Energetic Ocean

Program Type: Classroom Program	**Audience Type:** Grades 3–8

Description: Students will design a model offshore wind and wave energy farm to maximize the amount of energy the farm can produce.

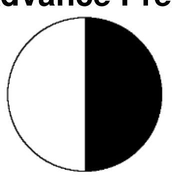
LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- Students will create a model of an offshore wind and wave energy farm using the benefits of wind turbines and wave energy converters to maximize energy output.
- Students will redesign their wind and wave energy farm based on various challenges such as migrating whales or shifting winds.

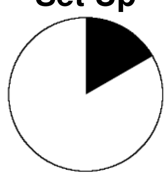
TIME REQUIRED

Advance Prep



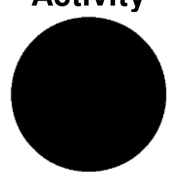
30 minutes

Set Up



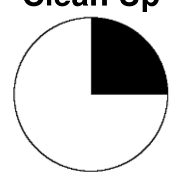
10 minutes

Activity



60-80 minutes*

Clean Up



15 minutes

* This activity can be adapted for a variety of student group abilities. See *Extension* for advanced variations.

SITE REQUIREMENTS

- Table space for each group of 3–5 students
- Power outlet near each table

PROGRAM FORMAT

Segment	Format	Time
Introduction	Large group discussion	10 min
Design, Test, Improve	Group activity	40-60 min
Wrap-Up	Large group discussion	10 min

SUPPLIES

Permanent Supplies	Amount	Notes
Cups	4/group	To elevate pegboard from the surface; sturdy paper or plastic cups work well
Pegboard	1/group	Approximately 24”x18” (with 1/8” holes 1” apart). *(*See Supply Note)*
Fan	1/group	Any electric fan. Will work best if it is at least 10 inches in diameter
Pinwheels	8–10/group	6” or larger Mylar pinwheels work best. **See note*
K’Nex®	16–20 rods and 8–10 round connectors/group	If possible, rods should be different lengths
Wave energy converter cutouts	6–8/group	See the *Appendix*
“How Much Does Energy Cost?” Worksheet	1/group	See the *Appendix*
“What We Know About…” Table	1/group	See the *Appendix*
Challenge Cards	3-5 sets	See the *Appendix*
Challenge Obstacles	1/group	See the *Appendix*
Sticky tack	1 pack	Or any firm but easily removable adhesive (even rolled pieces of tape)
Ruler at least 12” long	1/group	*(Optional)*
Scissors	1	For advance prep only
Painters tape or blue permanent marker	1	*(Optional)* for advance prep
Vis-à-vis (overhead projector) pens	1/group	*(Optional)* See advance prep
Meet an Engineer Video – Caity Clark	1	*(Optional)* Found on USB flash drive provided with manual and website listed in *Advanced Prep*
Computer, projector screen	1	*(Optional)* to show video
Laminator	1	*(Optional)*

**Note on Supplies:*

- Mylar pinwheels can be bought online from a variety of retailers. We found the ones from Century Novelty worked well. https://centurynovelty.com/products/jumbo-mylar-pinwheel
- Pegboard can be found at most hardware stores, usually sold in 4’x8’ sheets. Often, store employees are able to cut it on-site. Cut the sheet once the long way, to make two long strips, each 24” wide. Then cut each strip into five pieces approximately 19” wide, for a total of 10 pieces. **You can reuse the same pieces of pegboard for Smooth Travels, another engineering activity in the Designing Our World curriculum.**

ADVANCE PREPARATION

- Read the *Background Information* section at the end of this outline to familiarize yourself with the research that inspired this activity.
- Mark a "wave zone" on the pegboard by coloring with permanent marker or marking it with tape (make sure the tape doesn't cover the holes). The wave zone can be any shape, but is best if it is wider in the front (near the fan). Larger wave zones are generally more difficult. To broaden options, each side of the pegboard can have a different wave zone demarcation for varied challenge levels. You may choose to make all wave zones identical, or give each group a different design.

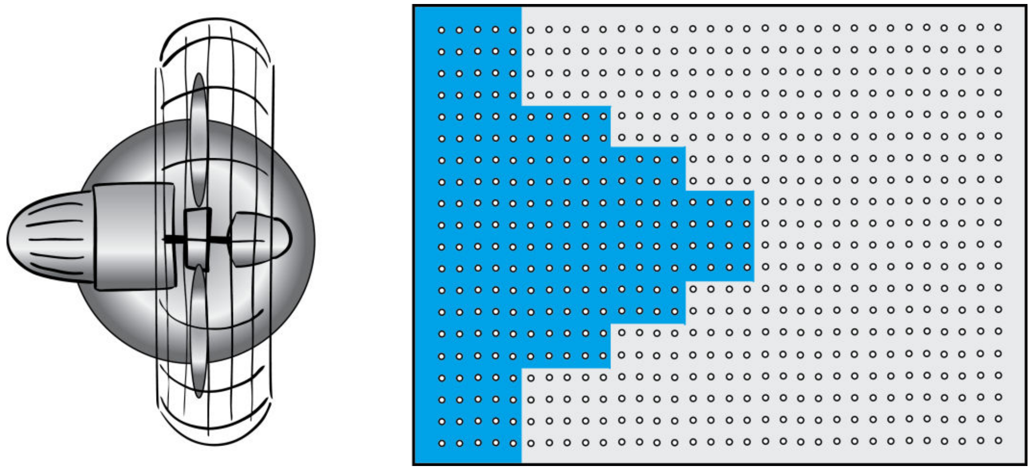


Figure 1: Possible wave zone shown in blue.

- Print and cut out materials (see Appendix). Laminate if desired:
    - Challenge Cards (3-5 sets total)
    - Challenge Obstacles (1 set per group)
    - Wave energy converter cutouts (6-8 per group)
    - Data sheets (1 per group) – If laminated, students can write and erase using Vis-à-vis overhead pens.
    - "What We Know About…" table (1 per group)
- Prepare the projector and computer to show the *Meet an Engineer Video – Caity Clark* found on the USB flash drive provided with this manual (if applicable), or at https://vimeo.com/254363516/9c385a2ef8
- If you can't show video to students, watch on your own for reference.

SET UP

- Prop up one pegboard per group using the cups. See the diagram below for a visual guide.
- Face pegboard so the wave zone is closest to fan.

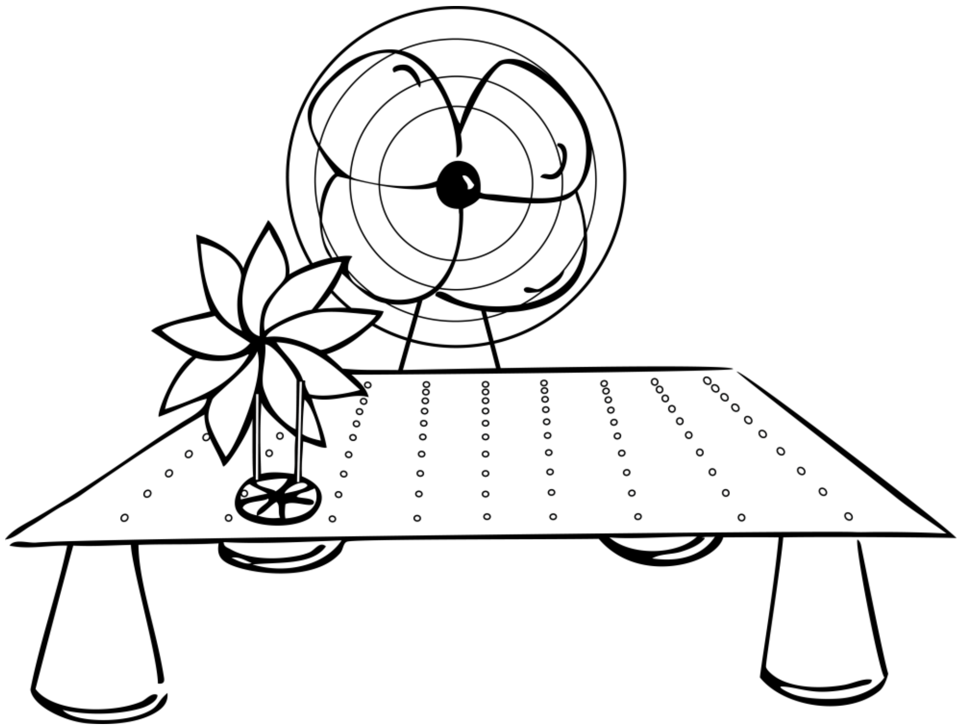


Figure 2: Example setup of the pegboard raised using cups.

- Arrange each table so there is an outlet nearby where the fan can be plugged in safely. Set a fan on each table and plug them in. Alternatively, have a testing station with one or more fans where students can bring their pegboards when they are ready to test their design. Create a raised surface at the testing station with cups.
- Distribute building materials to each table. Each group should get:
    - 20 K'Nex® rods of various sizes
    - 8–10 K'Nex® connectors
    - 8–10 pinwheels
    - 6–8 wave energy converter cutouts

INTRODUCTION

10 minutes

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

We use energy like electricity all the time without thinking about it. Phones, lights, cars, and refrigerators are just some of the things that we use on a daily basis. Where does all this electricity come from? There are three main categories for the energy that makes electricity: fossil fuels, nuclear energy, and renewable energy. Today we are going to focus on renewable energy.

What do you think sets this kind of energy apart from fossil fuels and nuclear energy? *It's environmentally friendly, sustainable*

What are some renewable energy sources? *Wind, solar, water, geothermal*

We are going to watch a short video of an engineer, Caity, explaining the work she does to help create more opportunities for renewable energy resources.

Show video if computer and screen are available. Otherwise, explain the main points from the video to students.

What two energy sources does Caity discuss?
Wind and wave energy

Where are these wind and wave energy farms located? *In the ocean (offshore)*

Why do wind turbines and wave energy converters work so well together? *Wave energy converters protect turbines from wave forces if placed in front of them, and wind turbines can still collect wind energy behind the wave energy converter to maximize space.*

Today you are going to engineer a model offshore energy farm where wind turbines above the water can be combined with wave energy converters in the water to gather even more energy from our energetic ocean.

GROUP ACTIVITY

Design, Test, Improve

40-60 minutes

Divide students into groups of 3–5. Introduce the materials and activity goals.

Here is your model ocean.

Show pegboard.

The blue area is what we call the wave zone, where waves are the strongest. These pinwheels represent the wind turbines, and these paper cutouts represent the wave energy converters.

Show each material.

You must decide where to place your turbines and wave energy converters to generate the most energy for the least cost.

Depending on the group, you may choose to demonstrate how to secure the pinwheels to the board with the K'Nex® for more stability and adjustability, or to let students figure this out on their own. See the diagram below for one way to assemble K'Nex® without spinning.

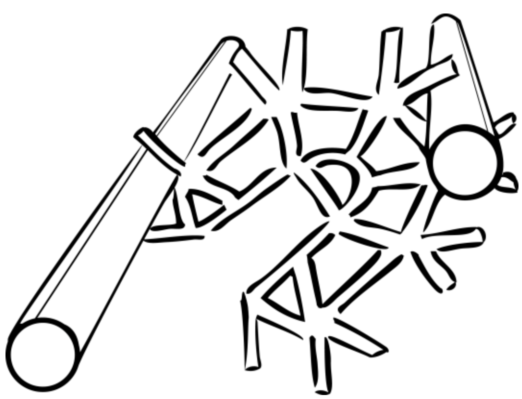


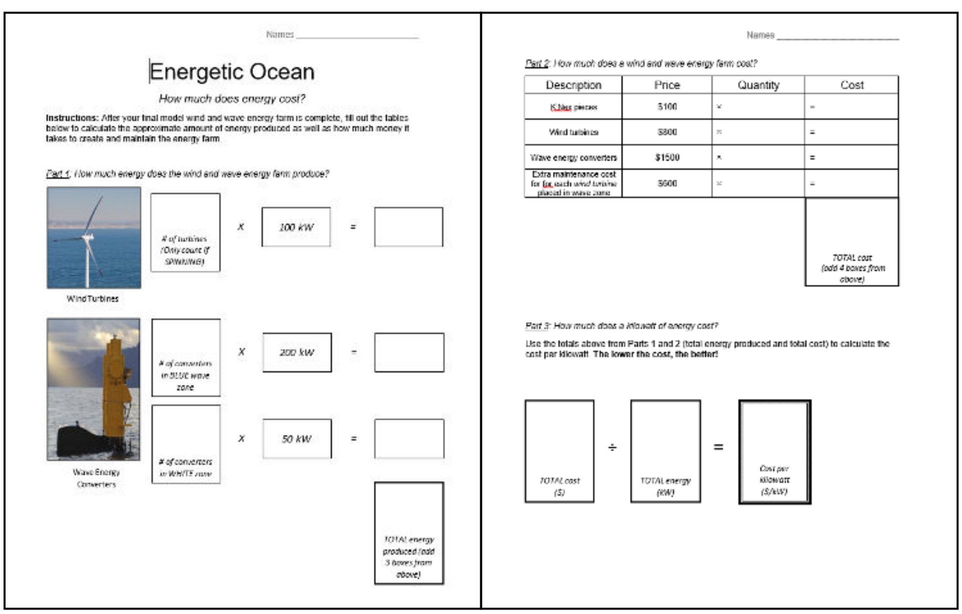
Figure 3: How to set up the K'Nex® so the pinwheels stay secure in the pegboard.

Your goal is to create as much energy as possible using these model wind and wave energy converters. Lets go over some important facts about wind turbines and wave energy converters before we begin our activity.

Hand out one copy of the *"What We Know About…"* table below to each group (See the *Appendix for full printable in English and Spanish)* and lead a discussion about what is the most important information to consider when designing an offshore energy farm. Complement the bullet points in the table with what you read in the *Background Information*. For students at a higher level of learning, you can read them the *Background Information* directly.

What we know about…	
Wind Turbines	***Wave Energy Converters***
• convert wind energy into electricity • don't affect the ocean waves • can block one another and not produce as much energy • allow for more effective maintenance when placed behind a wave energy converter, which leads to lower costs • can collect wind energy inside or outside the wave zone • produce more energy and fail less when they have a straight stream of fast air • will produce the same amount of energy with a wave energy converter placed in front • need to be anchored to the ocean floor	• convert energy from the "motion of the ocean" into electricity • don't affect the wind • protect wind turbines from waves, allowing maintenance crews easier access to wind turbines for repairs, even in high wave weather • work best when placed inside the wave zone, where the wave energy is greatest • absorb wave energy and consequently make smaller waves behind them

As you are testing out your ocean power plans, you will record your results on this data sheet.



Names ____________________

Energetic Ocean

How much does energy cost?

Instructions: After your final model wind and wave energy farm is complete, fill out the tables below to calculate the approximate amount of energy produced as well as how much money it takes to create and maintain the energy farm.

Part 1: How much energy does the wind and wave energy farm produce?

Wind Turbines: *# of turbines (Only count if SPINNING)* × *100 kW* = ____

Wave Energy Converters: *# of converters in BLUE wave zone* × *200 kW* = ____

# of converters in WHITE zone × *50 kW* = ____

TOTAL energy produced (add 3 boxes from above)

Names ____________________

Part 2: How much does a wind and wave energy farm cost?

Description	Price	Quantity	Cost
K'Nex pieces	$100	×	=
Wind turbines	$800	×	=
Wave energy converters	$1500	×	=
Extra maintenance cost for for each wind turbine placed in wave zone	$600	×	=
			TOTAL cost (add 4 boxes from above)

Part 3: How much does a kilowatt of energy cost?

Use the totals above from Parts 1 and 2 (total energy produced and total cost) to calculate the cost per kilowatt. **The lower the cost, the better!**

TOTAL cost ($) ÷ *TOTAL energy (kW)* = *Cost per kilowatt ($/kW)*

Pass out the Energetic Ocean worksheet: "How Much Does Energy Cost?" (See the *Appendix for full printable in English and Spanish).* In this worksheet, students will keep a record of the placement and success of their wind turbines and wave energy converters in order to determine the efficiency of their power plant. Remind students that the goal is produce the most energy for the lowest cost.

OPTIONAL VARIATIONS: For younger students—or if time is limited—eliminate the worksheet. Or, wait until the end and complete a single worksheet as a class, using one group's design as an example.

Optional discussion points before getting started:

- **Where is the best place for the wave energy converters?**
  In wave zone. In front of the wind turbine.

- **What about the wind turbines?**
  Outside of wave zone. Behind the wave energy converters.

- **How close can you place two turbines and have them both spin?**

- **How can you keep the wind turbines and wave energy converters from blocking one another?**

Allow students to build for 10-15 minutes. Set the speed of the fan to low or medium.

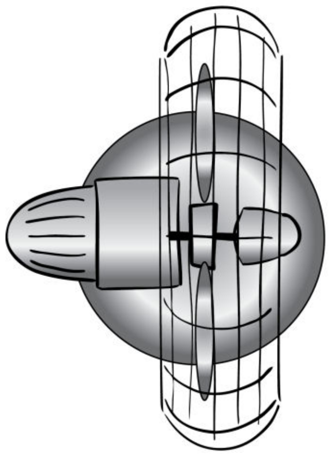
Design Challenges

After students have had some time to tinker with their designs, use the Challenge Cards found in the *Appendix*, to assign different challenges to each group depending on their current designs and/or the success of the group (e.g., if the design has very high windmills, give them the Bird Challenge card). The challenges don't have to be the same for every group. You may choose to give multiple challenges to groups working faster, or allow student groups to work through all the challenges at their own pace.

Explain the assigned challenge(s) to each group as you pass them their challenge card.

1) **Whale Migration:**

Whales migrate and travel great distances. Whales like to migrate through the area in which you are designing your wind farm. Redesign your farm to allow these whales to pass through safely without running into the turbines or wave energy converters.



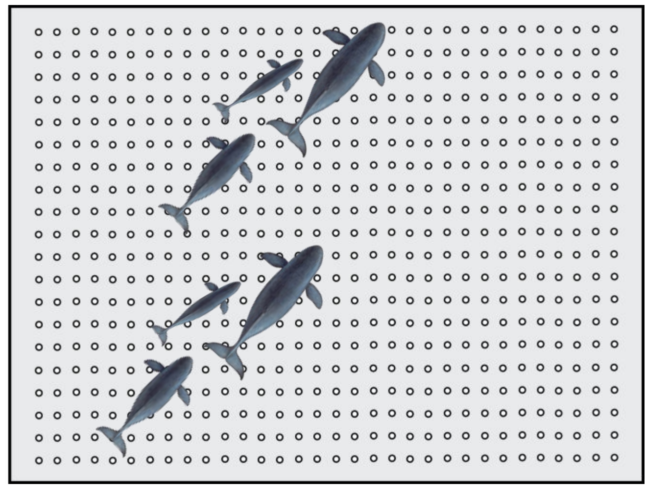


Figure 4: Example of whale migration challenge.

Using sticky tack, place laminated whale cutouts on the pegboard as shown in Figure 4. You may need to remove windmills and/or wave energy converters in the way of their migration paths and let students redesign that part of the model.

2) **Boulders:**

Some parts of the ocean floor are unsuitable for installing a wind turbine. The floor may be too unstable or not flat enough, and there may be big boulders in a part of your area that will prevent you from building there.

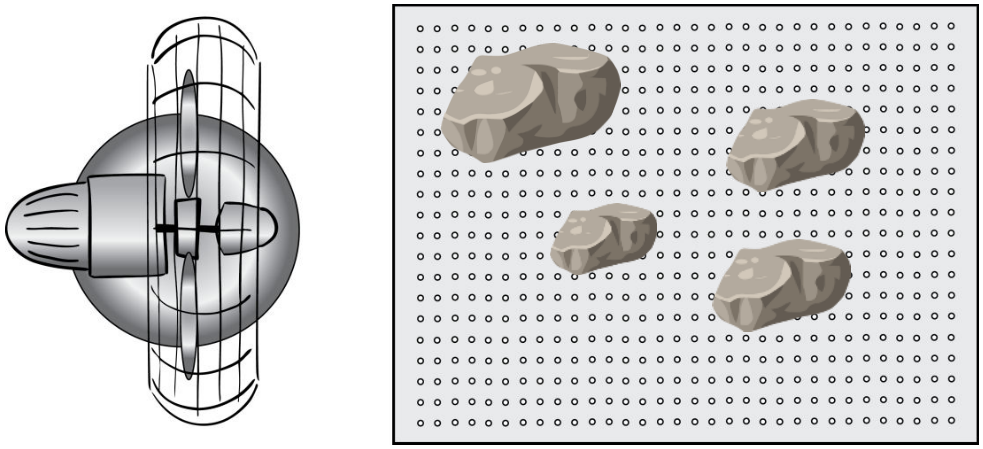


Figure 5: Example of boulder challenge.

Using sticky tack, place the laminated boulder cutouts on the pegboard similarly to the diagram shown in Figure 5. You may need to remove windmills and/or wave energy converters in the way.

3) **Birds**:
The area you have decided to build on has a lot of wind but it also is a favorite place for birds to ride the air current. In order to keep the birds from getting hurt and allow them to continue easily flying through the area, the top of all of your wind turbines must be shorter than 12”.

If rulers are not available, hold a piece of copy paper vertically to estimate the height (the long side of paper measures 11”).

4) **Shifting Wind**:
The direction of the wind can be affected by storms and temperature. As a result, wind direction can change with the seasons. Try redesigning your wind farm to maximize its efficiency in the face of seasons changing and wind shifting.

You can model the shifting wind by turning your fan to an angle. See Figure 6.

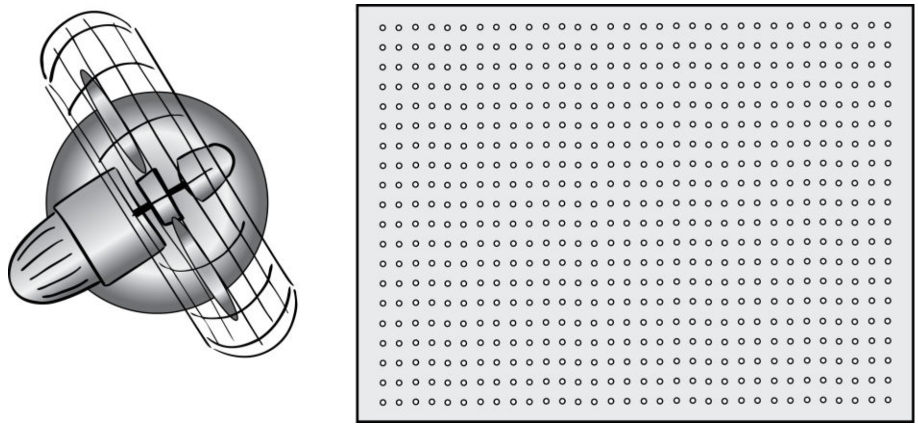


Figure 6: Example of fan placement for Shifting Winds challenge.

Move the fan so it is angled relative to the wave zone. If the fan has a rotating mode, you can use that instead.

WRAP-UP

10 minutes

When the groups are finished, host a final showcase to test all of the designs. **Before testing, let each group point out the notable aspects of their designs to the rest of the class.**

Test each power plan, looking at how many windmills and wave energy converters each group has set up and reviewing their efficiency on the "How Much Does Energy Cost?" worksheet.

Where are your wave energy converters and why did you arrange them that way?

Are all the wind turbines spinning at the same speed? Did the wind have to be stronger for some of them to turn?

How are your wave energy converters and wind turbines working together?

Why is it important to get our energy from sources like the wind and waves? Today, most things run on energy that comes from fossil fuels like coal and natural gas. Why should we change that and rely more on renewable energy?

Is it better to spend a lot of money making a wave energy converter able to withstand huge waves, or is it better to spend less money and put the wave energy converter in a place with smaller waves?

For an engineer, this kind of work involving competing objectives is fascinating. It's like a giant puzzle!

EXTENSION

Have students do their own research and determine the cost of different sources of energy. What are the "hidden costs" of non-renewable versus renewable energy sources?

CLEAN UP

5 minutes

Have students take apart their designs and return all materials where they found them

BACKGROUND INFORMATION

Wind and wave energy falls into a category of energy called **sustainable**, or **renewable**, energy. This category means that the source will not run out. Sustainable energy also releases significantly less pollutants than traditional energy sources.

Wind turbines convert wind into energy. Wind turbines produce more energy and fail less when they have a straight stream of fast air. However, when the turbines spin they decrease the speed of the wind as it passes, increasing turbulence so that any turbine in its **wake** produces less energy. A **wake** is the name for the area behind a turbine where there is decreased wind speed and increased turbulence.

Wave energy converters don't change the wind, and wind turbines don't change the waves (at least not enough to affect energy production). Therefore, a wind turbine will produce the same amount of energy when wave energy converters are put in front of it, but it will cost less to service each year. Plus, you get the additional energy from the wave energy converters!

Wave energy converters absorb wave energy and convert it to electricity. They can also protect turbines behind them from wave forces and wave-induced fatigue damage (or repetitive forces that cause failure over long periods of time). You would experience something similar to a turbine foundation and tower (the parts of the turbine in the water) if you were standing in the ocean or a river. You are feeling the repetitive force on your legs, and if someone were to stand in front of you, the person in front of you would feel the force instead, and protect you, so that you felt less force on your legs.

Absorbing wave energy also has ramifications for what we call "weather windows." When a turbine fails or needs maintenance, boats are only allowed to go service the turbine if the wave height is below 1.5 meters. As you can imagine, companies lose a lot of money watching a turbine not produce energy and waiting for a sunny day when the sea is calm to fix it. Placing wave energy converters to absorb wave energy reduces the wave height in these wind farms so that boats can go service the turbines more often (so instead of one day of fair weather, wave heights are reduced enough the day before and after the fair weather day that crews have three days to fix the turbine). This way, the wind turbine can produce energy and profit again more quickly and for a longer period of time. This latter point is particularly important for major repairs that take a lot of time to fix.

Background Information Courtesy of Caitlyn Clark, Doctoral Student of Mechanical Engineering at Oregon State University

Figure 7: Offshore wind farm. (Photo: viladetora.net).

Figure 8: Wave power technology in Scotland. (Image: waveenergyconsortium.com).

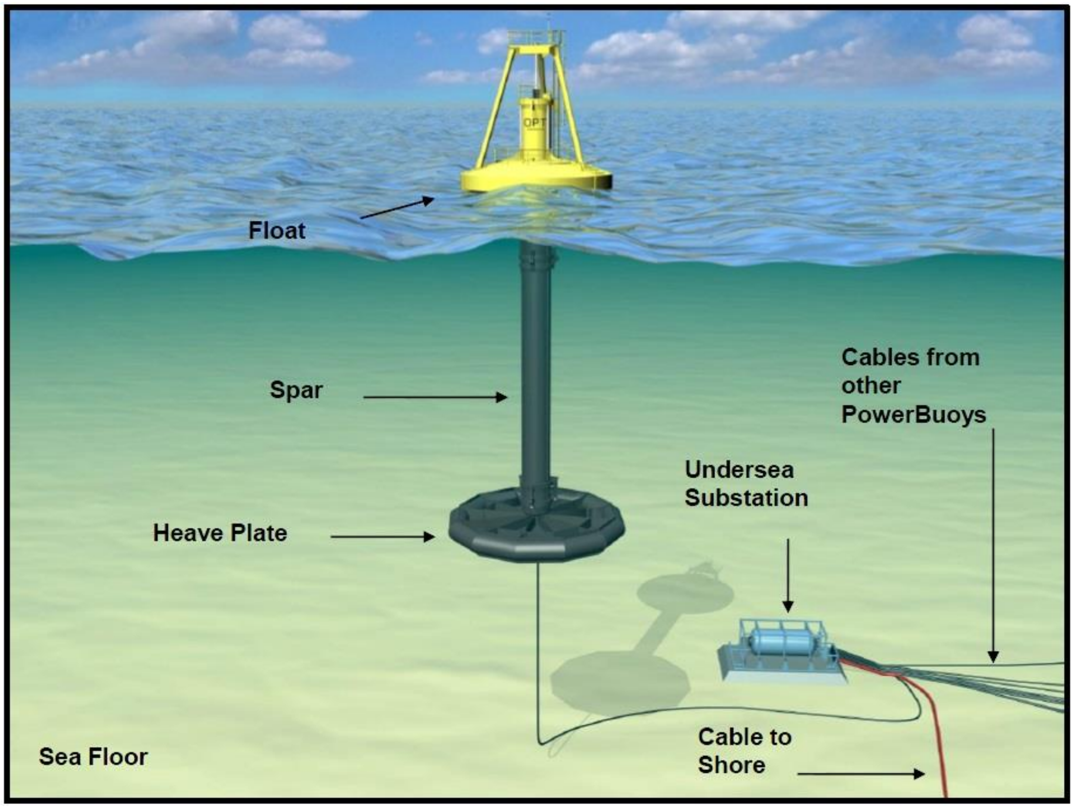


Figure 9: An example of a wave energy converter. (Image: oceanenergy.wikidot.com).

GLOSSARY

Offshore wind energy	The use of wind farms constructed offshore to harvest wind energy to generate electricity.
Renewable/sustainable energy	Energy that is essentially unlimited, without being reduced by the process of harvesting it (e.g., wave power, sunlight).
Wind turbine	A device that converts the wind's kinetic energy into electrical energy.
Wave energy converter	Technology that uses the motion of ocean surface waves to create electricity.
Weather windows	Periods of time when the weather is cooperative and wave swells are at a safe height for maintenance workers to get to a device that needs repair.

NEXT GENERATION SCIENCE STANDARDS

	Practices
✓	Asking questions and defining problems
✓	Developing and using models
✓	Planning and carrying out investigations
	Analyzing and interpreting data
	Using mathematics and computational thinking
✓	Constructing explanations and designing solutions
	Engaging in argument from evidence
✓	Obtaining, evaluating, and communicating information

	Crosscutting Concepts
	Patterns
✓	Cause and effect
	Scale, proportion, and quantity
✓	Systems and system models
	Energy and matter
	Structure and function
	Stability and change

	Disciplinary Core Idea	3	4	5	MS
	Physical Science				
PS1	Matter and Its Interaction	n/a	n/a		
PS2	Motion and Stability: Forces and Interactions		n/a		
PS3	Energy	n/a			
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	
	Life Science				
LS1	From molecules to organisms: Structures and processes				
LS2	Ecosystems: Interactions, Energy, and Dynamics		n/a		
LS3	Heredity: Inheritance and Variation of Traits		n/a	n/a	
LS4	Biological Evolution: Unity and Diversity		n/a	n/a	
	Earth & Space Science				
ESS1	Earth's Place in the Universe	n/a			
ESS2	Earth's Systems				
ESS3	Earth and Human Activity		✓	✓	
	Engineering, Technology, and Applications of Science				
ETS1	Engineering Design	✓	✓	✓	✓

<u>DCI Grade Band Endpoints</u>

3-5 ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (By the end of Grade 5)

3-5 ETS1.B: Developing Possible Solutions

- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (By the end of Grade 5)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (By the end of Grade 5)
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (By the end of Grade 5)

3-5 ETS1.C: Optimizing the Design Solution

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (By the end of Grade 5)

MS ETS1.A: Defining and Delimiting Engineering Problems

- The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (By the end of Grade 8)

MS ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (By the end of Grade 8)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (By the end of Grade 8)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (By the end of Grade 8)
- Models of all kinds are important for testing solutions. (By the end of Grade 8)

MS ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (By the end of Grade 8)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (By the end of Grade 8)

3-5 ESS3.C: Human Impacts on Earth Systems

- Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. For example, they are treating sewage, reducing the amounts of materials they use, and regulating sources of pollution such as emissions from factories and power plants or the runoff from agricultural activities. (By the end of Grade 5)

Performance Expectations

3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
5-ESS3-1	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

<u>Energetic Ocean</u>
Appendix

What we know about…	
Wind Turbines	***Wave Energy Converters***
• convert wind energy into electricity • don't affect the ocean waves • can block one another and not produce as much energy • allow for more effective maintenance when placed behind a wave energy converter, which leads to lower costs • can collect wind energy inside or outside the wave zone • produce more energy and fail less when they have a straight stream of fast air • will produce the same amount of energy with a wave energy converter placed in front • need to be anchored to the ocean floor	• convert energy from the "motion of the ocean" into electricity • don't affect the wind • protect wind turbines from waves, allowing maintenance crews easier access to wind turbines for repairs, even in high wave weather • work best when placed inside the wave zone, where the wave energy is greatest • absorb wave energy and consequently make smaller waves behind them

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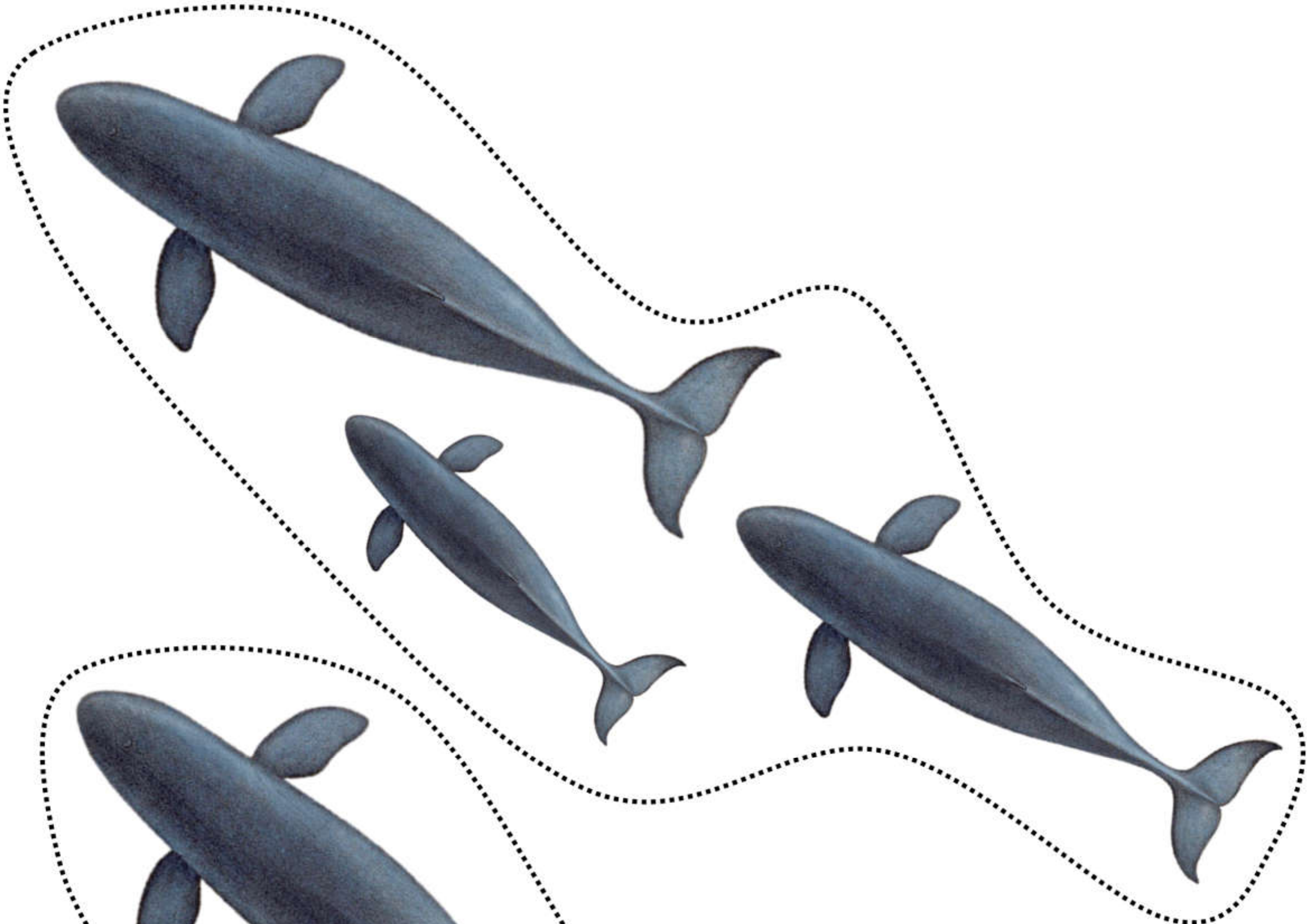
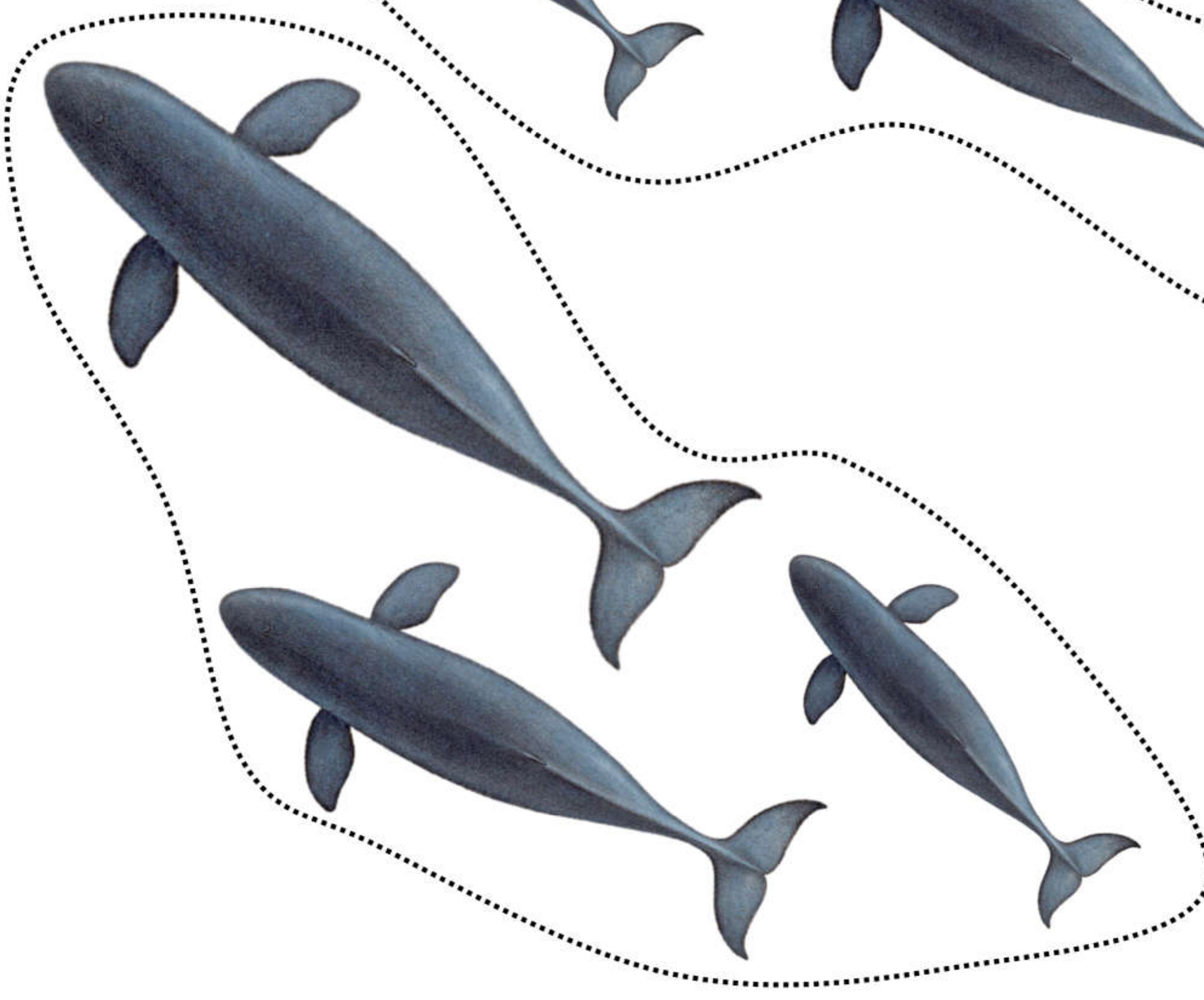
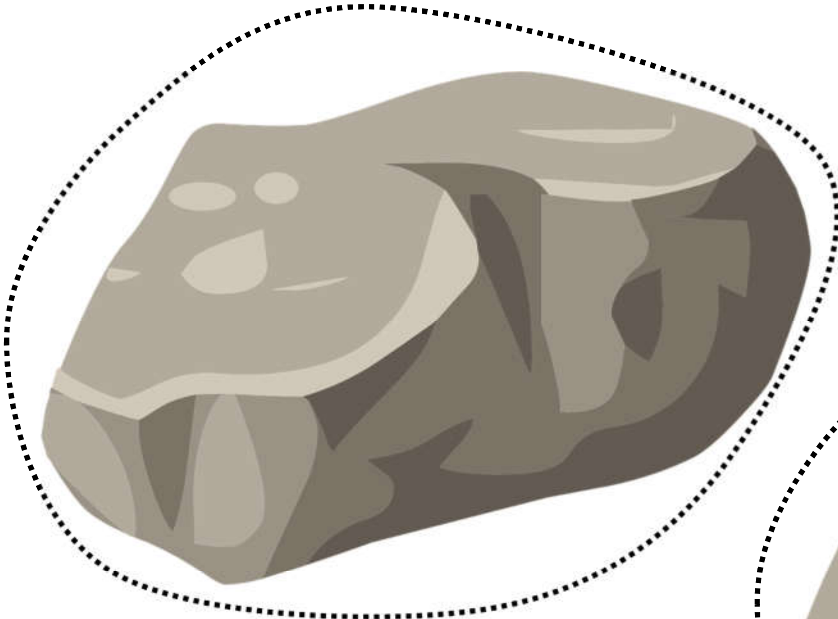
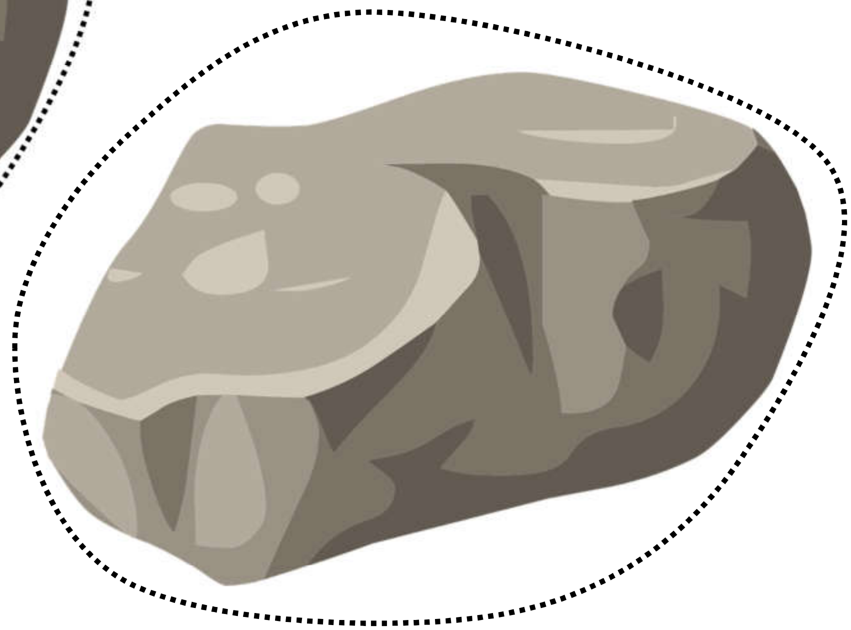
Qué sabemos sobre…	
Turbinas eólicas	***Convertidores de energía de olas***
• transforman la energía del viento en electricidad • no afectan el oleaje • se pueden bloquear entre ellas y no producir tanta energía • su mantención es más fácil cuando se colocan detrás de un convertidor de energía de olas, lo que significa un gasto menor • pueden funcionar tanto dentro como fuera de la zona de oleaje • producen más energía y fallan menos cuando tienen una corriente directa de viento rápido • los convertidores de energía de olas no afectan su eficacia • deben estar ancladas al suelo marino	• transforman la energía del movimiento del mar en electricidad • no afectan el viento • protegen a las turbinas eólicas del oleaje, lo que les permite a los equipos de mantención reparar las turbinas más fácilmente, aun cuando hay alto oleaje • funcionan mejor cuando se colocan dentro de la zona de oleaje, donde la energía de olas es mayor • absorben la energía de las olas y por consecuente crean olas más pequeñas detrás

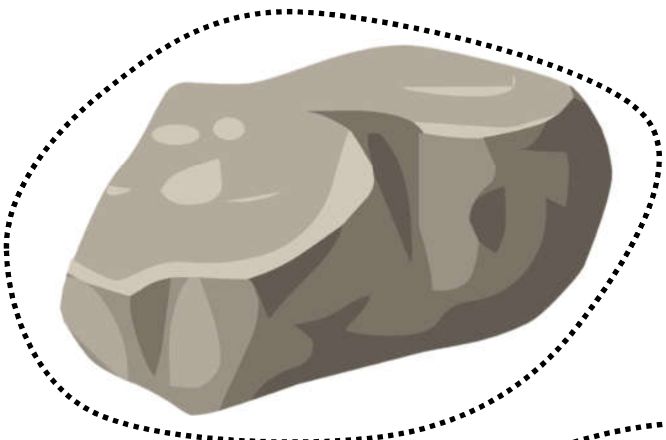
Qué sabemos sobre…	
Turbinas eólicas	***Convertidores de energía de olas***
• transforman la energía del viento en electricidad • no afectan el oleaje • se pueden bloquear entre ellas y no producir tanta energía • su mantención es más fácil cuando se colocan detrás de un convertidor de energía de olas, lo que significa un gasto menor • pueden funcionar tanto dentro como fuera de la zona de oleaje • producen más energía y fallan menos cuando tienen una corriente directa de viento rápido • los convertidores de energía de olas no afectan su eficacia • deben estar ancladas al suelo marino	• transforman la energía del movimiento del mar en electricidad • no afectan el viento • protegen a las turbinas eólicas del oleaje, lo que les permite a los equipos de mantención reparar las turbinas más fácilmente, aun cuando hay alto oleaje • funcionan mejor cuando se colocan dentro de la zona de oleaje, donde la energía de olas es mayor • absorben la energía de las olas y por consecuente crean olas más pequeñas detrás

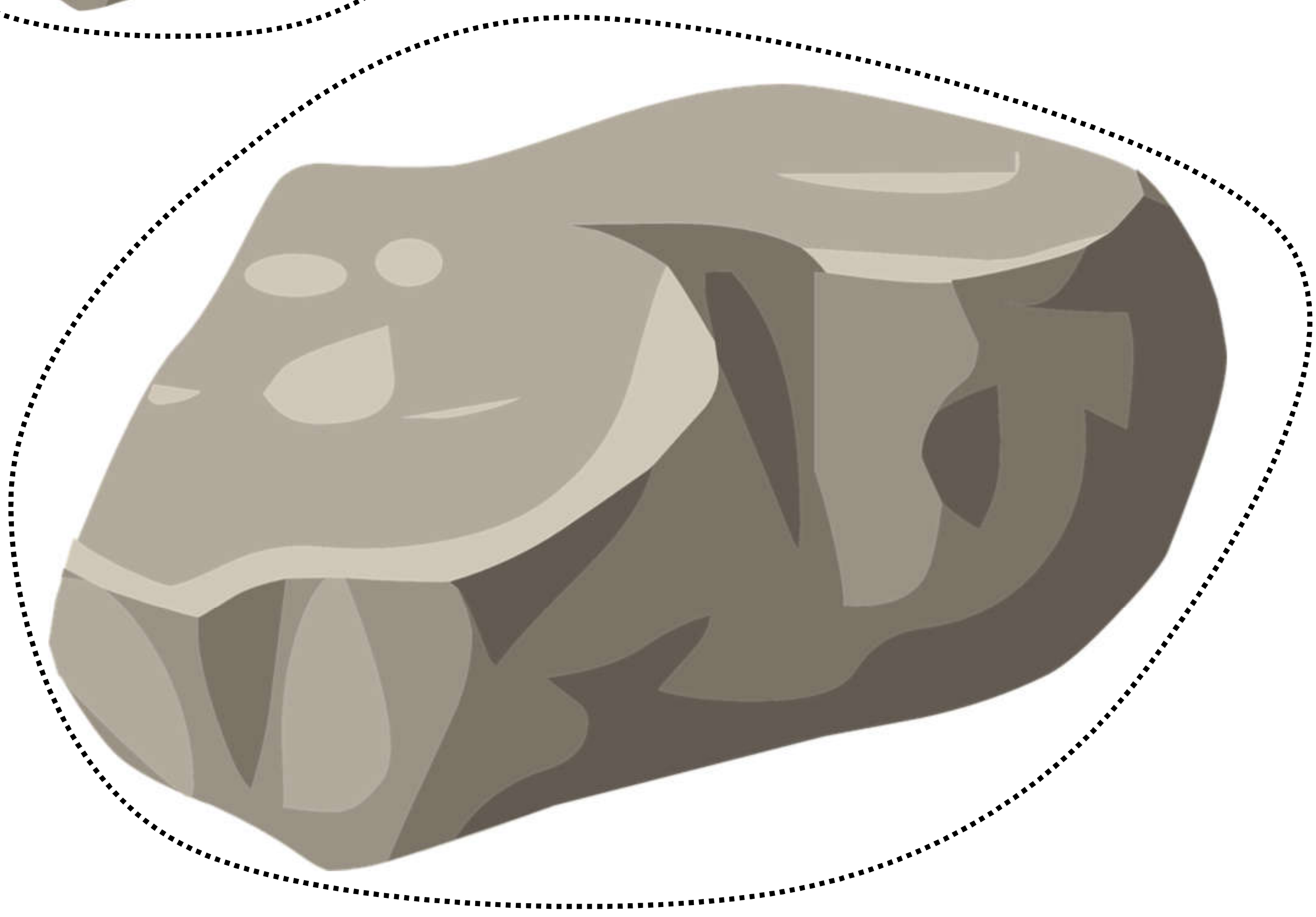


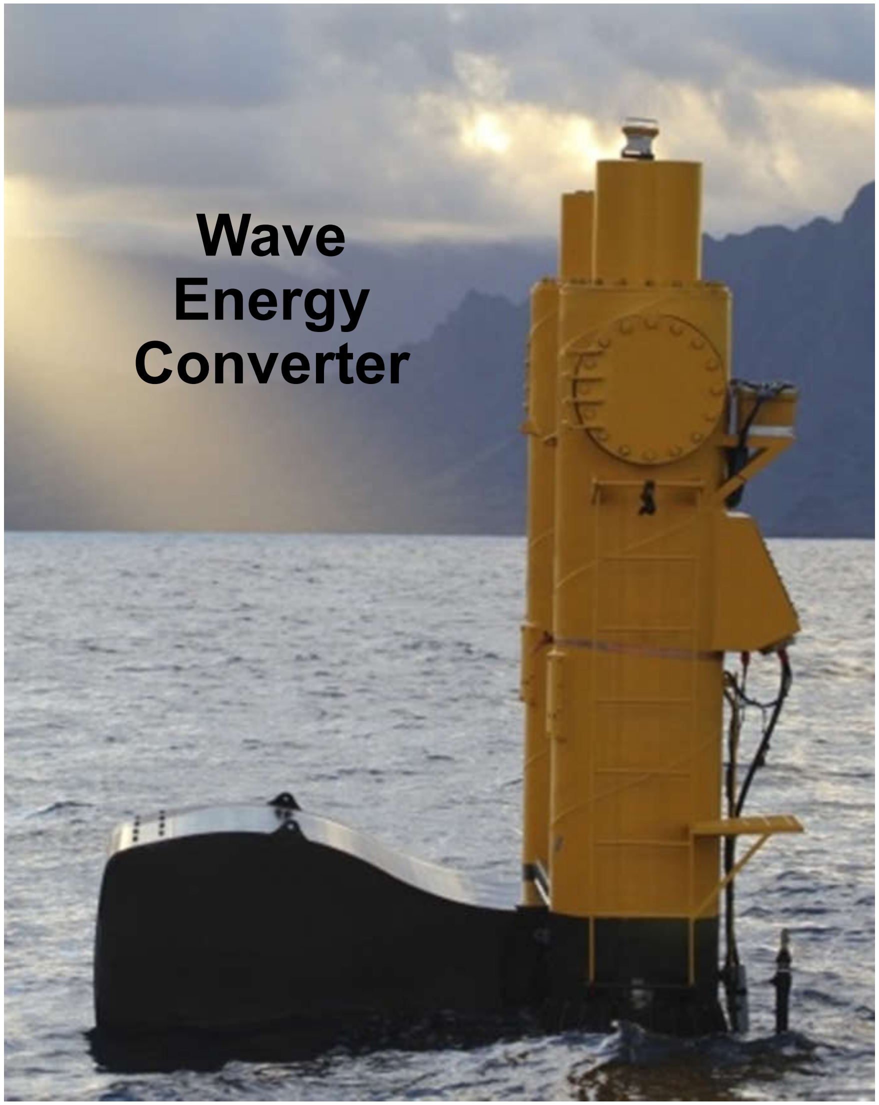


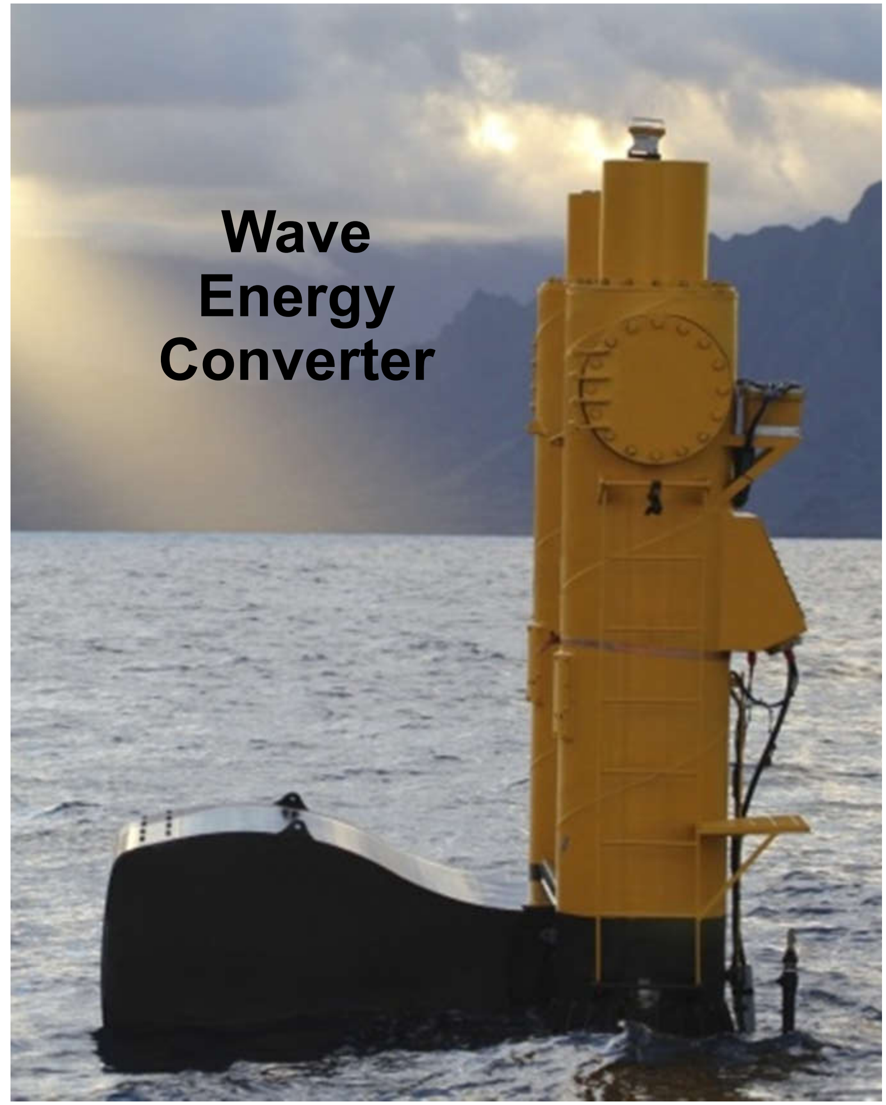









Wave
Energy
Converter


Wave
Energy
Converter


Convertidor de energía de olas


Convertidor de energía de olas

CHALLENGE

CHALLENGE

WHALE MIGRATION

Redesign your farm so the whales can pass through on their migration unharmed.

BOULDERS

There are giant boulders on the ocean floor that prevent you from building in certain areas.

CHALLENGE

CHALLENGE

BIRDS

Birds love to hang out in this area. In order to keep the sky safe for them, the top of your turbine cannot be more than 12 inches above the board.

SHIFTING WIND

The seasons and the temperature have changed, causing the wind to change directions slightly. Adjust your wind farm so it can still create just as much energy as before.

DESAFÍO

DESAFÍO

MIGRACIÓN DE BALLENAS

Vuelve a diseñar tu planta para que las ballenas puedan migrar de una forma segura.

ROCAS

Hay grandes rocas en el suelo marino que no te permiten construir ahí.

DESAFÍO

DESAFÍO

PÁJAROS

A los pájaros les encanta pasar por aquí. Para protegerlos, tus turbinas eólicas no pueden sobrepasar las 12 pulgadas sobre la tabla.

CAMBIO DE VIENTO

Las estaciones y la temperatura han cambiado, ocasionando un cambio en la dirección del viento. Rediseña tu planta para que siga generando la misma cantidad de energía de antes.

Names ___________________________

Energetic Ocean

How much does energy cost?

Instructions: After your final model wind and wave energy farm is complete, fill out the tables below to calculate the approximate amount of energy produced as well as how much money it takes to create and maintain the energy farm.

***Part 1**: How much energy does the wind and wave energy farm produce?*

Wind Turbines

# of turbines (Only count if SPINNING)	X	*100 kW*	=	

Wave Energy Converters

# of converters in BLUE wave zone	X	*200 kW*	=	
# of converters in WHITE zone	X	*50 kW*	=	
				TOTAL energy produced (add the 3 boxes from above)

Names ____________________________

<u>Part 2</u>: *How much does a wind and wave energy farm cost?*

Description	Price	Quantity	Cost
K'Nex pieces	$100	×	=
Wind turbines	$800	×	=
Wave energy converters	$1500	×	=
Extra maintenance cost for for each *wind turbine* placed in wave zone	$600	×	=
			TOTAL cost (add the 4 boxes from above)

<u>Part 3</u>: *How much does a kilowatt of energy cost?*

Use the totals above from ***Part 1*** and ***Part 2*** (total energy produced and total cost) to calculate the cost per kilowatt. **The lower the cost, the better!**

TOTAL cost ($) ÷ *TOTAL energy (kW)* = *Cost per kilowatt ($/kW)*

Nombres: ___________________________

Energetic Ocean
(Océano energético)

¿Cuánto cuesta la energía?

Instrucciones: Una vez que termines de diseñar tu planta de energía de viento (eólica) y de oleaje, completa las siguientes tablas para calcular aproximadamente cuánta energía es producida, y cuánto dinero cuesta la creación y el mantenimiento de tu planta de energía.

Parte 1: ¿Cuánta energía produce tu planta de energía de viento y olas?

Turbinas eólicas

Nº de turbinas (cuenta solamente las turbinas GIRANDO)	X	*100 kW*	=	

Convertidores de energía de olas

Nº de convertidores en zona AZUL	X	*200 kW*	=	
Nº de convertidores en zona BLANCA	X	*50 kW*	=	

Energía TOTAL producida (suma las 3 cajas de arriba)

Nombres: ___________________________

<u>Parte 2</u>: ¿Cuánto cuesta tu planta de energía de viento y olas?

Descripción	Precio	Cantidad	Costo
Piezas de K'Nex	$100	×	=
Turbinas eólicas	$800	×	=
Convertidores de energía de olas	$1500	×	=
Costo de mantención de *turbinas* en zona de olas	$600	×	=
			Costo TOTAL (suma las 4 cajas de arriba)

<u>Parte 3</u>: ¿Cuánto cuesta un kilowatt de energía?

Utiliza los totales de las partes 1 y 2 (energía total producida y costo total) para calcular cuánto cuesta cada kilowatt de energía. **¡Un costo bajo es mejor que un costo alto!**

Costo TOTAL ($)	÷	*Energía TOTAL (kW)*	=	*Costo por kilowatt ($/kW)*

FACILITATION GUIDE

Energetic Ocean

Description: Students will design a model offshore wind and wave energy farm to maximize the amount of energy the farm can produce.

Promoting collaboration and organization

- Circulate the room as teams are discussing their initial plan for their offshore energy farm. Encourage all students to provide input regarding the design plan.
- Encourage each member to pick where to put one of the pinwheels or wave energy converter cutouts. Then, facilitate a discussion about where to put remaining ones.
- Before students move anything, encourage discussion first. Why should we move this object? Will doing so yield a greater energy output?

Encouraging iteration

- There are many variations of this activity, and it can be adapted based on the needs and abilities of your group of students. Here are some questions that may facilitate further discoveries:
  - Can you try changing the heights of the wind turbines?
  - Should the tall/short ones go in front or in back?
  - Can you hear turbines knocking against one another? Remember that real wind turbines are hard and would probably break if they hit each other.
  - How can you make the turbines all spin at the same speed?
  - What happens with different speeds of wind? Does the wind still reach all of the turbines?

Helping those who are stuck

- Suggest that students try blowing on a pinwheel or holding it up to a fan. The students can then try holding up two pinwheels at a time and see how close together they can be and both spin.
- Have students stand where the fan is and lean down so their eyes are level with one of the middle-height pinwheels. Ask them if they can see all of their pinwheels. If not, maybe they should adjust their design.
- If pinwheels are rotating away from the fan, ask how they could alter the base to keep the pinwheel pointing towards the fan.

Real-world applications

- To minimize the need for everyday servicing, offshore turbines may have automatic greasing systems and heating and cooling systems to maintain the best conditions.
- Researchers at Oregon State University are working on a way to combine wind turbines and wave energy converters to maximize the amount of energy they can produce from one offshore farm. They use computers to solve the same problem we worked on today!