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Wave and tidal energy plants are 'green' technologies

Environmental impacts for a wave energy device, tidal stream and tidal range plants are potentially eight, 20 and 115 times lower respectively than for coal-generated power, averaged over five impact categories. An assessment of the amount of metal used by these technologies, however, shows an impact respectively 11 and 17 times higher than for coal- and gas-based power generators. These are the findings of a recent study, which compared the life-cycle environmental impacts of various wave and tidal energy devices with other forms of energy generation. The researchers conclude that wave and tidal energy plants qualify as 'green' technologies according to their definition, but that their impacts on marine ecosystems need further research.

Devices that harvest energy from the sea are promising sources of renewable energy; globally, there is estimated to be 1 terawatt (TW, equivalent to 1 billion kilowatts) of energy available from the tides, and twice that from waves[1].

However, the environmental impacts of wave and tidal energy technologies remain poorly understood. While renewable forms of energy are important for a low-carbon future, this does not necessarily mean they do not have other, negative environmental effects. This study assessed the environmental impacts of wave and tidal power devices in order to determine whether they should really be called 'green technologies'. The study defines these as technologies that do not alter the climate, conserve resources, have no harmful effect on human health or ecosystems, and are less harmful to the environment than conventional means of energy generations.

The researchers assessed:

- **three tidal stream devices**, which extract energy from tides using the current to rotate a turbine, in Ireland, Norway and the UK;
- **one tidal range plant**, which is similar to a hydropower dam, in Canada. These require large construction works and are only suitable in places where the rise of the tide is significant;
- **one device that harnesses energy from waves** by attaching a hinged flap to the seabed, in the UK.

A number of environmental impacts were assessed using life-cycle impact assessment (LCIA). Although some life-cycle assessment studies have been performed on wave and tidal power plants before, this is the first to consider impacts beyond climate change and to compare three different types of tidal energy device.

The LCIA was based on the ReCiPE methodology, which covers a wide range of potential impacts, including toxicity to humans and ecosystems, resource depletion, and potential effects on the climate. The assessments were based on the production of 1 kilowatt hour of electricity, fed into the grid by a wave or tidal energy harnessing plant. For each plant, the researchers considered the impacts of the installation, operation, maintenance and decommissioning phases.

Continued on next page.

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1. Renewable Energy Policy Network for the 21st Century, Renewables 2016 — Global Status Report: http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report_REN21.pdf

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Wave and tidal energy plants are 'green' technologies *(continued)*

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Using the results, the researchers compared the plants to each other, to established renewable energy technologies and to traditional methods of electricity generation. For the comparison, the focus was put on **climate change**, **particulate-matter formation**, **human toxicity**, **marine ecotoxicity**, and **metal depletion** impact categories.

The plants had, on average, 1.4 to 1.8 times higher impacts than an offshore wind power plant. However, compared to electricity generated from hard coal, their impacts were 13 to 21 times lower (excluding the metal depletion category, for which the tidal stream devices had around 10 times more impact).

Specifically, in terms of **climate impact**, all of the wave and tidal plants performed similarly to wind and solar power plants, with the tidal range plant performing even better and closer to hydropower. In terms of **particulate-matter emissions**, the findings were again similar to wind and solar. The wave and tidal plants outperformed hard coal in both of these categories. Although the results spoke less clearly in favour of wave and tidal energy plants when considering **human and marine toxicity**, the plants still far outperformed the production of electricity using hard coal.

Comparisons to natural gas were more varied. Electricity from natural gas had a lower impact on **metal depletion** and **human and marine ecotoxicity** than the wave and tidal energy plants, but the wave and tidal plants had up to 38 times lower impacts in terms of **particulate matter formation** and **climate change**.

Although the overall environmental performance of all the devices was good, the findings showed that these technologies use 11 times more **metal** than conventional coal-based energy generation and 17 times more metal than conventional gas-based energy generation. This is a drawback which is also identified for other renewable-power-generating technologies, such as wind and solar power plants.

Overall, averaged over the five impact categories, the environmental impacts of the tidal range plant were 1.1 times greater than for hydropower plants. The findings were similar when they compared the tidal stream devices to offshore wind farms (1.5 times higher). The wave energy device had three times more impacts than offshore wind power. However, compared to electricity generated from coal, the plants had eight (wave energy), 20 (tidal stream), and 115 times (tidal range) lower impacts averaged over the five impact categories.

Other tests showed that devices with long lifetimes and minimal material requirements have less environmental impact, which could help to optimise future design.

Although the researchers conclude that, according to their definition, wave and tidal energy plants do qualify as green technologies, they acknowledge that if wave farms are developed, impacts, especially on marine ecosystems, may increase. It should also be noted that the disturbance of mammal and bird communities was only studied at one of the mentioned plants and electromagnetic disturbances are unknown, so it is likely that environmental costs of the use of wave and tidal energy are higher than currently assumed; therefore, the researchers conclude, the potential for unknown effects on marine ecosystems should be explored in future research to enable more accurate estimations of environmental impacts.