Coastal Studies Institute
A Multi-Institutional Research Partnership

# *NC Renewable Energy Challenge Ocean Energy Rules*

### *Ocean Energy Introduction*

Ocean waves, tides and currents offer significant potential for electrical power generation. The development of ocean energy technology is a critical step in the expansion of our nation's energy portfolio. The Coastal Studies Institute (CSI), along with the Colleges of Engineering at North Carolina State University, NCA&T and UNC Charlotte are leading the North Carolina Renewable Ocean Energy Research Program designed to bring together the coastal, electrical and industrial engineering needed for the research and development of technologies to harness this form of energy and develop strategies for future integration into the energy needs for the state of North Carolina. The mission of CSI's Ocean Energy program is to *"Conceptualize, research, design, construct, operate and market new technologies to harness the energy of the ocean."*

Research scientists and engineers in the North Carolina Renewable Ocean Energy Research Program are investigating how and where to harness the energy available in the Gulf Stream, a warm water western boundary current that flows northward off the coast of North Carolina. The Ocean Energy category of the NC Renewable Energy Challenge asks students to create a turbine device that works in an underwater current and consider the logistical details of harnessing an ocean current and converting it to a useable form of electrical energy.

### *Ocean Energy Facts*

Be prepared to answer these questions about ocean energy. Use resources available at coastalstudiesinstitute.org or do your own research to answer them. CSI's YouTube channel is also a good resource for additional information.

1. What drives ocean currents? What are some of the different types of currents?
2. What is the Gulf Stream? What makes this a potential energy source? Where does the energy come from to create the Gulf Stream? Where does the Gulf Stream end up?
3. What are some examples of devices that utilize ocean hydropower? Where are ocean energy devices currently in use? Give a brief explanation of how they work.
4. The ocean is a constantly changing environment. What are some challenges to deploying equipment in the ocean?
5. What kind of technological breakthroughs are needed to make ocean power more accessible for the general public?
6. What does the future of power look like?

### *Ocean Currents Rules & Building Guidelines*

Ocean Currents Divisions: 4$^{th}$ – 8$^{th}$ grade; 9$^{th}$ to 12$^{th}$ grade

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*Size*

Your ocean energy device must fit within the testing area of a current flume tank (figure 1). The testing area is 36 inches X 36 inches X 48 inches deep. A current will be produced from powerheads that provides a flow of up to 1m/s. The device built needs to fit in the tank and be moored to the provided mooring platform (see figure 2). Your device should be able to stay in one place without holding onto it and should be secured to the 36in X 36in mooring platform. Depth of water in the testing area will be approximately 36 inches from the mooring platform to the surface.

Figure 1: Flume tank schematic

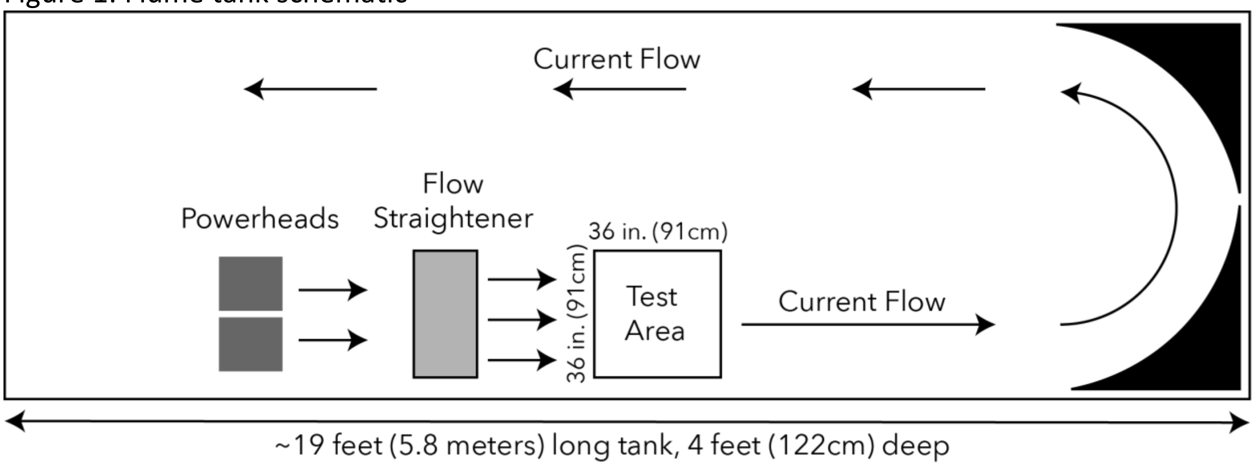



Figure 2: Mooring platform

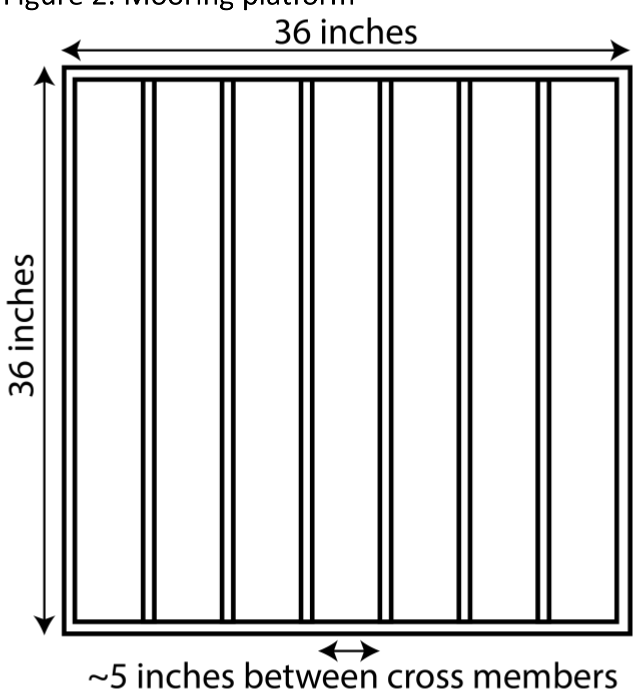


Figure 3: Device mooring platform

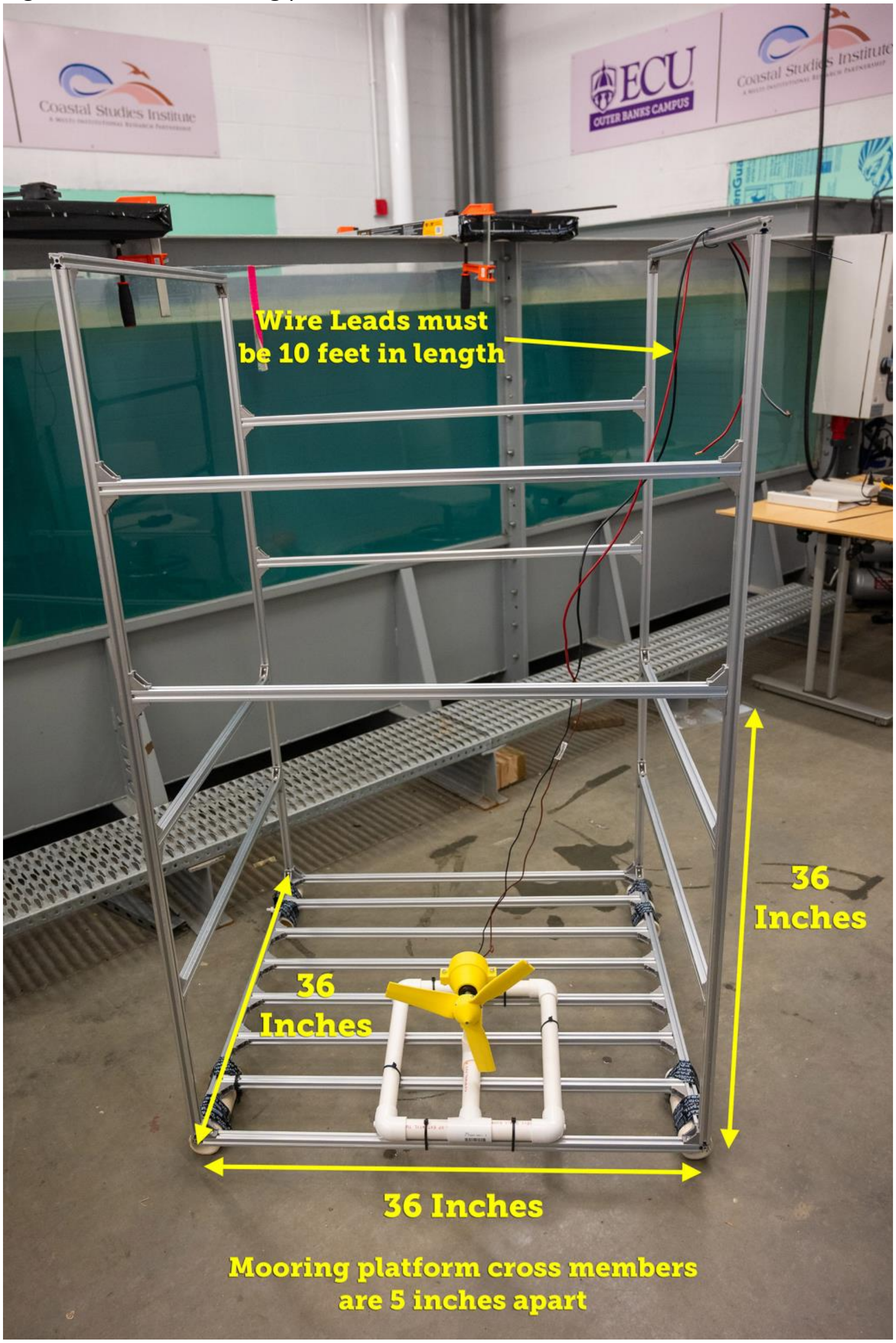


Figure 4: Device mooring platform being lowered into test area

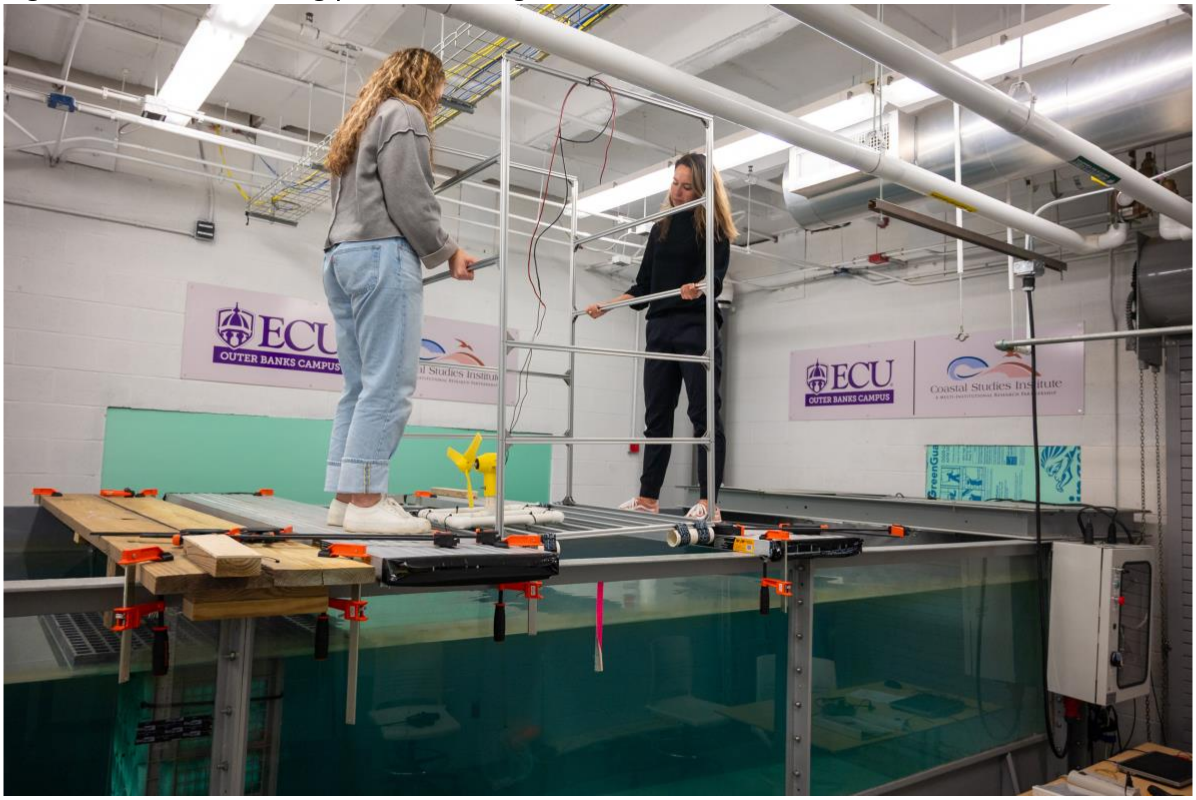
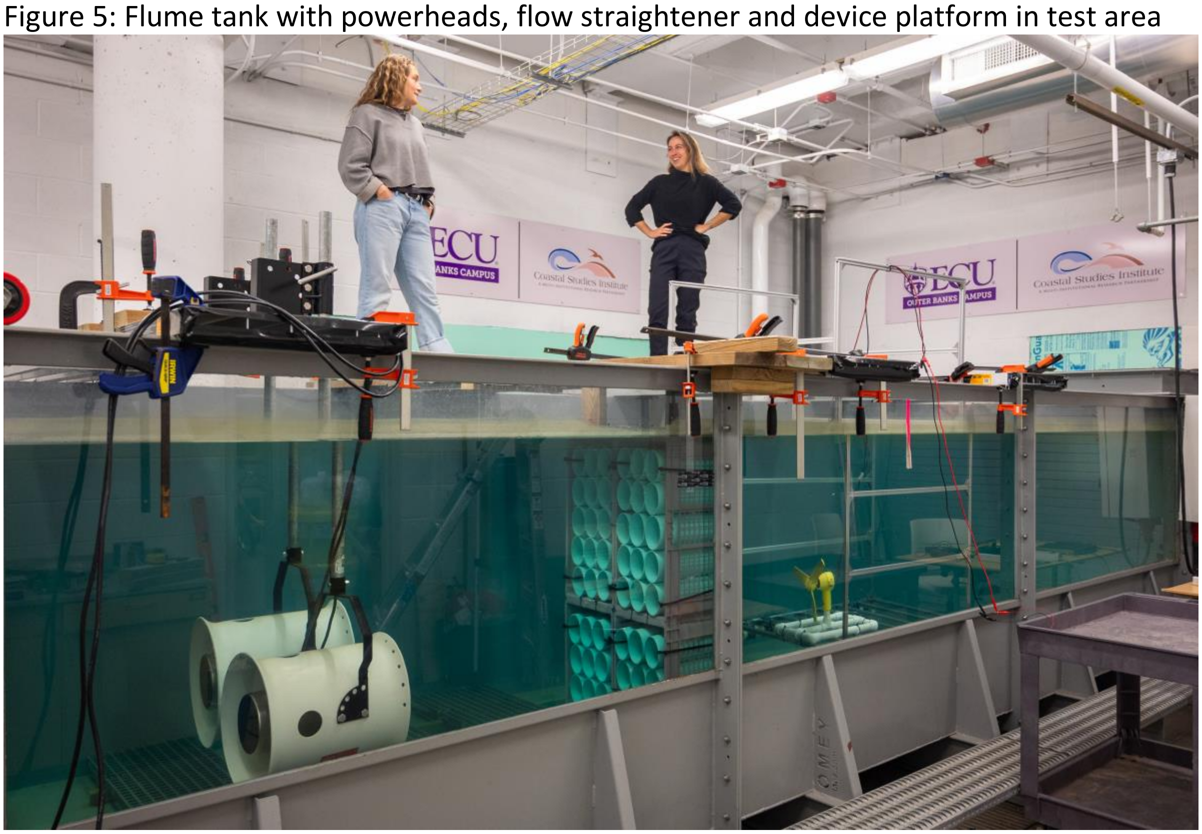



Figure 5: Flume tank with powerheads, flow straightener and device platform in test area



*Materials*

You can use any type of material to build your ocean energy device, but keep in mind that everything will get wet as we are testing it in a water tank. Repurposing materials is highly encouraged, and creativeness and ingenuity will be noted in the judging process.

*Generators*

KidWind produces a generator: https://www.vernier.com/products/kidwind/wind-energy/kw-gen/ that may be the simplest path. It is also possible to create your own generator.

*Blades*

There are a wide variety of possible blade shapes and materials. Remember the size requirements when constructing your blades. Consider the difference between air and water, and what kind of designs may be more efficient in a water current.

*Towers and Mooring*

Your underwater turbine needs to be supported in some way so that you are not holding it in the current. The device can be moored to the platform described above or float. Towers can be built out of almost anything and designing a system to hold a turbine in place is something engineers are currently working on to make harnessing Gulf Stream power feasible.

*Design Rules*

1. Each team must have its own turbine. Teams cannot share a turbine
2. Power must be generated completely from the water pump flow.
3. You must have wires that allow for your water turbine to be hooked up to the Vernier Software that will display energy generation. Wire leads must be at least 10 feet in length.
4. Your device will be placed under load – KidWind generators will be tested using a 30-ohm load.
5. You cannot use pre-manufactured turbine blades or air foils.
6. Your current turbine must be "free standing" in the tank and not require your assistance during testing.

*Testing*

1. Teams will have a 15-minute window directly for device preparation and attachment to the mooring platform before their assigned testing window.
2. Each team will have 20 minutes for their assigned testing window. Testing will occur in a large current flume tank. Current is produced by powerheads that may provide current speeds up to 1m/s. A flow straightener will be positioned between the powerheads and the testing area.
3. The dimensions of the testing area is 36 inches wide by 36 inches long and 36 inches in depth.
4. The tank is made of fiberglass and steel with acrylic viewing windows and will be filled with freshwater.

5. Each team will have up to four testing trials to create the highest energy output from their device. Testing trials are 30 seconds in length. Teams are allowed to fine tune and adjust their device between each testing trial within the 20-minute testing window. The highest output recorded will be used in calculating your final score.
6. To receive full marks for functionality, your current turbine must be able to start producing power without external assistance once the flume is activated.
7. During each test trial, the current tank will be running constantly. We will collect power and energy output data from the 0–30 second mark of the testing trial. Your energy output score will be calculated using a Vernier data-logging system that collects voltage and amperage readings simultaneously while calculating total power produced over the 30 second testing period.

***How You Will Evaluated***

30% - Total Energy Generation
25% - Device Design and Creativity
30% - Written Documentation of Design and logistical plan for using the Gulf Stream as an energy source.
15% - Instant Challenges

*Total Energy Generation (30%)*

The highest energy output over the 30 second trial. Each team's energy output will be ranked relative to other competitors. Each team will receive points based on rank.

a. Rank Method – The highest producing turbine will receive full available points (30), and there is a 2 to 5-point deduction for each lower ranked turbine.

b. Ratio Method – Turbines ranked by energy output percentage. If top turbine produces 100 watts and receives 35 points, a turbine that produces 80 watts would receive 80% or 28 points.

*Device Design and Creativity (25%)*

This is a 15- minute interview conducted by NC Renewable Energy Challenge judges intended to gain a better understanding your design process. You should be prepared to discuss/defend your choices and the end design. Judges may ask:

a. What kind of challenges did you face when building your turbine?
b. How did you waterproof your device?
c. How did you determine pitch of the blades?
d. What materials did you use? Why? How did they work underwater?
e. Did you redesign your turbine during the process?

*Written Documentation (30%)*

Students need to have some type of written material to display their design processes and their knowledge of ocean energy, turbines and water characteristics. Please also include details about the logistics of capturing energy from the Gulf Stream. Consider how the energy is harnessed, moved, stored, etc. These plans allow lots of room for creative thinking. Each team

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can decide how to show their knowledge through reports, notebooks, blue prints, powerpoints, poster board or even video (4-minute maximum and you are required to provide all AV equipment).

*Instant Challenges (15%)*
These challenges do not require any preparation. They will include some kind of engineering activity and will add 15% to the final score. Many times, Instant Challenges use the ratio method for awarding points. In some cases, participation is enough to earn points.

**Resources**
1. North Carolina Renewable Ocean Energy Project – this website provides some details on the work being done in North Carolina to harness energy from ocean waves and currents. https://www.coastalstudiesinstitute.org/research/coastal-engineering/renewable-ocean-energy-project-overview/

2. Bureau of Ocean Energy Management (BOEM) Ocean Current Energy https://www.boem.gov/Ocean-Current-Energy/

3. BOEM Technology White Paper - https://www.boem.gov/Ocean-Current-White-Paper-2006/