**GENERAL OVERVIEW OF CURRICULUM CONCEPTS FOR Marine Energy**

The curricula will include an introduction to wave and wind marine energy; provide a basic framework of what constitutes energy production at sea; and offer interactive activities including building a prototype wave powered electricity generator. Our funding request includes the costs associated with writing a bilingual curriculum in English and Spanish.

Scaled model $75 a student.

Bring speaker from Marathon, Ecowave, Oregon State University OSU Marine Pacific Energy Center - Ted Brekken, Bryson Robertson, Sarah Henkel. PacWave south, live chat.

**Section One – Introduction to Renewable Marine Energy**

**Week One – What is Renewable Marine Energy?**

Energy that can be captured from winds, waves, tides, and currents.

What creates all of these energy forms? - Description of wind, waves, tides and currents.

Wind lesson. Wave lesson. Tides lesson. Sea current lesson.

-NGSS: 1-PS4-1 Waves and Their Applications in Technologies for Information Transfer: Plan and

conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate (K-2)

-NGSSL MS-PS4-2 Waves and their Applications in Technologies for Info. Transfer: Develop and use a model to describe that wave are reflected, absorbed, or transmitted through various materials (Middle School 6-8)

Basics of Electricity, how to make the smallest mini - generator in the world.

**Week Two – Why is Marine Energy important?**

We need to move from carbon based to non-carbon-based energy.

The ocean exerts tremendous amounts of power which can be utilized as a renewable resource. The United States has the potential to generate more than half of the energy generated in the US in 2020 using marine energy.

Greenhouse effect and ocean acidification is much worse than wave energy installation.​

Advantages of wave energy​

1. Zero emissions​

Inherently, marine energy does not emit greenhouse gasses when generated, like fossil fuels do. ​

Turbines generate electricity through the power of waves, tides and currents making them a completely pollution-free, renewable energy source.​

If we can get the technology right, tidal power can be a huge part of the green energy mix, complementing solar power, wind turbines, geothermal, and hydropower.​

2. Renewable​

Like all alternative energy sources, marine energy is renewable. ​

Waves are created by wind, and wind is caused by uneven heat on the planet's surface driven mostly by the sun warming different locations at different rates. ​

Wind moves heat energy from one part of the planet to another, which causes waves to form. Because wind will always exist, waves will always be available at the surface of the water to generate electricity, making this a renewable source.

So, as you are harnessing energy from the changing tides, you don’t decrease the amount of energy the tides can produce in the future. The gravitational pull from the sun and the moon, which controls the tides, won’t cease to exist anytime soon.

3. Enormous energy potential​

The amount of kinetic energy that is exerted in a wave is huge - that energy then gets captured by wave energy converters to produce electricity. ​

For example, an average 4-foot, 10-second wave can put out [35,000 horsepower](https://www.oceanenergycouncil.com/ocean-energy/wave-energy/) per mile of coast. The ocean provides a lot of potential for energy production because it is constantly moving and generating energy.​

Tidal power plants are able to produce high amounts of electricity. One of the main reasons for this is because water is so dense - almost 800 times more dense than air. ​

This means that a tidal turbine will produce substantially more energy than a wind turbine of the same size. ​

Plus, even when water is moving at low speeds, the density of water allows it to power a turbine. So, tidal turbines have the potential to produce large amounts of electricity even if the conditions of the water aren’t ideal.

There is also a lot of potential because many countries have access to an ocean that can help power their electric grids.​

4. Reliable and predictable energy source​

Waves are hardly interrupted and almost always in motion. This makes electricity generation from wave energy a more reliable energy source compared to wind power, since wind is not constantly blowing. ​

Tidal currents are highly predictable. Low and high tides follow well-known cycles, making it easier to know when power will be produced throughout the day. ​

It also makes it easy to know how much power will be produced by turbines, since the power of the tides and currents can be forecasted accurately.

It should be noted that the amount of energy that is being transported through waves does vary every year, and from season to season. Generally, waves are more active in the winter because of the increased wind, which is due to colder temperatures.

**Week Three – What are the challenges to Marine Energy?**

Disadvantages of wave energy​

1. Environmental effects​

Because wave energy is still in its infancy, mostly in research, there is no measure of the environmental effects of large-scale power stations on the shore. ​

Building plants or electrical wires directly on the beach might prove challenging because they would be unsightly and can cause damage to marine life and the surrounding ecosystems. ​

Local fishing zones could be affected, or the plants could lead to more coastal corrosion. However, more research is needed to determine the true environmental impacts that wave energy plants could cause. ​

2. High costs​

Wave power is an emerging energy technology in the early stages of development, making speculating on costs difficult. ​

Wave energy systems have the potential to be as cheap as [$07.5 cents per kWh](https://www.oceanenergycouncil.com/ocean-energy/wave-energy/)to build, but will depend on location and maintenance costs. However, at the moment, the costs of wave power are generally very high because they are in the research phase of development and generally paid for by [government grants](https://www.offshore-energy.biz/united-states-grants-27-million-to-bring-wave-energy-tech-to-market/) or research grants. There are no energy companies utilizing wave energy at scale - something which would bring the cost down.​

Maintenance for these plants is projected to be very expensive because they will be submerged in constantly moving saltwater. Because constant movement can lead to more breaking, wave energy plants will most likely need regular (and costly) maintenance.

3. Hard to scale​

Perhaps the biggest con now is that no utility can install wave farms because they are not yet large enough to provide a significant amount of electricity. ​

While some wave energy systems have been tested in Scotland, Hawaii, and most recently, Australia, their power generation capacity is only about 2.5MW at their peak. The industry is expected to grow, but it remains challenging to implement wave energy generators at a usable scale.​

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For many ocean-bordering countries, wave energy could be a great addition to the renewable energy mix. ​

Waves would provide 24/7 energy that could be harnessed for clean electricity generation. Because wave energy is still in its early stages, it remains expensive to install and the potential environmental disadvantages are not yet fully known. ​

The bottom line is that wave power has enormous global potential. However, the industry needs more funding and research to finalize the technology involved so that countries and utilities can begin adding wave energy to their renewable energy arsenal.

Disadvantages of tidal energy​

1. Limited installation sites​

For a tidal power plant to be built, the potential installation site must meet very specific requirements. First, they need to be located on a coastline, which limits potential station sites to coastal states. ​

There are additional requirements a potential site must meet. For example, tidal power stations need to be built in places where the difference in height between high and low tide is significant enough to power turbines. ​

This limits where the power stations can be installed, making it difficult for tidal power to be implemented widely. ​

2. Expensive​

One of the biggest drawbacks to tidal power is the high upfront costs. Tidal energy turbines need to be much sturdier than wind turbines, because of the high density of water. The cost of constructing a tidal power generation plant varies depending on what type of technology they use. ​

Most of the tidal power plants that are currently in operation are made of tidal barrages, which are essentially low-walled dams. The construction of a tidal barrage is extremely expensive, since a whole concrete structure - plus turbines - needs to be put in place. ​

The cost barrier is one of the main reasons why tidal power has been slow to be adopted.

3. Environmental effects​

Just because tidal energy is renewable doesn’t mean it is completely environmentally friendly. The construction of tidal energy power stations can have a substantial impact on the surrounding ecosystem. ​

Tidal turbines have the same issue that wind turbines face with birds - marine life collisions. As turbines spin, fish and other sea life could swim into the blades leading to serious injury or death. Tidal turbines also create low level noise beneath the surface of the water that negatively impacts marine mammals, like seals. ​

Tidal barrages have an even larger impact on the local environment. Not only do they cause the same problems that turbines do on their own, but they also have a similar impact that dams have. Tidal barrages prevent the migration of fish, and cause flooding of surrounding areas that forever changes the landscape. ​

4. Energy demand​

While tidal power does have predictable power generation, it doesn’t have constant power production. We can know exactly when the tidal power plant will generate electricity, but that electrical generation might not match up with the demand for energy. ​

For example, if high tide is at noon, the tidal electricity will be produced around noon. Peak energy demand is usually in the morning and the evenings, with the lowest energy demand in the middle of the day. ​

So, the tidal power plant will produce all of this electricity, but it won’t be needed. So, tidal power would realistically need to be paired with battery storage to make the most out of the energy it produces.

The future of tidal power​

Tidal power has huge potential, especially as new technologies, like dynamic tidal power continue to be developed. ​

Currently, there are less than ten tidal power stations in operation globally. The two most popular tidal power plants, Rance Tidal Power Plant, and Sihwa Lake Tidal Power Station produce enough tidal energy to power 94,507 homes in the United States for an entire year. Not only is that a substantial amount of power, but the power also produced is predictable, and carbon-free.​

However, tidal power plants can have a substantial impact on the surrounding ecosystem, high upfront costs, and there are limited suitable sites for them. Hopefully, as technology continues to improve, we will be able to take advantage of the energy stored within the tides.

-NGSSL HS-LS2-7 Ecosystems: interactions, Energy, and Dynamics: design evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity (High School 9-12)

**Section Two – Marine Energy in Practice**

**Week Four – How do we capture Marine Energy?**

Wave Energy​

The natural up-and-down motion of ocean waves generates large volumes of kinetic energy. Wave energy devices capture this motion and convert it into electricity.​

Some wave energy devices look like ocean buoys that bob up and down. Others string together a long, snake-lake chain of floating tubes. They can work close to land or farther out in the open ocean.​

Wave energy is plentiful, but it’s also problematic. Waves rise and fall in multiple directions, and their velocity changes with the weather. That can make it difficult to get a reliable constant stream of energy. Also, only a few coastlines are optimal locations for wave-energy devices.​

The upside is that several prototype wave energy devices are already in the water, and they’re yielding clues on how to make wave energy more practical.​

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Tidal Energy​

Rising and falling tides generate substantial kinetic energy. The bigger the tide, the bigger the power potential. Tides rise and fall like clockwork, so tidal energy can provide a reliable stream of energy at specific times of day.​

Some tidal devices look like underwater wind turbines. Because water is so much denser than air, the turbines can turn relatively slowly and still produce a worthwhile stream of electricity. Another tidal technology creates dams that capture tidal waters and uses turbines to tap the flow, much like hydroelectric plants.​

Tidal energy’s impact on the subsea environment is a big unknown. Marine species may attach themselves to the devices, causing extra maintenance costs. Building tidal basins is expensive and disruptive as well. And large numbers of subsea turbines can affect the velocity of tides, which could shake up delicate undersea ecosystems.

Salinity Gradient Energy (SGE)​

Salinity gradient power exploits the energy produced when saltwater comes in contact with freshwater.​
The technology uses a membrane to separate saltwater from freshwater. One kind of SGE membrane generates an electrical current on its own, while another kind of SGE membrane produces pressure that can turn a turbine and generate electricity.​

These membranes anchor the technology. They must be extremely large to produce abundant volumes of energy. Right now they are very expensive and prone to fouling by algae and other aquatic life, but new companies are already trying out new membrane technologies. Innovations in nanotechnology could potentially make SGE economically viable.​

SGE could also work in wastewater plants to separate saline water and create electricity to help power the plant. That small-scale function could open the door to more substantial innovations that make the technology much more practical.​

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Ocean thermal energy conversion (OTEC)​

Water at the ocean’s surface is much warmer than water in the murky depths. OTEC uses this temperature gap to produce electricity.​

A complex system pumps water from up to a mile deep in the ocean. At the surface, a power station exploits the differences between hot and cold water to produce electric current. This requires no fossil fuel, and it can generate more energy than the pumping and production costs create.​

This technology works best in the tropics in areas where there is at least a 36-degree F (20 degrees C) difference between surface water and deep water. It also requires massive pipes to pump the cold water up. But the energy is extremely cheap once the power plant has been built, so it’s an intriguing option in a few specific areas of the globe.

Tidal kites are tethered to the seabed and carry a turbine below the wing. When the kite “flies” in a figure-eight shape in the tidal stream it maximizes the volume of water passing through the turbine.​

If you would attach a turbine to the kite and put it in the ocean, where a water current flows instead of the wind blowing,

Floating structures ​

For these systems, turbines are mounted to the underside of a floating platform or barge. They still tap the tidal currents, but for greatly reduced installation and maintenance costs.

Tidal barge or lagoon​

Involves building a specialized dam across the width of a river/estuary to take advantage of the change in the tide levels to produce power. A tidal lagoon works on the same principle, but the dam walls form a loop from the shore, rather than across the width of the river.​

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- Large environmental footprint upstream and downstream of the barrage. The footprint is reduced by using lagoons, but the environmental footprint is still significant​
- Visual Impact​
- Expensive​
- Long build period​
- Navigational impact

Tidal turbines Captures energy from the moving water in the tide using devices that look like underwater wind turbines. The flow of water causes the blades to spin and generate electricity.​

Rapid deployment, No visual impact, High reliability, High performance, environmentally friendly

How to make a super simple wave energy device[**here**](https://www.youtube.com/watch?v=5dK19QAqjgA)

-NGSS: 4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move (Grade 3-5)

-NGSS: 4-PS4-3 Generate and compare multiple solutions that use patterns to transfer information (Grade 3-5)

-NGSS: 4-PS3-2 Energy: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents

You tube demo video of wave energy conversion [here](https://www.youtube.com/watch?v=8miWW2QyN_4&t=1s)

You tube demo of tidal power [here](https://www.youtube.com/watch?v=VkTRcTyDSyk)

**Week Five – What is the value of Marine Energy**

* Is a clean energy resource and will be able to help countries in the transition to a 100% renewable energy economy ​
* Marine energy can harvest essential power to hard-to-reach communities ​
* It is a very predictable energy source due to the cyclical nature of waves, tides, and currents​
* Has the potential to provide 57% of U.S. electricity needs ​
* The grid value is not well-known due to the low amount of real-world deployments ​
* What is grid value?​

     ~Provision of a defined grid service, measurable benefit to grid performance, avoided costs to system investments or operations, revenue capture, and contribution to desired grid qualities

-NGSS: MS-ESS2-4 Earth and Human Activity: Construct an argument supported by evidence for

how increases in human population and per-capita consumption of natural resources impact

Earth’s systems (Middle School 6-8)

**Week Six – What is the history of Marine energy? What are the environmental or health issues?**

**Section Three – Marine Energy in business**

-NGSS: HS-ESS3-2 Earth and Human Activity: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios (High School 9-12)

**Week Seven – How do we start and develop a Marine Energy installation?**

Small scale right now - single technologies, no farms right now. Offshore outside of breaking waves. OSU PacWave deployments to test

Marine Energy management Fortune article [here](https://fortune.com/2021/09/28/wave-energy-upstarts/)

**Week Eight – Marine Energy and regulations and laws**

* The international Electrotechnician Commission is an international organization that publishes standards on all technologies related to electricity and electronics, which includes marine renewable energy devices ​

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* In 2007 established the IEC TC 114, Marine Energy – Wave, tidal and other water current convertors "to develop international, consensus-based standards for the marine energy industry" ​

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* The technical committee created standards that address: terminology, management plans and project development, resource assessments, electrical interfaces, and much more ​
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* Energy Policy Act of 2005: granted the Bureau of Ocean Energy Management authority for marine renewable energy projects on federal offshore lands. This allows for the expansion of marine energy on a wider basis.

**Week Nine – Occupations and Education in Marine Energy**

* Port Workers: Logistics Specialist, Docking Pilot, Crane Operator etc. ​

     - Work as a link between land and sea, receiving, packaging and loading heavy equipment​

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* Hydropower engineer​

     - Work in the field and in an office on hydropower plants, tidal power plants, water treatment and irrigation projects​

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* Water Research Technician​

     -Works on projects related to climate change related impacts on water resources ​

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* Renewable Energy Underwriter​

     -Evaluate and assess policy applications, review and quote risks, and work on project management ​

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* Geomatician/Cartographer​

     -Create digital maps with data from observations in the field, statistical databases, and satellites in order to share and analyze the data

What education do you need to work in marine energy?​

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* Various Certifications ​

     ~ Wave and Tidal Certification, Marine Energy Certificate ​

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* Obtain a Bachelor's degree in a related field​

     ~ Any type of engineering degree, a degree in biology , chemistry or environmental science ​

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* Marine Mechanic School​

     ~ Marine Mechanic Training, Boat building,

**Week Ten – Marine Energy companies**

Use storm beach analogy, blow holes, breakwaters

What is Wave Energy capture [here](https://www.linquip.com/blog/the-ultimate-overview-of-wave-energy-diagram/)

-NGSS: MS-PS4-1 Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave (Middle School 6-8)

Submerged wave power buoy [here](https://awsocean.com/archimedes-waveswing/)

Tidal Energy Capture [here](http://www.reuk.co.uk/wordpress/tidal/introduction-to-tidal-power/)

Needs to be in 30-40 meters of water, cables running from power unit to shore, what are the environmental issues around this, cable on sea bed, or in water. What are the environmental issues around the actual power unit?

Power units are anchored to the seabed? Sandy sea bed compared to reef. What environmental issues do we want to tolerate to harness alternative energy.

Use small examples of solar power on calculators or lights, to panels on roofs as a comparison to developing marine energy.

**Introduction to Marine Energy through a STEM/STEAM club**