HOW CAN WE USE OCEAN ENERGY TO GENERATE ELECTRICITY?

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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.

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!

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
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.

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.

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!

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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!
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