**Sandia Interactive Wave Energy Education Display (SIWEED)**

**Teachers Guide**

**Introduction:**

The Sandia Interactive Wave Energy Education Display (SIWEED) gives users a unique hands-on experience with wave energy. This interactive display comprises a small wave tank (about the size of fish tank), a wave maker, a small wave energy converter, and a small model town.

As students change the waves amplitude and frequency operating a graphic user interface, they observe how the energy generated by the wave energy converter (WEC) changes. The level of power generated is illustrated by the miniature town, which lights up as the generated power changes. This experience gives users a rare, up close opportunity to interact with marine hydro kinetic energy, and its possible applications to the blue economy.

There are a variety of science topics that relate to the SIWEED display. Regardless the grade level students can learn about wave energy in conjunction with grade appropriate science standards. The SIWEED display offers students a unique opportunity to see the practical applications of the sciences, learn about renewable energy, and engage hands on. The SIWEED display can be used to show basic science topics, like energy and waves, as well as introduce and start a discussion around climate change, renewable energy, and human impact.

Below is a list of teaching resources, relevant topics, and science standards. There are also premade slides giving an overview of wave energy and the wave tank, tailored to Elementary School, Middle School, and High School Students.

**Resources:**

**Videos:**

[Energy 101: Marine and Hydrokinetic Energy Video](https://www.youtube.com/watch?v=LXsuU_ZC56E), Department of Energy

* Great ~2-minute video giving an overview of waterpower. Appropriate for all grade levels.

[Advances in WEC Dynamics and Controls](https://www.youtube.com/watch?v=c4npWk_-Pjk), Sandia National Labs

* Overview of the controls research being done at Sandia

**General Information:**

[Marine and Hydrokinetic Glossary](https://www.energy.gov/eere/water/marine-and-hydrokinetic-technology-glossary), Department of Energy

* High level overview of the different types of devices

[Marine Energy Fact Sheet](https://www.energy.gov/sites/default/files/2021-05/EERE-water-MarineEnergy-Factsheet-FY21.pdf), Department of Energy

[Water Power Overview](https://celebrating200years.noaa.gov/magazine/wave_energy/welcome.html), National Oceanic and Atmospheric Administration

[Overview of the Marine Energy Industry](https://www.hydro.org/waterpower/marine-energy/), National Hydropower Association

* Good overview of relevant economic facts regarding Marine Hydro Kinetic Energy

[Advantages of Marine Energy](https://www.energy.gov/eere/water/advantages-marine-energy) ,Department of Energy

[Women of Water Power](https://www.energy.gov/eere/water/photos/women-water-power), Department of Energy

[Why is Marine Energy the Wave of the Future](https://www.climaterealityproject.org/blog/why-marine-energy-wave-future), Climate Reality Project

* Good overview of the advantages of MHK as well as some of the environmental concerns

**Lessons and Worksheets:**

[PRIMRE Educator Resources](https://openei.org/wiki/PRIMRE/STEM/Resources/Educator_Resources)

* Online database of lesson plans related to Ocean Energy

[Oak Ridge Institute for Science and Education, The Power of Waves Lesson Plan (grades 6-8)](https://orise.orau.gov/resources/k12/documents/lesson-plans/the-power-of-waves-final-version.pdf)

[Oregon State University, Wave Power and Generators Lesson Plan (Grades 6-8 and 9-12)](https://smile.oregonstate.edu/lesson/wave-power-and-generators)

[Department of Energy, Ocean Power Lesson Plan and Activities (Grades 5-8)](https://www.energy.gov/sites/default/files/2014/06/f16/ocean_power.pdf)

**Relevant Topics and Standards:**

Buoyancy

* The Wave Energy Converter can be used to illustrate the concept of buoyancy

Energy Conversion

* The wave tank demonstrates the transfer of kinetic energy into electricity.
* The wave tank demonstrates how kinetic energy is transferred from the waves to the WEC

Waves

* Students can change the frequency and amplitude of waves and then see the waves visually.
* Students can change the waves and see how much energy is then generated.

Generators and Motors

* The WEC is connected to a generator. As it bobs up and down power is created. This could be used to show students a real-life application of generators and motors.

Torque

* Torque controls on the WEC allow students to change the torque and see how the power output changes.

**Next Gen Science Standards:**

Elementary School

* [**K.Forces and Interactions: Pushes and Pulls**](https://www.nextgenscience.org/topic-arrangement/kforces-and-interactions-pushes-and-pulls)
* [**3.Forces and Interactions**](https://www.nextgenscience.org/topic-arrangement/3forces-and-interactions)
* [**4.Energy**](https://www.nextgenscience.org/topic-arrangement/4energy)
* [**4.Waves**](https://www.nextgenscience.org/topic-arrangement/4waves)

Middle School

* [**MS.Forces and Interactions**](https://www.nextgenscience.org/topic-arrangement/msforces-and-interactions)
* [**MS.Energy**](https://www.nextgenscience.org/topic-arrangement/msenergy)

High School

* [**HS.Forces and Interactions**](https://www.nextgenscience.org/topic-arrangement/hsforces-and-interactions)
* [**HS.Energy**](https://www.nextgenscience.org/topic-arrangement/hsenergy)
* [**HS.Waves and Electromagnetic Radiation**](https://www.nextgenscience.org/topic-arrangement/hswaves-and-electromagnetic-radiation)
* [**HS.Human Sustainability**](https://www.nextgenscience.org/topic-arrangement/hshuman-sustainability)

**Questions to Ask:**

**Basic Vocab List:**

This is a vocabular list of general principals relevant to the SIWEED. Discretion should used as to which topics and terms to include based on grade level.

**Hydropower** – Hydropower uses dams to convert the gravitational energy of water into electricity.

**Marine and Hydrokinetic Energy (MHK)** – MHK is the capture of energy from waves, tides, currents, and river flows. Unlike hydropower, MHK does not require building dams and/or diversions.

**Wave Energy Converter**

**Torque –** The rotational force. Put simply it is how hard an object is spun or twisted around a point.

**Buoyancy -**

**Buoy -**

**Wave Maker -**

**Amplitude -**

**Frequency -**

**Kinetic Energy -**

**Power -**

**Electricity -**

**Waves -**

**Tides -**

**Water Currents** – the bulk flow of the ocean

**Renewable Energy -**

**Wave Probe –**

**Wave Reflection -**

**Angular Velocity –** The speed at which something rotates on a particular axis of

**SIWEED Wave Worksheet**

Wave Energy Converters harvest the energy of waves, but not all waves are created equally. How do you think the size, shape, and frequency of the wave will impact the power harvested by the WEC?

|  |  |  |
| --- | --- | --- |
| **Table 1** |  |  |
|  | **Prediction** | **Describe Your Thinking** |
| **If the frequency increases what do you think will happen to the power produced by the WEC?** |  |  |
| **If the amplitude increases what do you think will happen to the power produced by the WEC?** |  |  |

With the wave maker in function mode change the amplitude and frequency of the wave maker. Observe the power meter and take note of how it changes.

**What happens when the frequency is low, and the amplitude is high?**

**What happens when the amplitude is high, and the frequency is low?**

**Can you find an ideal frequency and amplitude combination that creates the most power?**

**SIWEED Damping Worksheet**

Wave Energy Converters harvest the energy of waves. The amount of energy generated by a wave energy converter is not just dependent on the size of the waves, it also depends on how the wave energy converter responds to the waves. To increase the amount of power generated we use something called dampening.

**Before we get going on the WEC we are going to run a small experiment with just our hands.**

* For this experiment you are going to press and rub your hands together and record your observations below.
* You will run this experiment three times:
  1. Once with your hands pressed together as lightly as possible
  2. Once with medium pressure
  3. Once while pressing your hands together as hard as you can
* Take a break between each trial to ensure your hands can cool down.

|  |  |  |
| --- | --- | --- |
| **Table 1** |  |  |
|  | **How much heat did your hands produce?** | **How fast could you rub your hands together?** |
| **Pressing hands together as lightly as possible** |  |  |
| **Pressing hands together with medium pressure** |  |  |
| **Pressing hands together as hard as you can** |  |  |

**Which trial created the most heat?**

**Complete the sentence:**

As we press our hands together harder, we create \_\_\_\_\_\_\_\_\_\_\_ (more / less) heat but the speed at which we can rub our hands together \_\_\_\_\_\_\_\_\_\_(increases / decreases).

**The heat from our hands is like the power produced by the WEC. The pressure we apply is equivalent to the damping we apply to the WEC.**

**Based on your observations above fill out your predictions for the WECs behavior.**

|  |  |  |
| --- | --- | --- |
| **Table 2** |  |  |
|  | **How much power will the WEC produce?** | **How fast will the WEC move up and down?** |
| **Low damping** |  |  |
| **Medium damping** |  |  |
| **High damping** |  |  |

**Now run an experiment! While keeping the waves consistent change the damping of the WEC and see how the speed and power of the WEC change.**

|  |  |  |
| --- | --- | --- |
| **Table 3** |  |  |
|  | **How much power did the WEC produce?** | **How fast will the WEC move up and down?** |
| **Low damping** |  |  |
| **Medium damping** |  |  |
| **High damping** |  |  |

**What was the ideal damping to create the most power?**

**Do these results surprise you? Explain your answer**