DARE
Devon Association for Renewable Energy

FACTSHEET 9: Introduction to Wave Power

Introduction

Waves are generated by the wind as it blows across the ocean surface. They travel great distances without significant losses and so act as an efficient energy transport mechanism across thousands of kilometres. The energy can be captured by various devices, which produce enough movement either of air or water to drive generators that converts the energy into electricity.

1. The Fuel

The energy contained in ocean waves can potentially provide an unlimited source of renewable energy. Wave energy is a concentrated form of solar energy. Ocean waves are created by the interaction of wind with the surface of the sea and the UK has wave power levels that are amongst the highest in the world.

The initial solar power level of about 100W/m2 is concentrated to an average wave power level of 70kW/metre of crest length. This figure rises to an average of 170kW/metre of crest length during the winter, and to more than 1,000 kW/metre during storms.
Wave energy converters extract and convert this energy into a useful form. The conversion usually makes use of either mechanical motion or fluid pressure, and there are numerous techniques for achieving it, e.g. oscillating water/air columns, hinged rafts, and gyroscopic/hydraulic devices. The mechanical energy is then converted to electrical power using a generator.
Wave energy converters can be deployed either on the shoreline or in the deeper waters offshore. East-facing sites in the UK are unsuitable because of the limited energy associated with easterly winds, while bottom friction reduces power levels where the water depth is less than 80 metres. As a result, the inshore resource is usually only one-quarter or less of the deep-water resource.
The South West has very good wave energy resources particularly the areas exposed to the prevailing westerly ocean swell, broadly the sea area offshore from Ilfracombe to the Isles of Scilly.

2. The Technology

There are three main types of wave power machines, some of which sit on the shoreline while others are free-floating:

Oscillating water column
An oscillating water column is a partially submerged, hollow structure that is installed in the ocean. It is open to the sea below the water line, enclosing a column of air on top of a column of water. Waves cause the water column to rise and fall, which in turn compresses and depresses the air column. This trapped air is allowed to flow to and from the atmosphere via a Wells turbine, which has the ability to rotate in the same direction regardless of the direction of the airflow. The rotation of the turbine is used to generate electricity.

Buoyant moored device
A buoyant moored device floats on or just below the surface of the water and is moored to the sea floor. A wave power machine needs to resist the motion of the waves in order to generate power: part of the machine needs to move while another part remains still. In this type of device, the mooring is static and is arranged in such a way that the waves' motion will move only one part of the machine.

Hinged contour device
A hinged contour device is able to operate at greater depths than the buoyant moored device. Here, the resistance to the waves is created by the alternate motion of the waves, which raises and lowers different sections of the machine relative to each other, pushing hydraulic fluid through hydraulic pumps to generate electricity.

The main problem with wave power is that the sea is a very harsh, unforgiving environment. An economically-viable wave power machine will need to generate power over a wide range of wave sizes, as well as being able to withstand the largest and most severe storms and other potential problems such as algae, barnacles and corrosion.

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3. Cost

As a consequence of the competing designs and lack of long term commercial operating experience, actual cost data is virtually non-existent and developers have had to make estimates of costs. The estimates always show projected cost per kWh, falling over time due to better designs and increasing unit size. Given the state of technology there is little doubt that many designs can generate electricity but the key question is can they do so cheaply. It would be straightforward to build very strong devices capable of withstanding all the storm conditions expected - the difficulty is constructing at minimum capital cost and having minimum operating cost (for maintenance and repair) so that the overall cost of generation is kept as low as possible and is competitive with alternative forms of generation.

4. Current Uses

There are two wave power devices in the UK. Total installed capacity currently stands at 1.25 megawatts.

The first type of device is the LIMPET (Land Installed Marine Powered Energy Transformer), a 500-kilowatt shoreline oscillating water column on the Scottish island of Islay.

The second, the 750-kilowatt Pelamis sea snake, is an example of a hinged contour device. It is the first deep-water grid-connected trial and is currently installed at the European Marine Energy Centre in Scotland, where it is undergoing testing.

Pelamis system is towed out to sea. Image Ocean Power Delivery

5. Potential

Marine energy could provide around 20 per cent of the UK's electricity needs but only if there is sufficient investment in the appropriate technology.

A report by the Carbon Trust concludes that wave and tidal power could eventually provide a cost effective way of generating energy and offers a real alternative to other renewable sources such as wind and solar power.

However, in the short-term the initial set-up costs of marine energy are high as it requires extensive research and development. Yet the Carbon Trust believes that sufficient investment now could lead to a strong UK marine energy sector.

John Callaghan, programme engineer at the Carbon Trust, said: "The UK leads the world in marine renewables technology development."

He added: "Given our superb natural resources and long-standing experience in offshore oil and gas, shipbuilding and power generation, the UK is in prime position to accelerate commercial progress in the marine energy sector and secure economic value by selling marine energy devices, developing wave and tidal stream farms and creating new revenues from electricity generation.

6. Future Development

Wind-generated waves on the ocean surface have a total estimated power of 90 million gigawatts worldwide. Due to the direction of the prevailing winds and the size of the Atlantic Ocean, the UK has wave power levels that are among the highest in the world. Wave energy has the potential to provide as much renewable energy as the wind industry, but the development of wave technology is currently at the same stage that the wind industry was in 10 years ago.

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