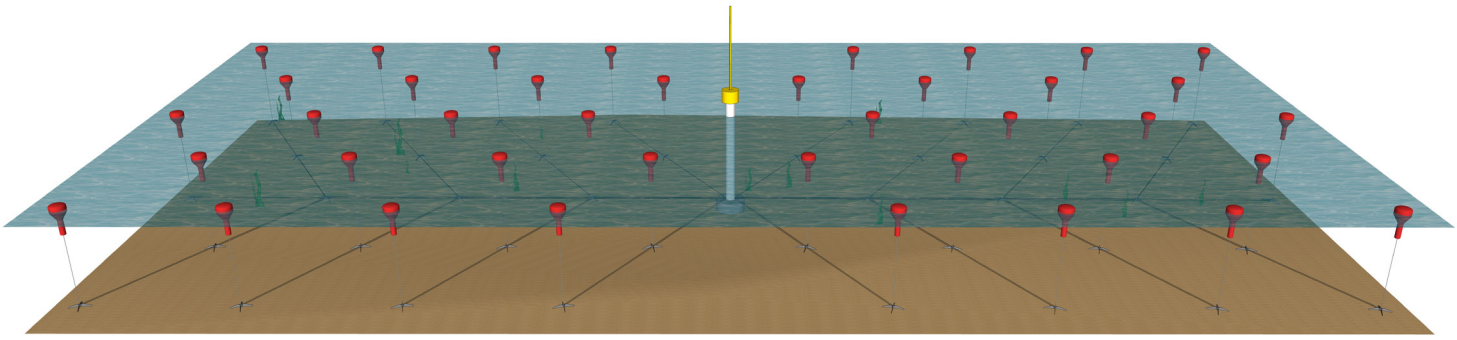
Hydraulic collection system for WEC developers with power smoothing and electricity generation in a central tower



Challenge

The main challenge in wave power is the large variation in size and energy content of waves. The peak power in a large wave is in the order of 30-40 times higher than in an average wave at the same site. Components in the system need to be sized for the peak power while revenue will be in proportion to the average power, the annual energy output.

The purpose of the power take-off in a wave energy converter (WEC) is to capture energy from the varying wave movements and convert it into electricity. Power is captured by applying a damping force against the movements of the buoy. The damping force that captures the most power depends to a large extent on the wave size. It is therefore essential that this force can be controlled and optimized for every wave.

The cost of components in the power take-off can be significantly reduced and the efficiency increased if the captured power is smoothed before the generator by an energy storage device. Such devices can however be very expensive and may also compromise the damping force control of the buoys, in which case the power capture performance is reduced.

WECs with hydraulic power take-offs often use a fixed displacement hydraulic cylinder in combination with hydraulic accumulators. The cost of hydraulic accumulators is however high, and the damping force cannot be controlled since it is dependant on the level of stored energy in the form of gas compression in the hydraulic accumulator. Hydraulic accumulators provide excellent power smoothing but increase the levelized cost of energy.

WECs with mechanical power take-offs can capture more than twice as much energy from the waves but often have limited energy storage capabilities to smooth the captured power before the generator.

OHT technology

OHT offers WEC developers and infrastructure partners:

- A high pressure fluid collection system for WECs with power smoothing and electricity generation in a central tower.
- A low-cost and efficient energy storage, in the form of a weight that is lifted with a rack and pinion drive inside the tower, providing constant pressure in the collection system and constant power output.
- PTO functionality which enables wave-by-wave damping force control in buoys. The hydraulic cylinder is replaced by a rack and pinion connected to a multi displacement pump arrangement.
- Reduced CAPEX and increased annual yield.

The collection tower is generic. Any WEC buoy can be adapted to connect to the hydraulic collection system. The tower can preliminarily be scaled up to 50-100 MW. A commercial size array will include several towers.

Partnering opportunities

OHT is during 2015-2016 developing a system design specification for a 10 MW demonstration array in cooperation with WEC developers, suppliers, test centers and research institutions. A test rig in the scale of 1:5 of the collection system and tower is planned for 2016-2017. Current cooperation opportunities include:

WEC companies: Evaluation of hydraulic collection, damping force control and gravity storage features for their WECs with hardware in the loop simulations in the test rig.

OEMs and Suppliers: Participation in subsystem design and integration in hydraulic, mechanic, and electrical systems.

Test centers and Research institutions: Participation in designing test programs, validation and benchmarking.

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Technology road map

2014 - 2015: An evaluation project to analyze the benefits of combining core technologies from the Swedish wave power companies Ocean Harvesting, CorPower and Waves4Power in a 1 MW array, comprising the OHT collection tower and 5 WECs. The project included evaluation of alternative system configurations, analysis of technical interfaces and functionality, development and integration of simulation models for collection system, tower and buoys, and simulations to generate data on annual production and load statistics of components in the systems. Key results included performance benchmarking for different control strategies and energy storage configurations, showing an increase of the annual power output by up to 5 times with detailed control of phase and damping force compared to a passive PTO.

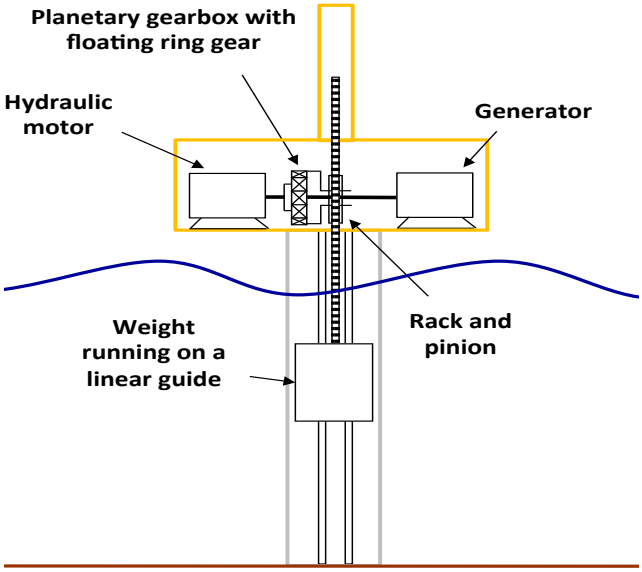
2015 - 2016: A new collaboration project with the same WEC developers was started in September 2015, with financing from the Swedish Energy Agency. The objective is to develop a system design specification for a 10 MW demonstration array comprising 40 buoys and one collector tower with OHT´s patented gravity storage technology. The project includes optimisation of the system configuration and component sizing for the lowest levelized cost of energy (LCoE) over a 20 year life cycle. A supply chain for the collection system will be established. OHT´s current small scale test rig will also be extended with a hydraulic link and connected to the simulation models for hardware in the loop simulations.

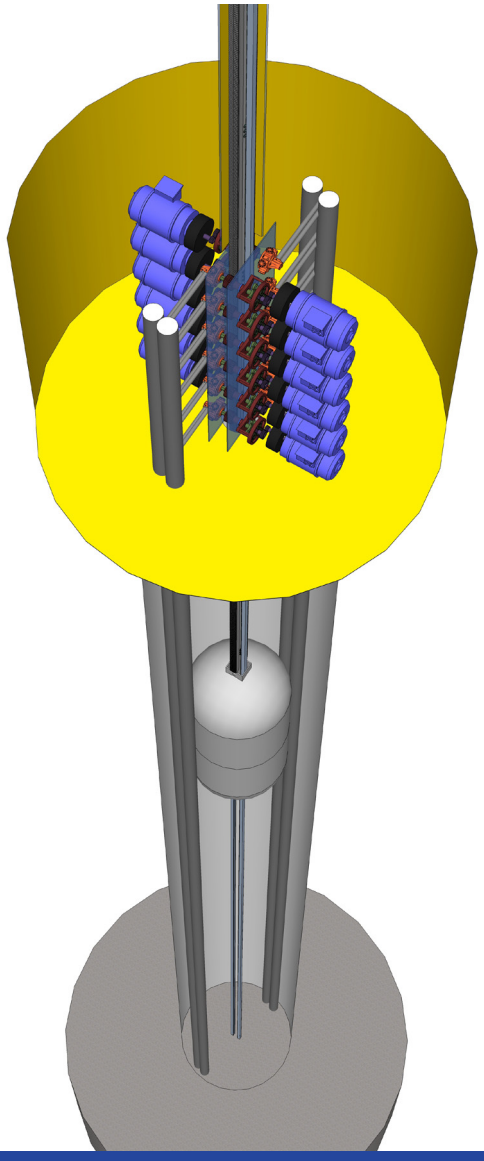
2016 - 2017: Design and build of a new test rig in scale 1:5 of the 10 MW WEC array with hydraulic collection from 2-5 simulated buoys giving input to servo motors connected to hydraulic pumps. The main objective is to prove the design for the collection system and the tower drive train.

WEC developers are invited to evaluate hydraulic collection, damping force control and gravity storage features for their buoys through hardware in the loop simulations in the test rig and other simulations in Matlab/Simulink.

2018 - 2019: Sea trials in the same scale with 2-5 WECs in an array at a European test center. The collection tower is planned to remain installed at the test bed after the sea trial, to allow other WEC developers to test and evaluate their WECs with OHTs hydraulic collection system.

2020- : A first 10 MW demonstration array project in collaboration with a WEC partner and an infrastructure partner.





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