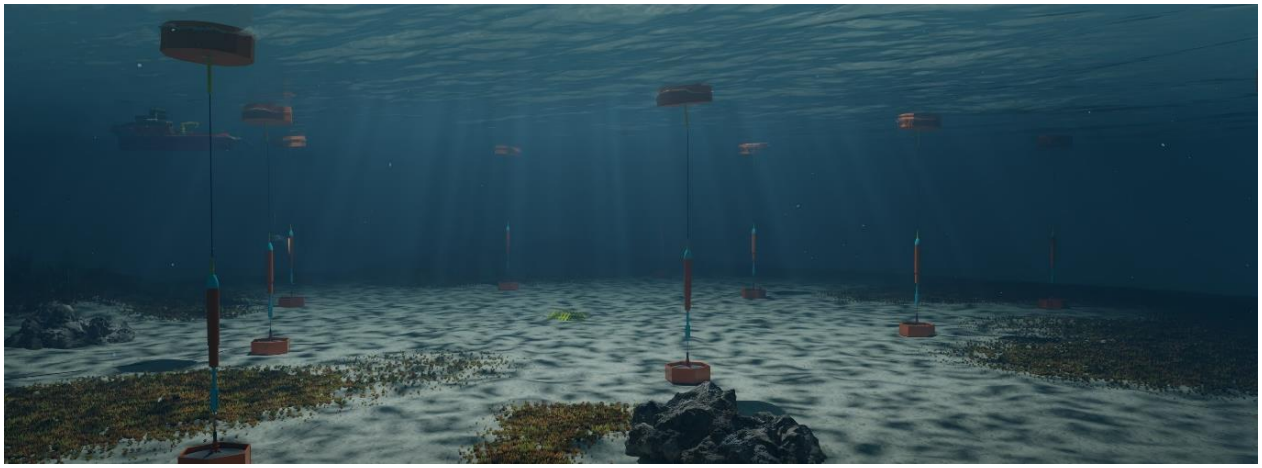
OCEAN HARVESTING

Generating Electricity One Wave at a Time

Cost of Material and CO2 Footprint 7x Lower per MW for Wave Power compared to Floating Wind Power

Karlskrona/Gothenburg, Sweden; 5 July 2023



InfinityWEC is a 500 kW wave energy converter with advanced control technology to maximize energy output from every wave, designed to use mainly low cost and low carbon materials. InfinityWEC is suitable for the same areas as floating wind power, in 80 – 200m water depth. A comparison of the material efficiency shows that InfinityWECs cost and CO2 footprint per MW installed capacity are 7x lower compared to floating wind power.

The Levelized Cost of Energy (LCOE) is the standard metric for renewable energy technologies. LCOE gives the complete picture for an installation and is derived from cost of equipment (CAPEX), operation & maintenance (OPEX) and annual energy production (AEP). Early-stage technologies must use assumptions and estimations of unknowns and learning curves, to compare LCOE with mature and established technologies such as offshore wind power, which already has several GW of power installed.

The material efficiency is an important complement to the LCOE to estimate the economic potential of renewable energy technologies. This is a straightforward metric to benchmark emerging technologies versus mature and established technologies. It assumes that cost per ton for each material is the same for all technologies, as well as the CO2 equivalent per ton. This makes it possible to calculate and compare the total cost and CO2 emissions of materials used per MW installed capacity.

Mikael Sidenmark, CEO, says: “The reason for the exceptional techno-economic potential of InfinityWEC is the combination of firstly using mainly low-cost materials such as concrete in the buoy and high-density ballast in the gravity base anchor, and secondly, the design of the power take-off with very high annual energy production per ton of steel.”

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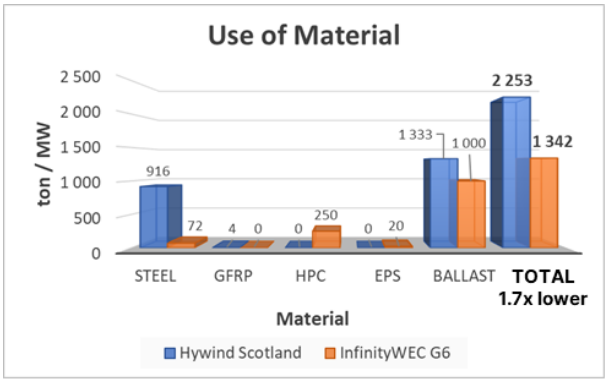
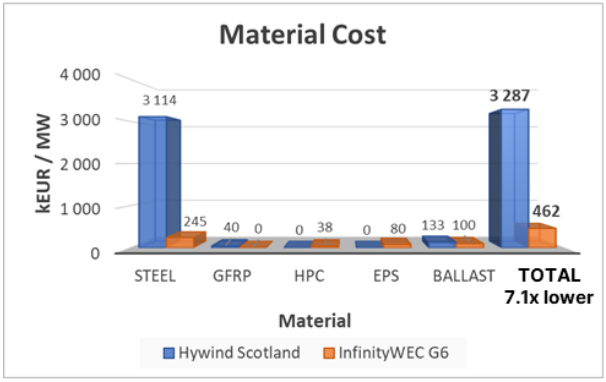
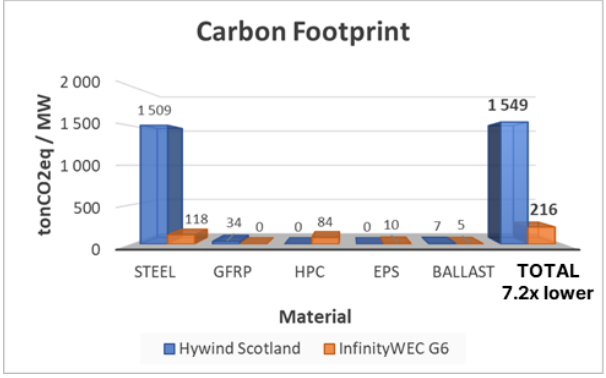
Material Efficiency - InfinityWEC vs Floating Wind Power

Material efficiency is derived from the amount in tons of each type of material used per MW installed capacity. These weights are then combined with the corresponding price and CO2 footprint per ton for each material.

InfinityWEC targets the same ocean areas as floating wind power, with installation depth of 80 – 200 m, and for this reason Hywind Scotland is used in this comparison. Hywind Scotland consists of 6 MW wind turbines and in this example it is compared to 6 MW clusters of InfinityWEC. Power export characteristics from an InfinityWEC cluster match the grid connection from a wind turbine. The comparison is therefore limited to the clusters / wind turbines since similar power export infrastructure can be used.







Compared to the floating wind turbines used in Hywind Scotland, it is estimated that both material cost and CO2 footprint per MW is about 7x lower for InfinityWEC:

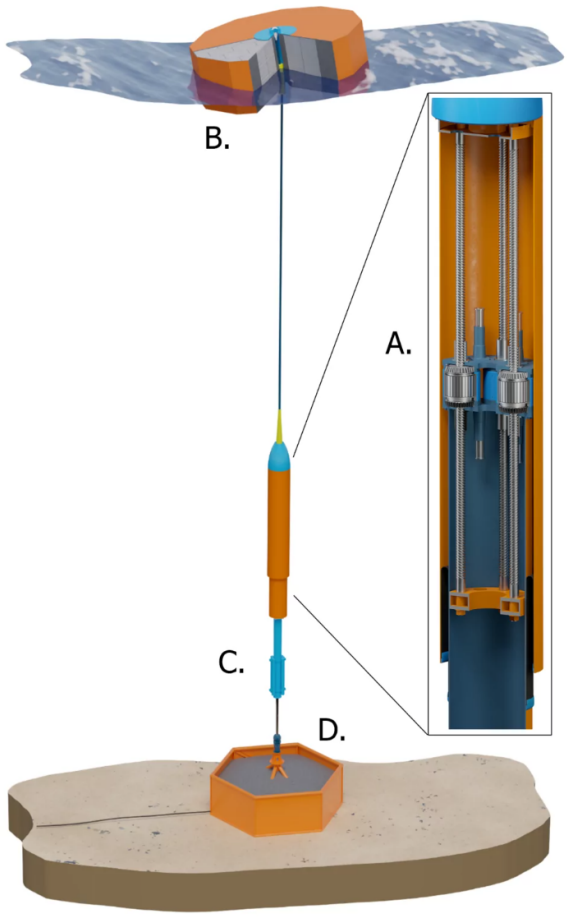
- The total weight of InfinityWEC is almost 2x less.
- InfinityWEC mainly uses low cost and low carbon materials.
- 75% of the total mass of InfinityWEC is ballast in the gravity base anchor, 20% is HPC and EPS in the buoy, and only 5% is steel, mainly used in the power take-off.
- The mass of floating wind turbines consists of 60% ballast and 40% steel, including the anchor. GFRP used in the wind turbine blades is only a fraction of the total weight.

Material Cost	**EUR/ton**
Steel	3400
High Performance Concrete (HPC)	150
Low Carbon Cellular Plastic (EPS)	4000
Glassfibre Reinforced Plastic (GFRP)	9500
Ballast (Magnadense)	100

Carbon Footprint	**tonCO2eq/ton**
Steel	1,640
High Performance Concrete (HPC)	0,335
Low Carbon Cellular Plastic (EPS)	0,480
Glassfibre Reinforced Plastic (GFRP)	8,100
Ballast (Magnadense)	0,005

Ref: Hywind Scotland - Environmental Statement
Ref: Hywind Scotland - Brochure

500 kW InfinityWEC Wave Energy Converter



A. PTO with Instant Force Control

A combination of ball screw actuators and a hydrostatic pre-tension system provides instant force control in the power take-off (PTO), enabling advanced control algorithms to increase energy output, reduce loads and improve reliability.

Ball screws convert linear motion and force into high speed rotatory input to direct drive generators/motors, providing high efficiency, high power density and high reliability.

The PTO hull is split in two halves, being pushed together by the surrounding water pressure close to the seabed. This way half of the PTO control force is provided "for free", reducing cost and improving overall efficiency.

Optimal Force Control

Predictive optimal control of the PTO force to maximize power output in every individual wave.

Depending on wave resource, the annual energy production is increased 25-50% compared with sea state tuned (non-predictive) optimal control.

B. Concrete Buoy

Buoy made as a honeycomb structure consisting of thin walls of high-performance concrete and EPS cores. Compared to steel:

Same weight, 4x lower cost, 3x lower CO2 footprint

Manufactured on site, 10x faster

Unsinkable, solid structure

C. Protection Spring

Soft end-stop spring in the form of a pre-charged gas accumulator integrated with the hydraulic tidal cylinder.

Maximum end-stop force reduced to half

Power produced also in storm conditions

D. Easily Deployed Anchor

Concrete anchor cage, easily deployed and then filled with ballast through a down pipe from a transportation vessel.

Manufactured on site

Low cost

About Ocean Harvesting and InfinityWEC

Ocean Harvesting is a privately held company with offices in Karlskrona and Gothenburg, Sweden. After years of research within the wave energy sector, the company started in 2017 to develop the InfinityWEC wave energy converter.

InfinityWEC is:

- **Efficient -** Breakthrough power take-off ensuring maximum power output from every wave in combination with a structurally efficient design.
- **Reliable -** Holding the buoy submerged through the crest of large waves to secure survival and enable continued power production also in the harshest wave conditions.
- **Scalable –** High volume roll-out enabled by centralized mass production of PTOs with a size suitable for efficient transportation, while buoys are manufactured on the site with locally sourced materials.
- **Ideal partner for Wind & Solar -** Producing power at different times, improving balance between electricity supply and demand. Shared infrastructure and operational costs.
- **Low Levelized Cost of Energy (LCOE) –** Annual energy production of 2 GWh per WEC estimated to 100 EUR/MWh at 100 MW deployed capacity and <35 EUR/MWh at 5 GW deployed capacity, highly competitive compared to all other energy production.

What makes InfinityWEC so competitive is the advanced power take-off system, which uses a combination of ball screw actuators and a constant pre-tension force using hydrostatic pressure, to provide instant control of the force applied on the buoy to control its motion (phase control) and capture energy. This enables the use of model based predictive force control, maximizing the electricity production from every individual wave, which dramatically increases the annual energy production compared to sea state tuned force control. A unique survival function holds the buoy submerged through the crest of large waves, protecting the system from excessive load and enabling electricity to be produced also in the most severe wave conditions.

InfinityWEC is engineered for sustainable large-scale production and effective logistics. InfinityWEC's prime mover (buoy) is made of concrete casted with locally sourced materials at the installation site in a process common in civil engineering, minimizing transportation. A special high strength and sustainable concrete mix has been developed in collaboration with RISE Research Institutes of Sweden, enabling a prime mover with equivalent weight to a conventional steel hull, but at 1/4 of the cost, a 1/3 of the CO2 footprint and which is 10x faster to manufacture.

The excellent performance and reliability, combined with a modular design where all critical parts are easily manufactured, transported, installed and maintained, make InfinityWEC a very competitive solution for the future global energy market.

The market for InfinityWEC ranges from utility-scale wave farms for electricity and hydrogen production to the power and H2-gas grid on the mainland, to off-grid power supply for island communities and other offshore industrial installations such as oil- & gas platforms and aquaculture.

Read more: oceanharvesting.com

About Wave Power

The estimated global theoretical potential of wave power exceeds the global use of electricity[1] and is available in coastal areas where most of the population lives.

Wave power produces electricity more consistently than wind and solar power, and therefore needs only half as much energy storage to balance electricity generation to a constant power level throughout the year, reducing the overall cost of balancing electricity supply and demand. In addition, electricity is produced at different times compared to wind and solar power, which helps to reduce variations and interruptions in the grid, further reducing the overall cost of electricity.

Wave power will be an important part of the future renewable energy mix, contributing both to lower cost of energy and a more stable energy system.

1. OES An International Vision for Ocean Energy 2017