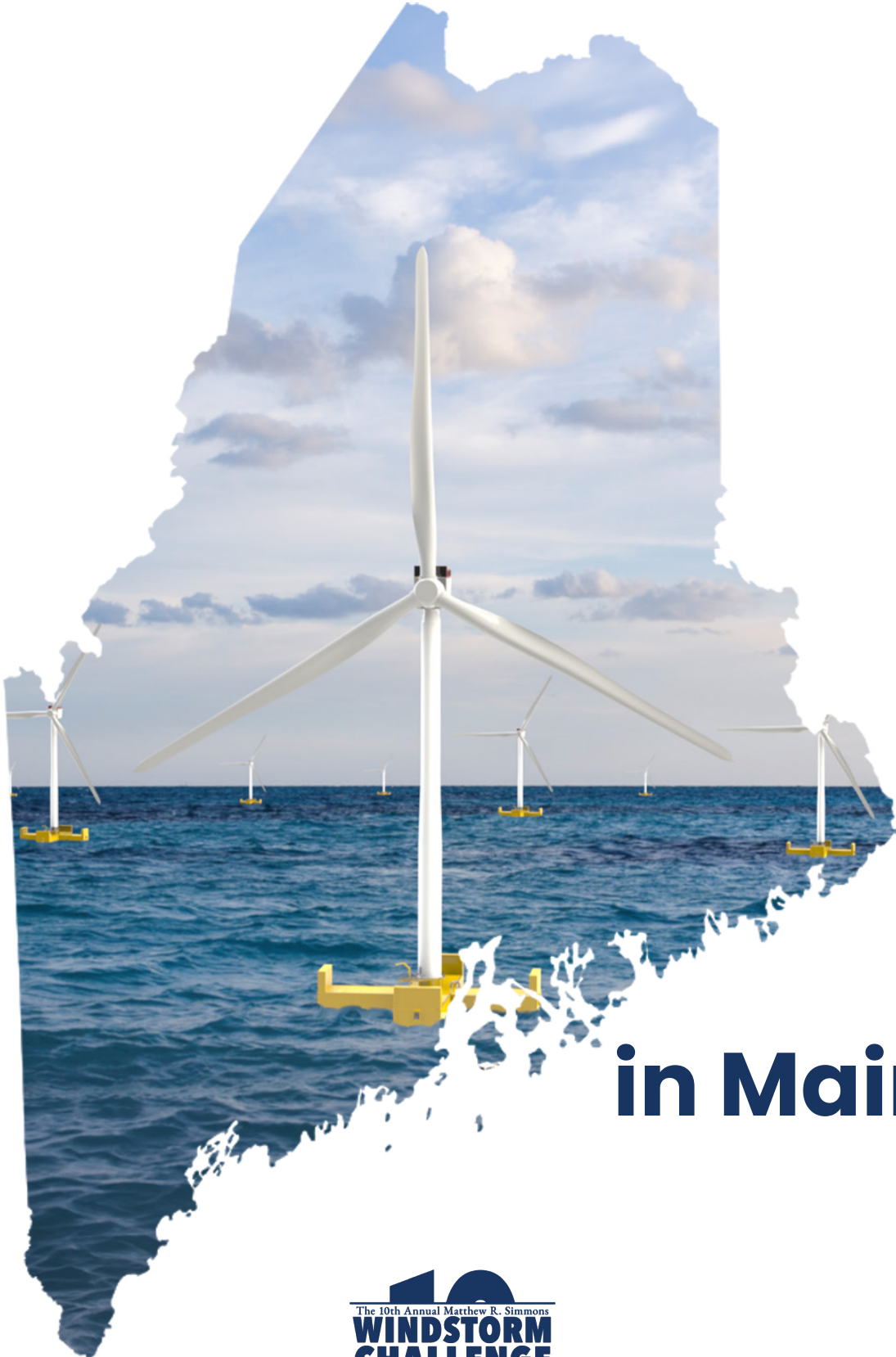
BENEFITS:

- 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)

Offshore Wind Potential



in Maine

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
**BUILD YOUR OWN
OFFSHORE WIND
PLATFORM**



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

ACTIVITIES
**DR. HABIB DAGHER
TED TALK**



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

VOLTURNUS +



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

UMaine's VoltturnUS 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 VoltturnUS hull and collaborate with local contractors and manufacturers to support Maine jobs.

OFFSHORE WIND JOB CREATION



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.

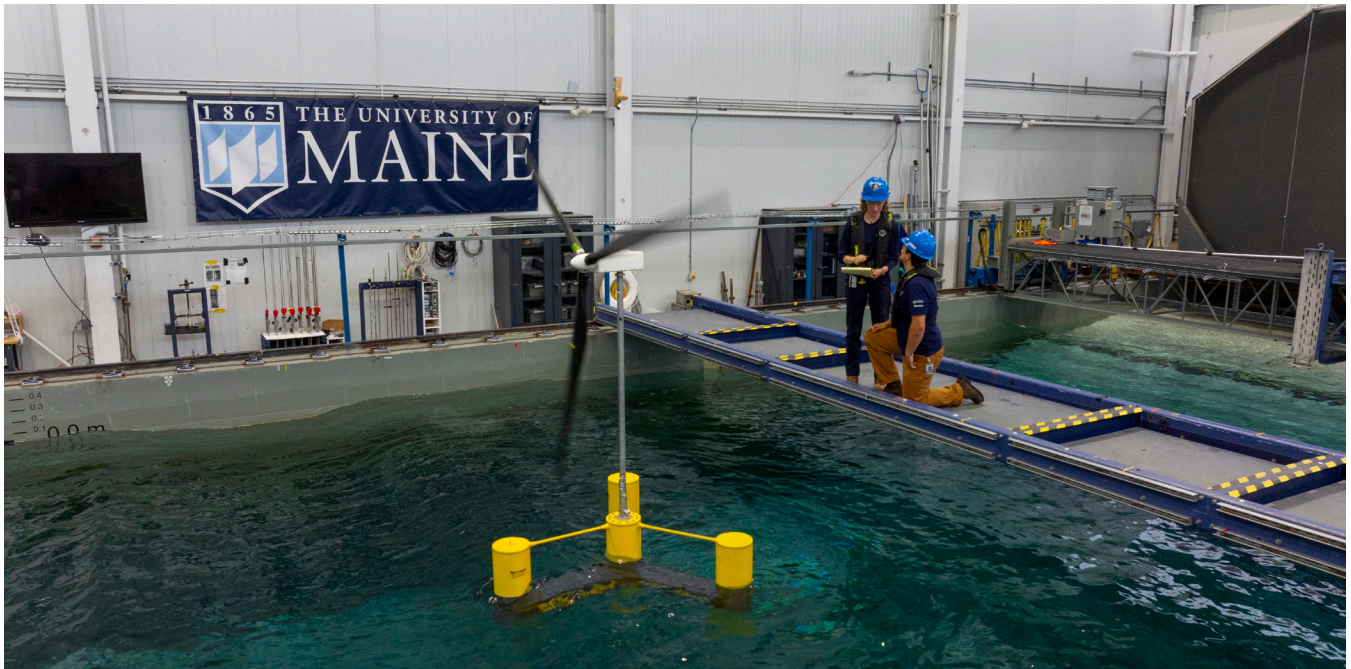
Construction and Installation: crane operators, electricians, mechanical engineers, line workers, welders.

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

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

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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