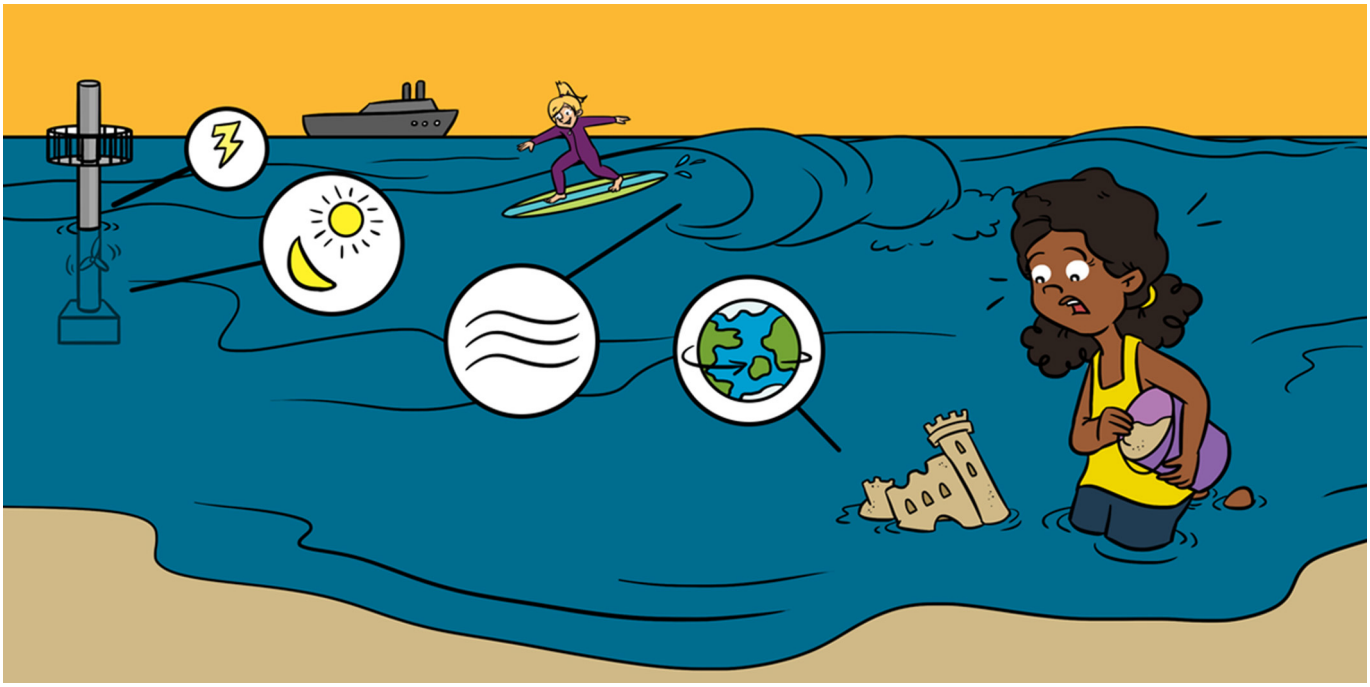
frontiers FOR YOUNG MINDS

EARTH AND ITS RESOURCES
Published: 09 August 2021
doi: 10.3389/frym.2021.609510



HOW CAN WE USE OCEAN ENERGY TO GENERATE ELECTRICITY?

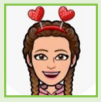
M. Luisa Martínez[1*], *Rodolfo Silva*[2] *and Janaina Garcia*[1]

[1] *Network of Functional Ecology, Institute of Ecology, A.C. (INECOL), Xalapa, Mexico*

[2] *Laboratory of Coasts and Ports, Institute of Engineering, Universidad Nacional Autónoma de México, Mexico City, Mexico*

YOUNG REVIEWERS:

EMILKA
AGE: 15



MARYSIA
AGE: 15

The oceans represent almost 70% of the surface of our planet, and they are in constant movement through waves, tides, and currents. These movements are formed differently: waves develop because of the action of the wind; tides because of the moon and the sun, and currents because of differences in water temperature and the rotation of the planet. Ocean movements bring food and oxygen to the plants and animals that live in the oceans and on the coasts. Waves and tides also help shape the coastline by erosion and accumulation of sand. Ocean movement is also important for humans: we have fun swimming in the waves, the tides help with fishing, and the currents are useful for moving ships across the ocean. This unending movement of the ocean can also be used to produce clean, renewable electric power.

THE OCEAN AS A BATTERY?

More than 70% of the surface of our planet is covered by water. Of this, most water is found in the oceans and only 2% is freshwater in lakes, rivers, and ice. There are almost 200 countries in the world, and just over 150 have access to the sea. Many species live in the oceans, in ecosystems including coral reefs and seagrass beds near the coasts, and in the open water. The global scientific community is working hard to determine the number of species in the oceans, but the task is difficult. Currently, the Ocean Biodiversity Information System[1] reports a little more than 147,000 species. However, because it is estimated that more than 80% of the oceans remain unobserved, the number of species living in the ocean is expected to be *much* larger than what we know so far, maybe millions of species.

[1] https://obis.org/.

In addition to being home for many thousands of creatures, the sea is like a battery that constantly receives, absorbs, and releases energy. The sun is the main source of energy for the oceans, both directly, through light and heat energy, and indirectly, by heating the air to produce winds. The oceans also receive energy from the pull exerted on the Earth by the moon, planets, and the sun. These forces mean that the water of the ocean is in constant motion: waves rise and fall, tides come and go, and currents flow around the globe. These movements are very important for Planet Earth: they provide food and oxygen for the plants and animals of the seas and they also help mold the coastline through erosion and accretion, which is the buildup of sand. What if all this unending ocean movement could be used to produce a **renewable** source of electricity, too? This is more than just a scientist's dream—keep reading to learn more!

RENEWABLE

Renewable is a natural energy source such as tides, waves, and ocean currents which are always available.

THE FORMATION OF WAVES, OCEAN CURRENTS, AND TIDES

Waves are produced by winds blowing across the surface of the sea. The time between each wave varies from 4 to 30 s. Waves occur both far out at sea and close to the coasts. When the wind blows hard, as occurs during a storm, the waves become higher. Tsunamis are a different type of wave. They are produced by earthquakes, volcanic eruptions, and the impact of meteorites landing in the sea. For example, when the earth shakes during an earthquake, the water moves, and then gigantic tsunami waves form in the open sea and travel toward the coasts. In this article, we will be focusing on the types of waves that normally occur, not tsunamis.

Ocean currents are mainly formed by the rotation of the Earth, variations in the seabed, and the differences in the temperature and salinity (saltiness) of the waters in the sea. Some ocean currents are very strong and the major currents even have specific names. Some currents carry warm, or even hot water; others carry cold water. These

currents affect the weather. For example, the Gulf Current starts in the warm waters of the Gulf of Mexico and travels to northern Europe, giving the places it passes warmer temperatures. Near the coast, we can find powerful, shorter currents due to the shape of the seabed. These currents keep the water oxygenated and transport nutrients away from the coast.

Tides are produced mainly by the magnetic attraction of the moon and the sun on earth's oceans. As the moon and the sun move, the water in the oceans is drawn toward or away from the coasts, producing a rise and a fall in the level of the sea. Depending on the coastline, high and low tides can occur once or twice a lunar day, 24 h 50 min, which is the time it takes the moon to go around the earth. The tidal changes in sea level are very small in some places, while in others they are extremely noticeable. For example, some islands, such as Mont Saint Michel in northern France, are joined to the mainland at low tide by a road that crosses the sands. But at high tide, the road is covered by deep water and the people on the island are cut off for about 9 h.

PRODUCING ELECTRICITY FROM WAVES, CURRENTS, AND TIDES

The unending movement of waves, currents and tides can be used to produce clean, renewable electricity for our homes, schools, and industries [1]. To harvest the energy from the ocean, special devices are used. To capture the energy, certain parts of these devices move as the water moves, and the movement generates electricity that is then transported to the coast. Buoys and turbines are two examples of devices that can be used to capture the energy from the ocean's movement.

Buoys are structures that float on the sea and move up and down with the motion of the waves. These buoys are attached to various mechanisms such as a cylinder that moves a **piston** driving a generator that can convert the movement into electricity. The buoys can be attached to long columns called **spars**, which are anchored to the seabed (Figure 1), or the entire device can be free-floating in the ocean (**Video 1**). These devices can be placed in the deep waters of the open sea, or closer to the coast.

Turbines can also be used to harness the energy of ocean currents (Figure 2, **Video 2**). Turbines have blades, kind of like propellers, that can be turned by the force of the ocean currents. The spinning turbine is attached to an electricity-generating device, and as the turbine spins like a propeller, a series of gears increase the rotation of the rotor allowing the turbine generator to produce electricity. Ocean currents are almost constant in direction, speed, and flow, and they carry large amounts of energy. Turbines can also be used to harvest the energy from currents that are produced by tides. Sometimes a type of dam

BUOY

Buoy is a floating structure that moves up and down with the motion of the waves.

PISTON

Piston is a tightly fitting cylinder or disk which moves within another cylinder, either to compress or move a fluid there, such as air or water, or to transform energy.

SPAR

Spar is a thick, strong pole to support a buoy.

VIDEO 1

Producing electricity from ocean waves.

TURBINE

Turbine is an engine that provides power because a rotor is continually turning due to pressure from fast moving water or wind.

VIDEO 2

Producing electricity from ocean currents and tides.

Figure 1

An example of how electricity can be generated using wave movement. The floating buoy is attached to a spar, which is a long column attached to the seabed containing electricity-generating machinery. Electricity is produced as the waves move the buoy up and down the spar, which moves a piston that drives a generator. Then the electricity is sent to the coast through an underwater cable.

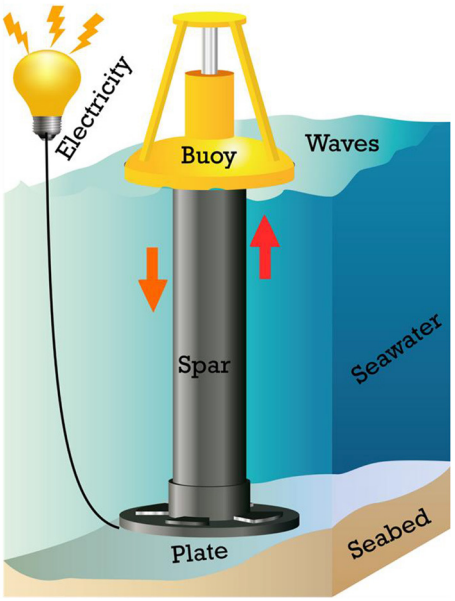


Figure 1

Figure 2

Energy can be generated from ocean currents and tides using turbines. The blades of the turbine are turned by the currents, and the energy is captured by an electricity-generating device which is attached to the blades.

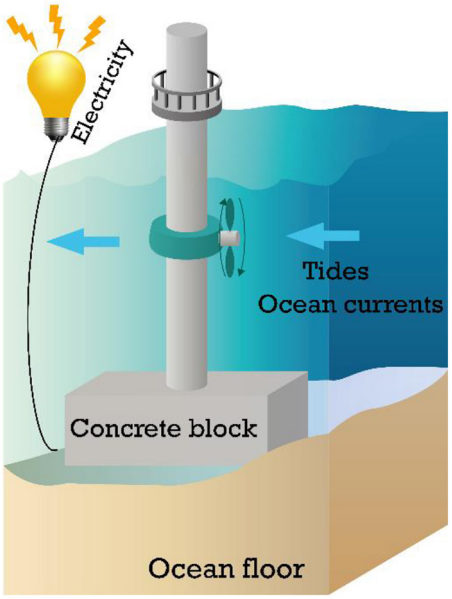


Figure 2

BARRAGE

Barrage is a dam placed in a stream or river to increase the depth of the water.

called a **barrage** is constructed to store water at high tide; at low tide, the gates of the barrage are opened, and the stored water flows out fast enough to move a series of turbines.

Once electricity has been produced by these devices, it can be transported to the coast through an underwater cable or stored in special batteries.

OCEAN ENERGIES: CHALLENGES AND OPPORTUNITIES

While these devices may seem quite simple, inventing machines that will work in all weather conditions, sometimes in deep water, it is a real challenge for scientists. The costs involved in designing, installing, and maintaining these technologies can be extremely high. The ocean environment is often harsh and dangerous, and conditions can be unpredictable, meaning strong structures are required to withstand the aggressive nature of the ocean. Support and funding are still needed for further research, to test prototypes, and to develop full-scale devices that can provide a stable supply of clean, renewable electricity.

Additionally, precautions must be taken to avoid undesirable effects on the environment. For example, these devices may alter ocean currents, causing food and larvae to stop following their natural patterns. Also, if the turbines produce noise, it can disorientate marine animals, causing them to collide with devices or nearby land. Early research has shown that fish and marine mammals *can* avoid hitting the devices; but sometimes they do not. It is important for scientists continue to research how local plants and animals respond to these devices. As new information is collected, we will know how to build and install these devices so that energy production does not have a negative effect on the plants and animals of the ocean.

Despite these challenges, there is great potential for generating electricity using techniques that harvest the movement of the oceans. In theory, the energy of ocean movements could supply the world's energy demand many times over! Energy harvested from the movement of the oceans is renewable, meaning it will not run out like fossils fuels eventually will. Another big advantage is that creating electricity from ocean energy does not generate CO_2, and therefore does not contribute to global warming and climate change. Continued research into these electricity-generating technologies is worth the effort because climate change is a growing problem. It is critical that we reduce the emission of CO_2 into the atmosphere, to protect the future of the earth and all its creatures! So, the next time you are at the ocean, in addition to having fun and enjoying the fantastic beauty of the sea's natural features, remember that someday the ocean might even help us to obtain the electricity we use in our everyday lives! There are endless possibilities!

ACKNOWLEDGMENTS

We appreciate the help of Jill Taylor in proof-editing the text for style and grammar. We also thank Valeria Chávez for developing the concept for the videos, Edgar Muñoz for his work on the graphics of the figures and videos, as well as Miriam Silva for lending her voice to the production of the videos.

REFERENCES

1. Uihlein, A., and Magagna, D. 2016. Wave and tidal current energy–a review of the current state of research beyond technology. *Renew. Sustain. Energy Rev.* 58:1070–81. doi: 10.1016/j.rser.2015.12.284

SUBMITTED: 23 September 2020; **ACCEPTED:** 13 July 2021;
PUBLISHED ONLINE: 09 August 2021.

EDITED BY: Sanae Chiba, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan

CITATION: Martínez ML, Silva R and Garcia J (2021) How Can We Use Ocean Energy to Generate Electricity? Front. Young Minds 9:609510. doi: 10.3389/frym.2021.609510

CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

EMILKA, AGE: 15
Hi! My name is Emilka, but friends call me Emi. I am interested in biology and chemistry. I am also crazy about theater from a young age and I love watching series (my favorite one is *The 100*), I like to meet new people and study about different cultures from around the world. Traveling is the reason why I am learning English, but my dream is to speak fluently in more than 3 languages. *May we meet again!*

MARYSIA, AGE: 15
My name is Marysia and I am 15. I am really interested in math, but I also like geography. I started learning English long ago and I think it is the most useful thing I learned so far. I am also a dancer. I have been in a polish folk dance group since 2012 and I cannot see my life without it. I am a huge fan of "Hunger games," so may the odds be ever in your favor and have a nice day!

AUTHORS

M. LUISA MARTÍNEZ

Dr. Martínez is a senior researcher at the Institute of Ecology (INECOL) in Xalapa, Veracruz, Mexico. She has a Ph.D. in ecology and environmental sciences, and her studies focus on coastal ecosystems, mostly beaches and coastal dunes. She studies the ecology of the beach and coastal dunes, how to restore these ecosystems, and the ecosystem services they provide. She has published nearly 100 scientific papers, 16 books, and 20 book chapters. She works in the CEMIE-Océano Project (https://cemieoceano.mx/) to study and mitigate the potential environmental impact that ocean-energy devices could have on the environment. https://www.researchgate.net/profile/M_Martinez5. *marisa.martinez@inecol.mx

RODOLFO SILVA

Dr. Silva has a Ph.D. in coastal and port engineering from the University of Cantabria, Spain. Coastal engineers build structures to protect the coast. He is currently a researcher and professor at the Institute of Engineering in the National University of Mexico (UNAM). Since 1995, Dr. Silva has been the head of the coastal and oceanographic group at UNAM and the Mexican Center for Ocean Renewable Energies (https://cemieoceano.mx/). He has 160 journal publications, 28 books, 31 book chapters, and many conference publications and technical reports produced for local governments, national ministries, and companies in Mexico and internationally. https://www.researchgate.net/profile/Rodolfo_Silva7.

JANAINA GARCIA

Dr. Garcia is a biologist and mangrove specialist at ETIV do Brazil, Itacaré, Bahia, Brazil, who received her Ph.D. at the Institute of Ecology (INECOL) in Xalapa, Veracruz, Mexico. She works at an NGO as an environmental education and conservation programs coordinator, focusing on mangrove restoration. She has also worked as SwimTayka coordinator, offering swimming lessons, drowning prevention, and environmental education for kids (https://www.etivdobrasil.org/about-us-en/#team). In her master's and Ph.D. studies, she investigated the role of mangrove plants in protecting the coast from waves and rising sea levels, and how these plants work as a natural filter against pollution. https://www.researchgate.net/profile/Janaina_Garcia2.