



# FLORES

Offshore Renewable Energies  
partnership in the Pact for Skills

## Educational Materials for the Offshore Renewable Energies

Secondary School Guidebook

**Lesson 4:** Ocean currents energy

# 4



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## About this guidebook

**Forward Looking at the Offshore Renewables** (FLORES) will promote the core activity of the Large-scale partnership launching the Pact for Skills in the Offshore Renewable Energies (ORE) sector. FLORES will support the most committed stakeholders in the ORE, underpinning the success of the offshore renewable energy strategy with the stimulation of dedicated training offers. The partnership will promote the skilling process for the new jobs expected in the sector, estimated to account for between 20,000 and 54,000 new workers in the following five years and contribute to improve upskilling opportunities in the field of the actual ORE workforce.

FLORES prepared a set of educational materials for secondary school teacher presenting six topics:

- 1) introduction to offshore renewables;
- 2) wind energy;
- 3) solar energy;
- 4) ocean currents energy;
- 5) wave energy;
- 6) tidal energy.

For every lesson there is a guidebook and additional sources as well as a PowerPoint presentation aimed at developing practical Science, Technology, Engineering and Mathematics (STEM) experiences for secondary school students.

The objective of these educational materials is to empower teachers to introduce offshore renewable energy as a new topic and seamlessly integrate ocean literacy into their lessons. It is a «teach the teacher» resource that equips educators with the methodology required to independently craft lesson plans, while also providing them with a curated selection of existing resources.

This guidebook is aimed at students in secondary school, and the content can be adapted to younger and older students ranging from 12-18.

Project duration: January 2023 – December 2024 (24 months)

[www.oreskills.eu](http://www.oreskills.eu)

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# Guidebook



## Offshore renewable energies: ocean currents energy

This document is intended for secondary school teachers and serves as a guide for lessons introducing wave energy as an energy source.



**Duration:** approx. 45 minutes

*Lesson time can be extended with the use of additional materials provided under the scenario.*



**Target group:** secondary school pupils



**Learning objectives:**

- ▶ To familiarize pupils with the definition of ocean currents energy.
- ▶ To explain how ocean currents are created and how energy can be generated from it.
- ▶ To inform about the potential and status of ocean currents energy.
- ▶ To learn about the advantages and disadvantages of using this type of energy.

### Competencies and skills to be developed:

- ▶ Ability to define ocean currents energy.
- ▶ Ability to present the advantages and disadvantages of ocean currents energy.
- ▶ Ability to transform information about ocean currents energy into logical and understandable conclusions.
- ▶ Ability to express opinions on the determinants of development of ocean currents energy.

### Proposals for evaluating learning outcomes (elective):

- ▶ Evaluation of students through their activity in discussion and participation in group tasks.
- ▶ Oxford debate on future of ocean currents energy. [Example: Debate's title: "Ocean currents energy could power a clean energy future." The class is divided into 2 groups. The task of one group is to prove the truth of the thesis, while the opposition team argues against the thesis while trying to demonstrate the flaws in the opponent's argument. The role of the teacher is to moderate the discussion. Evaluation of students is based on their activity and preparation's level.]
- ▶ A short quiz to test students' understanding of ocean currents energy.

### Including diversity and inclusive aspects in teaching:

- ▶ During the lesson, the teacher should pay attention to the different perspectives and approaches of the students towards ocean currents energy.
- ▶ Encourage open discussion and respect for different points of view.
- ▶ Enable students to conduct their own research and experiments to explore a topic according to their individual interests.
- ▶ Show sensitivity to the needs of students with different religious beliefs, gender, disabilities, and background ensuring that they have equal opportunities to be included in the learning process.
- ▶ Recognize that your classroom may include students whose parents/family/close relatives/family friends work in the fossil fuels industry. It's vital to create a safe and inclusive space where they can freely learn, ask questions, and share their perspectives on renewable energies, fostering a richer and more holistic dialogue for all.

**Lesson scenario:****Offshore renewable energies – ocean currents energy****Lesson objectives:**

- ▶ To familiarize students with the definition of ocean currents energy.
- ▶ To introduce ocean currents energy as a renewable energy source, along with its advantages and disadvantages.
- ▶ To understand the status and key determinants of ocean currents energy development.

**Working methods:**

- ▶ Lecture
- ▶ Discussion
- ▶ PowerPoint presentation
- ▶ Brainstorming

**Work format:**

- ▶ Group work

**Teaching tools:**

- ▶ Multimedia projector
- ▶ Multimedia presentation
- ▶ Film
- ▶ Computer with Internet access

**Course of the lesson:****I. Introduction (5 minutes)**

- 1 Welcoming students and introducing the topic of the lesson.

**II. Lecture with multimedia presentation (35 minutes)**

- 1 The teacher defines ocean currents, discusses why they are so important and shows a map with the location of the most important ocean currents.
- 2 The teacher displays the video from NASA to help the pupils to visualize the movement of ocean currents:  
[https://svs.gsfc.nasa.gov/3827#media\\_group\\_351520](https://svs.gsfc.nasa.gov/3827#media_group_351520).
- 3 The teacher briefly explains the mechanism of generating electricity from ocean currents.
- 4 The teacher presents the basic information about two ocean currents energy projects that have been demonstrated so far.
- 5 The teacher presents the advantages and disadvantages of the ocean currents energy.
- 6 The teacher moderates the discussion on the future of this technology and to wrap up asks pupils what take-aways they have from the lesson.

### III. Summary and conclusion (5 minutes)

- 1 Encourage students to explore the topic and seek other information on the subject.
- 2 Thank students for participating in the lesson.

## Comments on the slides

### Slide 3 - Ocean currents

Ocean currents are large and almost unvarying movements of water in the seas and oceans resulting from the presence of wind, differences in the temperature or salinity of the water, and the rotation of the earth.

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.

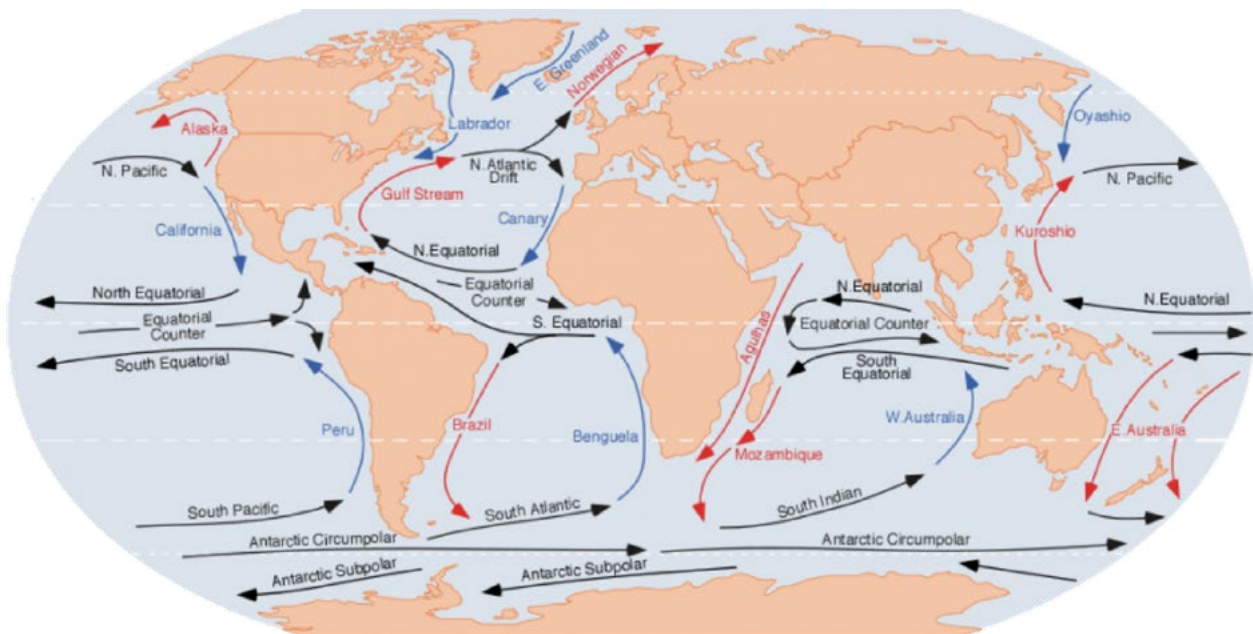


Figure 1. Global distribution of the major ocean currents.

### Why are currents important?

Currents are important as they maintain the ocean waters at a stable low temperature. The ocean absorbs heat from the sun and stores it as it moves. The movement of warm and cool water helps warm and cool the air. This helps control our climate and weather patterns around the world. Currents benefit all marine species by providing a transportation system around the seas. For example, ocean currents move plankton, fish, and different types of chemicals like salt, oxygen, and carbon dioxide around the world.



### Slide 5 - Ocean currents energy?

The energy of ocean currents can be used to generate electricity. Although the power carried by ocean currents across the globe amounts to many terawatts, the use made of this resource remains negligible.

Turbines can also be used to harness the energy of ocean currents. Turbines have blades, similar to propellers, that can be turned by the force of the ocean currents. The spinning turbine is attached to an electricity-generating device, and because the turbine spins like a propeller, a series of gears increases the rotation of the rotor allowing the turbine generator to produce electricity.

### Slide 6 - Ocean currents energy potential

The total worldwide power in ocean currents has been estimated to be about 5,000 GW, with power densities of up to 15 kW/m<sup>2</sup>.<sup>1</sup>

The locations of the currents are well known and studied. The streams with the highest velocities include the Gulf Stream (off North America), the Agulhas Currents (off South Africa), the Kuroshio Current (off East Asia) and the East Australian Current (Lewis et al., 2011). There have been few studies, however, on the potential ocean power that could be harnessed from such streams. Research has shown that, for example, **the Florida Current has a potential of 20 GW** across its cross-section, but it remains open as to how many of these cross sections could be used and what impact it would have on overall flow (Hanson, 2014).<sup>2</sup>

### Slides 7,8 & 9 - Ocean currents energy demo projects

#### Gulf Stream

The Florida-based South National Marine Renewable Energy Centre (SNMREC), a marine energy R&D centre with close collaboration with local universities, has small-scale test berths for ocean current deployments in the nearby Gulf Stream. Equipped with a deep-sea anchor bases at 350 metres below the surface, the devices are suspended at 90 metres depth. A first 24-hour test of an ocean current device in such a berth was successfully conducted in May 2020.

The powerful Gulf Stream flows north at 3 to 5 miles per hour from the Florida Straits to Cape Hatteras. Moving at 8 billion gallons of water per minute, its energy-dense Florida portion alone could yield 4 to 6 gigawatts of clean, renewable energy.

#### Kuroshio Current

Kairyu prototype – 330 ton turbine<sup>3</sup>

Japan is located near the Kuroshio, one of the world's most powerful ocean currents, and one estimate states that if the energy present in the Kuroshio could be harnessed, it would amount to approximately 205 GW, which is comparable to Japan's total electric power generation.

Over the past decade, IHI Corporation has been developing a 100-kilowatt-class generator that can harness the power of ocean currents. In February 2022, the firm

<sup>1</sup> Sea-Floor Power Generation System.

[https://www.researchgate.net/publication/347439875\\_Sea-Floor\\_Power\\_Generation\\_System](https://www.researchgate.net/publication/347439875_Sea-Floor_Power_Generation_System)

<sup>2</sup> Innovation Outlook, Ocean Energy Technology. IRENA, 2020

<sup>3</sup> IHI Demonstrated the World's Largest Ocean Current Turbine for the First Time in the World.

[https://www.ihi.co.jp/var/ezwebin\\_site/storage/original/application/5a7bd9898dee90868aa1e085beb50b.pdf](https://www.ihi.co.jp/var/ezwebin_site/storage/original/application/5a7bd9898dee90868aa1e085beb50b.pdf)



announced it had completed a 3.5 year-long trial and that the turbine should be expected to be up and running sometime in the 2030s.

Kairyu worked 50 metres below the surface of the water, attached to the ocean floor. There it could change its position on its own, positioning itself relative to the current so that the movement of the water masses drives the turbines.

Besides this, relatively little attention has been devoted to extracting energy from ocean currents, which can be attributed mainly to the fact that open ocean currents are often in much deeper waters and much further offshore, which complicates the deployment and mooring technologies. In addition, the environmental impacts are largely unknown, and assessment is complicated. The stage of development is therefore lower than that of any other ocean energy technology. It can be expected that more attention will be given to ocean current energy extraction once tidal energy is fully commercial and long-term studies are available.

Although barely tested so far, the technologies to harness ocean currents are expected to be similar to those to harness tidal streams. The focus has specifically been on hydrokinetic devices that are adapted to the lower current speed. However, new tidal technologies are emerging that are suited for lower speeds by default. It therefore remains unclear which technology will be used when ocean currents will be harnessed for electricity generation.<sup>4</sup>

#### Slide 10 - Drivers

- ▶ **Environmental Sustainability:** One of the primary drivers is the need for clean and sustainable energy sources. Ocean current energy is considered an environmentally friendly option because it produces electricity without greenhouse gas emissions, air pollution, or other harmful environmental effects.
- ▶ **Consistency and Reliability:** Ocean currents offer a consistent and predictable source of energy. Unlike solar and wind energy, which can be intermittent, ocean currents flow continuously, making them a reliable option for continuous power generation.
- ▶ **Renewable Energy Goals:** Many countries have established renewable energy targets and commitments to reduce carbon emissions. Ocean current energy is seen as a way to contribute to these goals, helping to diversify the energy mix and reduce dependence on fossil fuels.
- ▶ **Energy Security:** Reducing dependence on fossil fuels and diversifying the energy portfolio can enhance energy security. Ocean current energy can contribute to a nation's energy independence and resilience by providing a stable source of clean power.
- ▶ **Economic Opportunities:** Ocean current energy projects can stimulate local economies through job creation, investment, and support for related industries. The development, installation, and maintenance of ocean current energy infrastructure can provide economic benefits to coastal regions.

#### Slide 11 - Barriers

The main challenge is the difficulties inherent in the use of the **appropriate technologies**, which, due to its location deep in the sea, has too many risk factors. In addition to technical troubles, there are also concerns about too much **interference with the environment**, which could end up with disastrous consequences. These include the possibility of an imbalance in the aquatic environment and - difficult to estimate - the consequences for the Earth's current climate balance. It is possible that upsetting the natural circulation of ocean currents would prove to be a process that is too costly from the point of view of interfering with nature in comparison to the possible benefits.

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<sup>4</sup> IRENA (2020), Innovation outlook: Ocean energy technologies, International Renewable Energy Agency, Abu Dhabi.

## QUIZ: Ocean currents energy

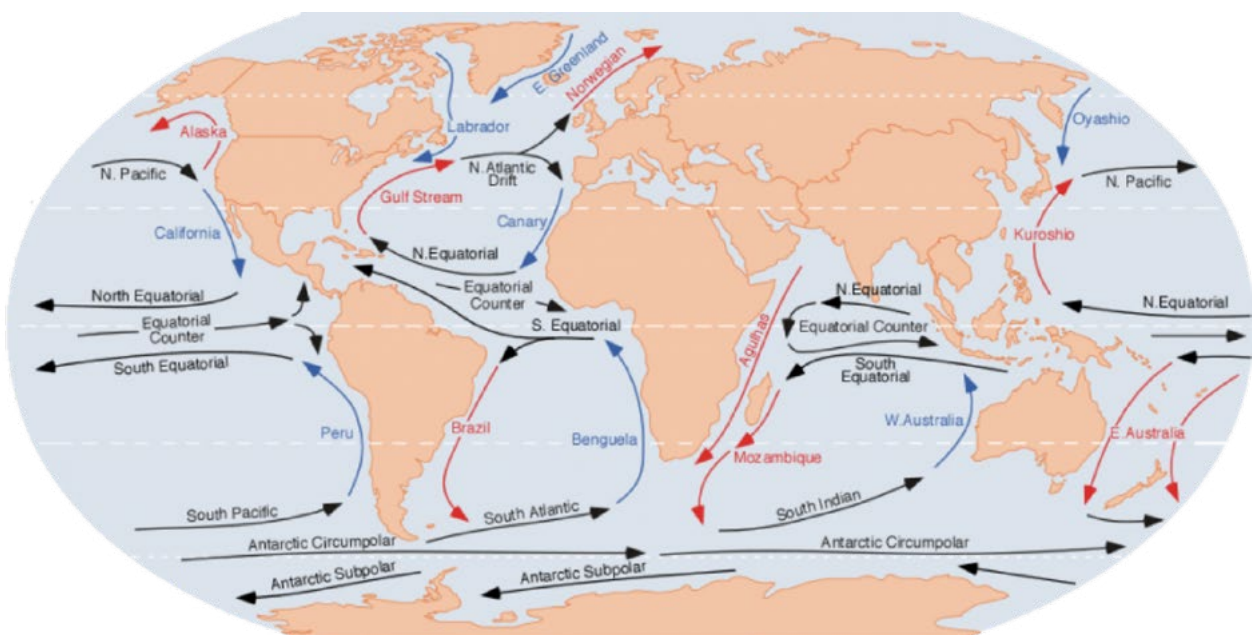
**Guidelines:** Adapt the quiz to your needs. You can use available apps, such as Kahoot, to create an online version or print and hand out to pupils.

### Task 1: Mark whether the given sentence is true or false

- Ocean current energy is considered an intermittent and unreliable source of power.  
☐ TRUE    ☐ FALSE  
 Answer: False.
- Turbines are the most common devices used to capture energy from ocean currents.  
☐ TRUE    ☐ FALSE  
 Answer: True.
- Commercial-scale ocean current energy projects are already operational around the world.  
☐ TRUE    ☐ FALSE  
 Answer: False.
- Ocean current energy projects are limited to a few specific locations globally.  
☐ TRUE    ☐ FALSE  
 Answer: True.

### Task 2: Single-choice test. Mark the correct answer

- Ocean currents are strongest in which region of the world?  
☐ a. The North Atlantic  
☐ b. The South Pacific  
☐ c. The Arctic Ocean  
 Correct answer: a



Additional sources



## Reports

- ▶ IRENA (2020), Innovation outlook: Ocean energy technologies, International Renewable Energy Agency, Abu Dhabi.  
<https://www.irena.org/publications/2020/Dec/Innovation-Outlook-Ocean-Energy-Technologies>

## Websites:

- ▶ Ocean-Based Perpetual Energy  
<https://oceanbased.energy/>
- ▶ How Can We Use Ocean Energy to Generate Electricity?  
<https://kids.frontiersin.org/articles/10.3389/frym.2021.609510>
- ▶ National Geographic. Ocean currents  
<https://education.nationalgeographic.org/resource/ocean-currents/>
- ▶ Minesto  
<https://minesto.com/>

## Articles:

- ▶ IHI Demonstrated the World's Largest Ocean Current Turbine for the First Time in the World  
[https://www.ihi.co.jp/var/ezwebin\\_site/storage/original/application/5a7bd9898dee90868aa1e1e085beb50b.pdf](https://www.ihi.co.jp/var/ezwebin_site/storage/original/application/5a7bd9898dee90868aa1e1e085beb50b.pdf)
- ▶ Japan tests deep-ocean current turbines in search of new renewables  
<https://newatlas.com/energy/ihi-nedo-kairyu-ocean-current-turbine/>
- ▶ Capturing the green energy of the deep blue sea  
<https://www.washingtonpost.com/climate-solutions/2020/06/09/capturing-green-energy-deep-blue-sea/>
- ▶ Minesto completes testing on ocean current renewable technology  
<https://www.power-technology.com/news/minesto-ocean-current-testing/>



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