MARITIME REPORTER AND ENGINEERING NEWS

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From Green Water can come

Green Energy

Wave energy represents a significant untapped energy source. As Professor Jo Hermans from the University of Leiden says: "Worldwide the economically exploitable amount of wave energy is estimated at 2,000 TWh/year, an average power of 200GW over a year. This is quite a lot: the equivalent of 200 large power stations." But the challenge is to generate a predictable amount of energy, in a reliable way, at a reasonable cost.

The challenges of wave energy are very similar to those of the offshore industry: safe and economic design, production, transportation, installation, maintenance, repair and removal. That is why MARIN decided to use its expertise to further develop this type of renewable energy. For this MARIN used an 'Inverse concept' - inversing the objectives of offshore engineering. Instead of reducing the motions and green water of ships and offshore structures, the concept maximizes the motions and green water as a means of extracting energy from waves. This initiative was dubbed the "Green Water Concept".

The concept works following these steps:

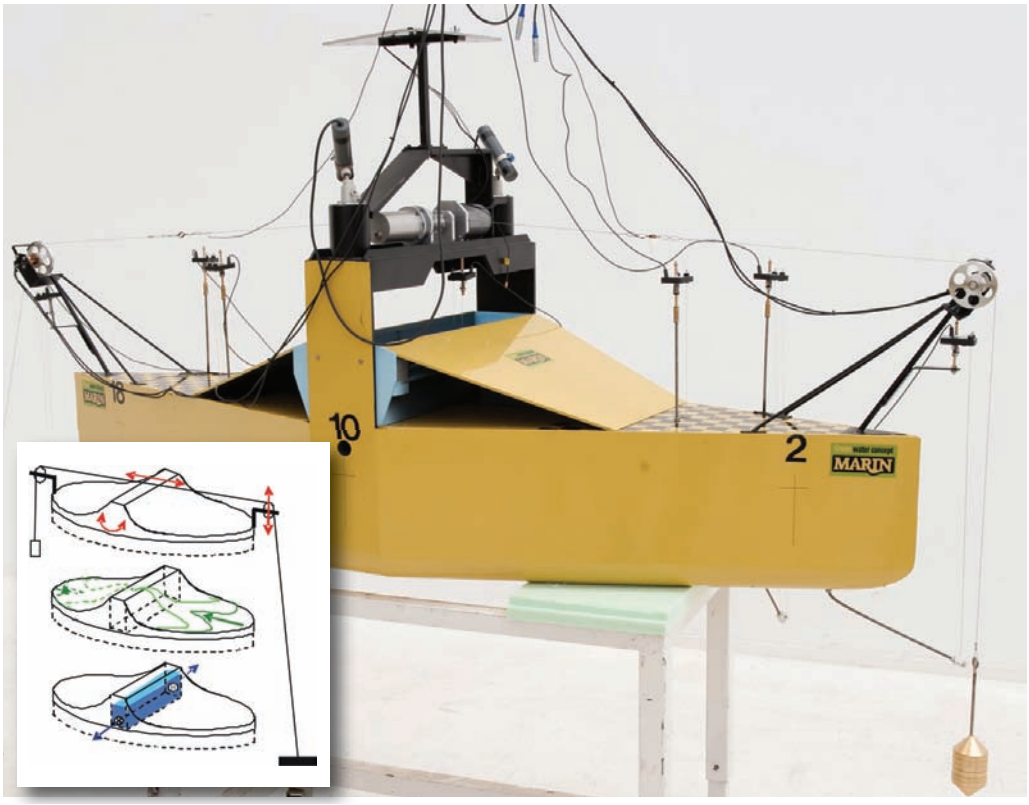
1. Through maximized pitch motions, the bow makes large vertical motions relative to the seabed, to which it is connected with a wire. The wire moves relative to the structure and can be attached to an electrical generator (first Power Take Off).

2. At the same moment, waves exceed the freeboard and green water flows onto the deck. Green water comes from the front and sides and forms a high velocity water jet. This concentrated jet, together with the upward pitch motions, allows the green water to flow into a higher reservoir at the centre of the structure.

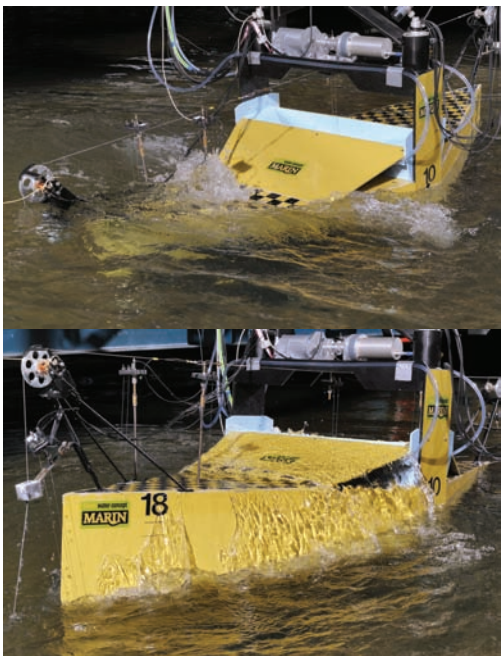
3. The green water in the reservoir then flows back into the sea through low water head turbines (second Power Take Off).

The concept was initially developed using diffraction theory and VOF simulations with the ComFLOW method. In May, the first successful model tests were carried out, including the modelling of an electrical and hydraulic Power Take Off (PTO).

With the Green Water Concept' MARIN wants to stimulate the development of wave energy. Therefore, the Dutch maritime and offshore industry was invited to take over the further development in the RENEW-ABLE project. Now the complete range of companies needed to make wave energy a success are working together, including Bluewater Energy Services, Damen Shipyards, Heerema Marine Contractors, Huisman Equipment, Imtech Marine & Offshore, Meteoconsult and TU Delft. MARIN will stay involved as advisor: applying its knowledge but also learning more about the challenges of wave energy. This way we will be ready to give an independent advice to any company that wants to bring this form of renewable energy a step further.



Phases of the Green water concept (inset) and the model before it went into the basin (above).



Testing of the Green water concept including its Power Take Off.

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Power Take Off Modeling

An important aspect of wave energy conversion is accurate modelling of the Power Take Off (PTO). At the moment energy is converted into electricity in the PTO, the hydrodynamic behaviour of the structure is changing. A few basic PTO types can be identified:

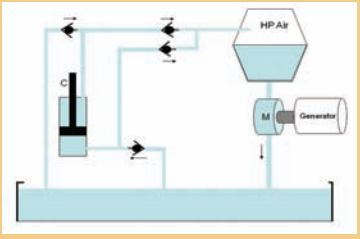
• Grid connected PTO running at a fixed RPM, used in tidal current stream systems. Energy is delivered to the grid when the environmental conditions "try" to increase the generator RPM above the fixed RPM.

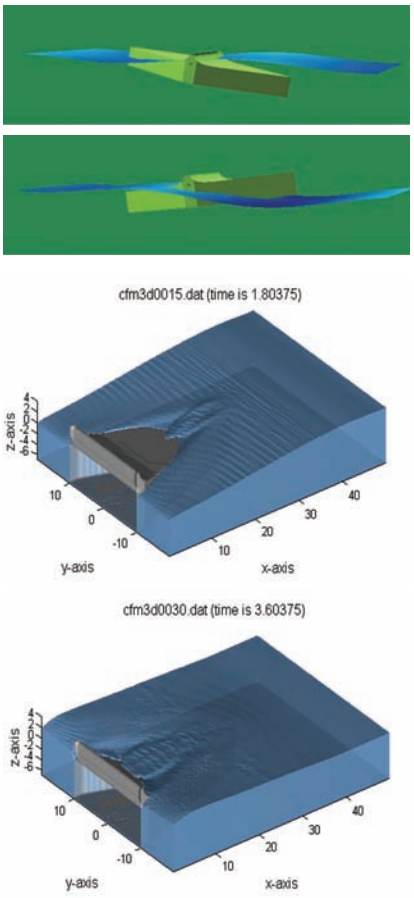
• PTO based on hydraulic cylinders delivering high pressures to smoothing accumulators. Hydraulic motors connected to these accumulators are used to drive an electric generator. This is often used in wave energy conversion systems.

• Linear PTOs based on direct-driven, stand-alone electric generators. The damping force produced in the PTO will have a linear relation to the PTO speed in case of a constant resistive load.

During scale model tests a flexible system is desired in order to simulate different PTO types and allow easy modification of settings. MARIN works with complete electric equivalents of PTO types using electric motors, feedback devices, digital controllers and dedicated software programs. These systems exert a realistic force on the structure as a function of motions and PTO characteristics. From an "electric point of view", these simulators will not produce real energy that can be used to predict full-scale figures. Therefore, damping forces and a complete set of structure motions are measured to determine the dissipated mechanical energy, independent of converter efficiency. In this way measurement and control technology work closely together to make PTO modelling possible in model scale testing.

Schematic model of a hydraulic Power Take Off and actual PTO in a test modeling its hydraulic characteristics.





Modelling of the Green water concept with diffraction theory and ComFLOW simulations