European Commission

Science for Environment Policy

Environmental impacts of ocean-energy systems: a life-cycle assessment

23 September 2016
Issue 471

[Subscribe](#) to free weekly News Alert

Ocean-energy technologies — which harvest renewable energy from the sea — will have a significant role to play in a future low-carbon society. A recent life-cycle analysis of different ocean-energy devices has found that life-cycle environmental impacts are caused mainly by the materials used in the mooring, foundations and structures. Improving the efficiency and lifespan of the devices, as well as improving mooring and foundations and deploying devices further out at sea, will help to further reduce the life-cycle environmental impact of ocean-energy systems, according to the study.

Oceans are a source of renewable energy, with the potential to contribute to a more sustainable energy supply in the future. Technologies to harness ocean power are still at the early stages of development, although ocean-wave and tidal-current technologies, which obtain energy from the movement of the waves and tides respectively, are among the most developed of the ocean-energy systems.

To better understand the potential environmental impacts of ocean-energy systems, this European Commission Joint Research Centre (JRC)[1] study conducted a life-cycle assessment[2] of them. The researcher focused on electricity-producing ocean-wave and tidal-current devices to assess the cradle-to-grave environmental impacts associated with: sourcing and using materials and energy to produce the devices, their installation, operation and end-of-life disposal (recycling, incineration and landfilling), as well as any transport connected with the devices. The study did not take into account any effect on the habitats of ocean fauna and flora, the migration of fish and marine mammals or the impact on birds, nor did it account for the environmental impact of noise generated underwater.

Data on the components, structure, mooring, foundations, cable connections, maintenance and installation operations were sourced from the JRC's ocean-energy database, which contains information on 186 wave- and tidal-energy devices.

Further information on materials and processes was obtained from commercially available Life Cycle Inventory (LCI) datasets. The environmental impacts of the ocean-wave and tidal-converter devices were assessed in terms of the devices delivering one kilowatt hour (kWh) of electricity to the European grid system.

In all, the study assessed the impacts of eight types of wave-energy and seven types of tidal-energy devices on 13 environmental impact categories: global warming, acidification, ozone depletion, particulate matter emissions, ionising radiation, human toxicity (cancer), human toxicity (non-cancer), summer smog, freshwater eutrophication, marine eutrophication, terrestrial eutrophication, freshwater ecotoxicity and resource depletion.

The greatest environmental impact for almost all devices and all categories was related to the amount of material used in the devices, mainly for foundations, mooring (such as for securing to the ocean floor or to the foundations), and structural components. Any assembly, installation, use and transport-related impacts were insignificant by comparison.

Continued on next page.

Source: Uihlein, A. (2016). Life cycle assessment of ocean energy technologies. *The International Journal of Life Cycle Assessment.* DOI:10.1007/s11367-016-1120-y. This study is free to view at: http://link.springer.com/article/10.1007/s11367-016-1120-y.

Contact:
andreas.uihlein@ec.europa.eu

Read more about:
Climate change and energy, Environmental technologies, Risk assessment, Water

To cite this article/service: "Science for Environment Policy": European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol.

1. Institute for Energy and Transport, Joint Research Centre, European Commission. https://ec.europa.eu/jrc/en/science-area/energy-and-transport

2. Life-cycle assessment is designed to identify environmental impacts that are caused by, and proportional to, the flows of products and materials (the transportation of raw materials, parts, components and products) related to an activity. It does not cover other environmental impacts of the energy technologies in question, such as direct interaction with marine life or impacts of construction on the sea floor.

European Commission

Science for Environment Policy

Environmental impacts of ocean-energy systems: a life-cycle assessment *(continued)*

23 September 2016
Issue 471

Source: Uihlein, A. (2016). Life cycle assessment of ocean energy technologies. *The International Journal of Life Cycle Assessment.* DOI:10.1007/s11367-016-1120-y. This study is free to view at: http://link.springer.com/article/10.1007/s11367-016-1120-y.

Contact: andreas.uihlein@ec.europa.eu

Read more about: Climate change and energy, Environmental technologies, Risk assessment, Water

For one type of tidal-energy device, the horizontal-axis turbine (in which the movement of the tides causes a rotor mounted on a horizontal axis to turn, generating power) material inputs to mooring and foundations contributed most of the environmental impact in 11 out of the 13 impact categories, except for freshwater eutrophication (which was mostly affected by polycarbonate (a plastic) used in the nose cone of the devices, copper in cables and electrical connections, and stainless steel materials) and ionising radiation (which was affected by the electricity used in the manufacturing processes). For point absorbers, a type of floating wave-energy device that is secured to the seabed and converts water movements to electrical power, material inputs to structural components, then for mooring and foundations, dominated the environmental impacts in all impact categories, again except for freshwater eutrophication and ionising radiation.

Mooring and foundations accounted for more than 40% of the total, life-cycle greenhouse gas (GHG) emissions in more than three-quarters of the wave-energy and tidal-current devices. Total GHG emissions ranged from 15 to around 105 grams of carbon dioxide equivalents per kilowatt-hour (g CO_2eq/kWh), with an average of approximately 53 g CO_2eq/kWh. This is a similar order of magnitude as for other renewables.

Devices will be deployed as arrays or farms, similar to wind farms, in the future, which should reduce the environmental impacts, as cables, electrical hubs, substations and other components would be shared, the researcher says.

The study also includes scenarios of possible future improvements. For example, increasing the efficiency of horizontal-axis turbines and point absorbers could also reduce the life-cycle environmental impacts for all categories by 76% and 56%, respectively. Extending the lifetime by 50% by improving the durability of both devices could also reduce the environmental impacts by 33% for all impact categories. Improving mooring and foundation systems, e.g. by using mooring lines and gravity bases instead of foundations (for example, piles and support towers), could reduce the environmental impacts for all impact categories, up to 58% for horizontal-axis turbines and up to 14% for point absorbers.

In addition, moving devices further offshore to tap into greater ocean-energy resources could reduce environmental impacts, although the impact from longer cables may offset some of the potential reductions, according to the researcher.