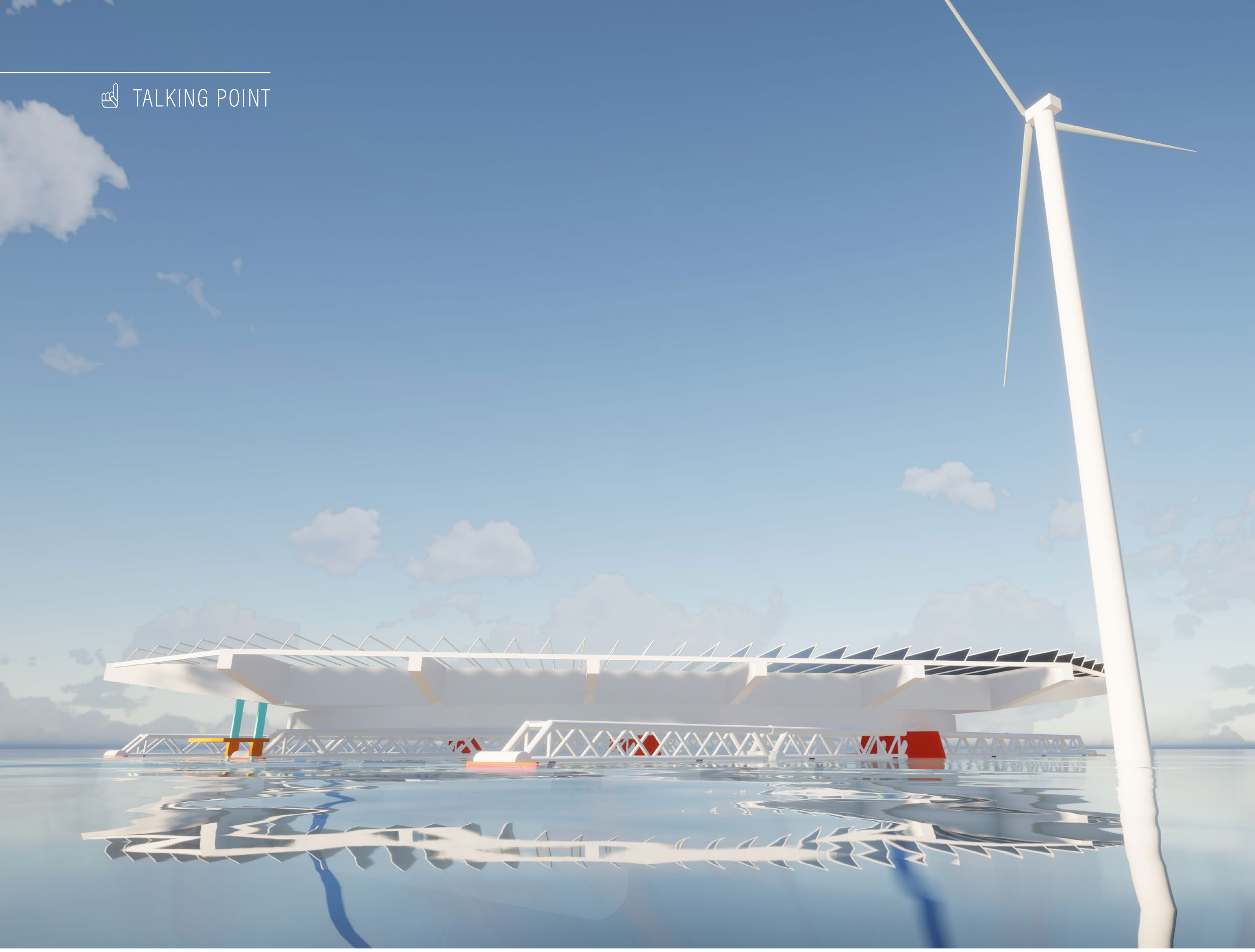


Green energy from the waves

The wave turbine, a pioneering project developed by the WUPROHYD design office, promises to tap into the vast energy potential of sea and ocean waves. This innovative renewable energy system is expected to have a capacity ranging from 2.5 to 3 terawatts, equivalent to 2,500,000 to 3,000,000 megawatts.

The WUPROHYD design office, the first of its kind in Poland, has conceived and patented an innovative prototype technology for harnessing sea wave energy to generate electricity.

Central to this technology is a sophisticated wave turbine, designed as a converter for harnessing the power of sea waves. Currently, the project has reached a Technology Readiness Level of RTL4, indicating that model tests have been conducted on two different profiles of the turbine rotor.

These tests have validated the anticipated rotational motion of the turbine rotor induced by the circular movement of water particles. Theoretical assessments have pegged the efficiency of the turbine at approximately 7%, making it well-suited for direct coupling with power generators.

Operation and construction

In the current categorisation of wave converters into terminators and attenuators, the wave turbine falls under the classification of a terminator. Positioned along the long side parallel to the wave crest or trough, it swiftly absorbs wave energy. Consisting of a rotor that revolves around a horizontal, fixed axis within a supporting structure, the turbine aligns parallel to the wave crest or trough.

Submerged below the water surface, the rotor operates seamlessly, leveraging the circulating movement of water particles to rotate smoothly. Its full rotation occurs within the period T of the wave, during which it captures both the kinetic and potential energies of the wave motion.

In Figure 2, phase 3 illustrates a depth equal to half the wavelength (h = L / 2), where the wave undulations vanish. Consequently, a significant portion of the wave energy flows beneath the converter turbine, rendering an approximate turbine efficiency of 7% deemed satisfactory.

Moreover, this efficiency could potentially increase further, as model studies are slated to optimize the rotor profile. To augment energy yield, multiple rows of turbines will be necessary, with each successive row capturing energy that eludes the preceding one. Essentially, this entails employing the terminator converter in an attenuating configuration.

Leveraging the wave-induced rotation of the turbine rotor offers a significant simplification in the process of converting wave energy into electrical energy. Direct coupling of the turbine rotor to a power generator via simple gearing facilitates this conversion.

This represents a considerable advantage over existing converters, which do not capitalise on the oscillating motion of wave water particles to drive power generators. Presently employed converters typically transform wave motion into either air or fluid motion, subsequently utilizing an air or water turbine to drive a power generator. Consequently, existing converters are intricate mechanical devices.

Figure 1 depicts the configuration of a converter using a novel wave turbine design, wherein a generator is mounted on the stationary axis of the turbine rotor and linked to it through a straightforward transmission system.

Hybrid offshore power plant guarantees reduced Levelised Cost of Energy

The use of sea wave energy remains largely underdeveloped. Currently, there are no installations that can be deemed offshore power plants in terms of installed capacity. Most are costly prototypes with low efficiency, capturing only a fraction of wave energy.

The primary hurdle in offshore energy development is the immense wave forces in marine environments, necessitating robust load-bearing structures for seabed or floating devices, along with complex converters. Given the challenging sea conditions, we've devised a solution: a floating offshore power plant, a sort of energy island. This innovation allows for the large-scale harvesting of sea and ocean energy resources in a simplified manner.

The invention is a floating structure, approximately 250 meters long and 200 meters wide, comprising three underwater hulls with a total displacement of 78,000 tons and a maximum draft of 20 meters. These hulls are interconnected by frames and anchored to reinforced concrete anchors on the seabed.

Between the hulls, multiple rows of horizontal axis wave turbine converters are positioned perpendicular to them. Automatic adjustment of mooring lines ensures the turbines align parallel to the wave crest or trough. The combined capacity of the installed wave turbines for Baltic Sea conditions is 1.6 megawatts.

To minimise investment costs, the energy island is equipped to harness energy from other renewable sources. This includes a sun-tracking rotating deck with 40,000 square meters of solar panels and a wind turbine generating 16 megawatts or more.

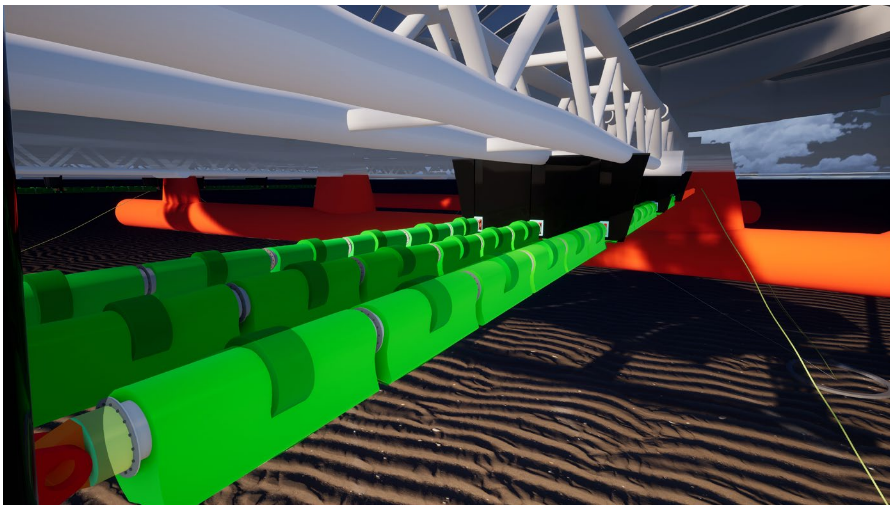


Figure 1: Visualization of the converter using a wave turbine

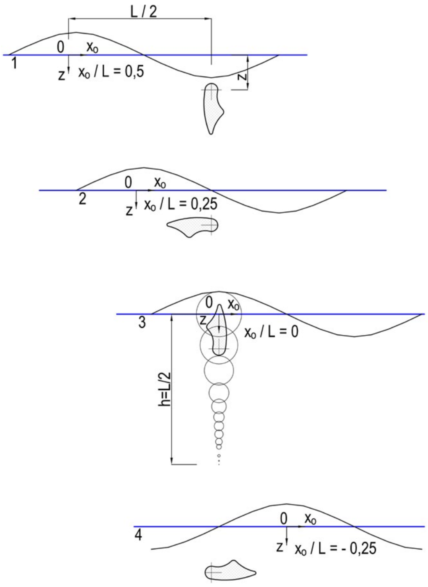


Figure 2: Phases of turbine rotor rotation under wave action

In the Baltic Sea, each module of this eco-friendly offshore power plant will have a minimum capacity of 21 megawatts. However, in the North Sea, where wave energy is more abundant, the minimum capacity could reach up to 34 megawatts per module.

Manufacturing technology

The load-bearing structure of the energy island is engineered to be self-erecting and affixed to reinforced concrete anchors. This design offers a clever solution, as it allows for assembly and outfitting to a significant extent in a dry dock. Considering its dimensions when fully open, constructing the structure in an open position would be impractical.

This approach minimises the costs associated with installing the energy island at sea, reducing reliance on expensive floating cranes and tugs to only essential needs. For handling smaller equipment components, the structure is equipped with a crane capable of traversing along tracks mounted on its trusses.

Furthermore, the exceptional stability of the three-hull structure decreases downtime due to adverse weather conditions, during offshore operations. Practically, the manufacturing process only necessitates a pontoon and tug for transporting the equipment elements that weren't pre-installed in the dock.

Additionally, the reinforced concrete anchors are designed to be buoyant. Upon reaching their destination, they will be submerged by filling their ballast tanks with water. If required, the anchors can be raised by expelling water from the ballast tanks using compressed air.

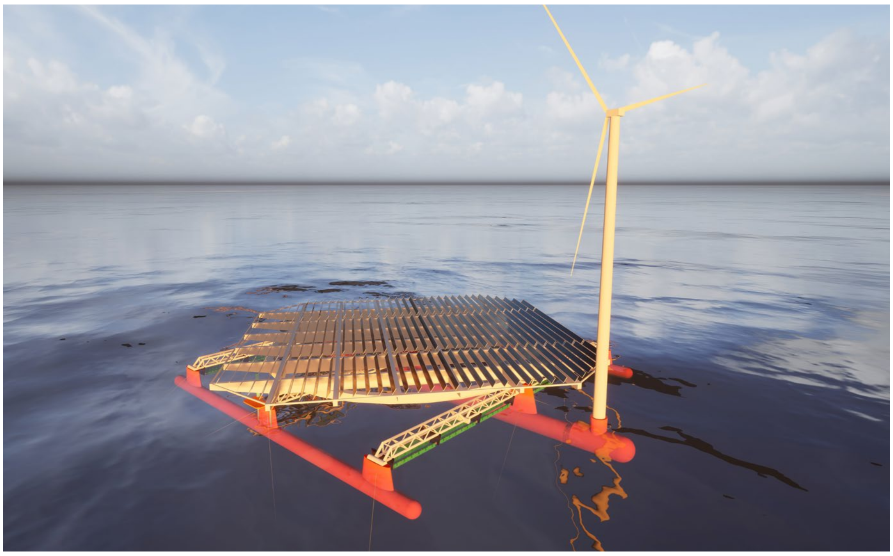
Advantages of the proposed solution

The energy island exhibits several distinguishing characteristics. This includes a reduction in the Levelised Cost of Energy (LCOE) in comparison to other floating structures relying solely on wind and solar energy. Moreover, it generates electricity predictably and steadily from three independent renewable energy sources.

Constructed using 'floating' technology, the energy island uses floating platforms instead of traditional foundation solutions employed for seabed wind turbines. This design allows for independence from water depth, enabling effective operation regardless of depth variations. Consequently, extending depth merely requires lengthening mooring lines, obviating the necessity for a more robust foundation structure.

Additionally, the energy island can be positioned at significant distances from the shore and at considerable depths to minimize visual impact on the landscape. The primary cost associated with this placement pertains to laying longer cables rather than necessitating a more substantial foundation structure.

Furthermore, the island facilitates optimal operation of photovoltaic panels at lower temperatures, enhancing efficiency and enabling increased energy production through a sun-tracking system, which is economically unfeasible on land.



Offshore power plant module: General view

Its high displacement capacity also allows for the production of green hydrogen. Lastly, by harnessing the energy of sea wind waves, the island can serve as a protective barrier for coastal areas.

Energy from the sea

The seas and oceans cover approximately two-thirds of the Earth's surface, harbouring an estimated wave power of around 2.5 to 3 terawatts (TW). This abundance underlines the significance of sea wind waves as a substantial renewable energy source. Integrating such a vast resource into the renewable energy system promises to enhance stability and predictability of production, consequently reducing the need for extensive energy storage capacity.

The technology developed by WUPROHYD in the conceptual phase is dedicated to unlocking these immense energy resources for practical use.

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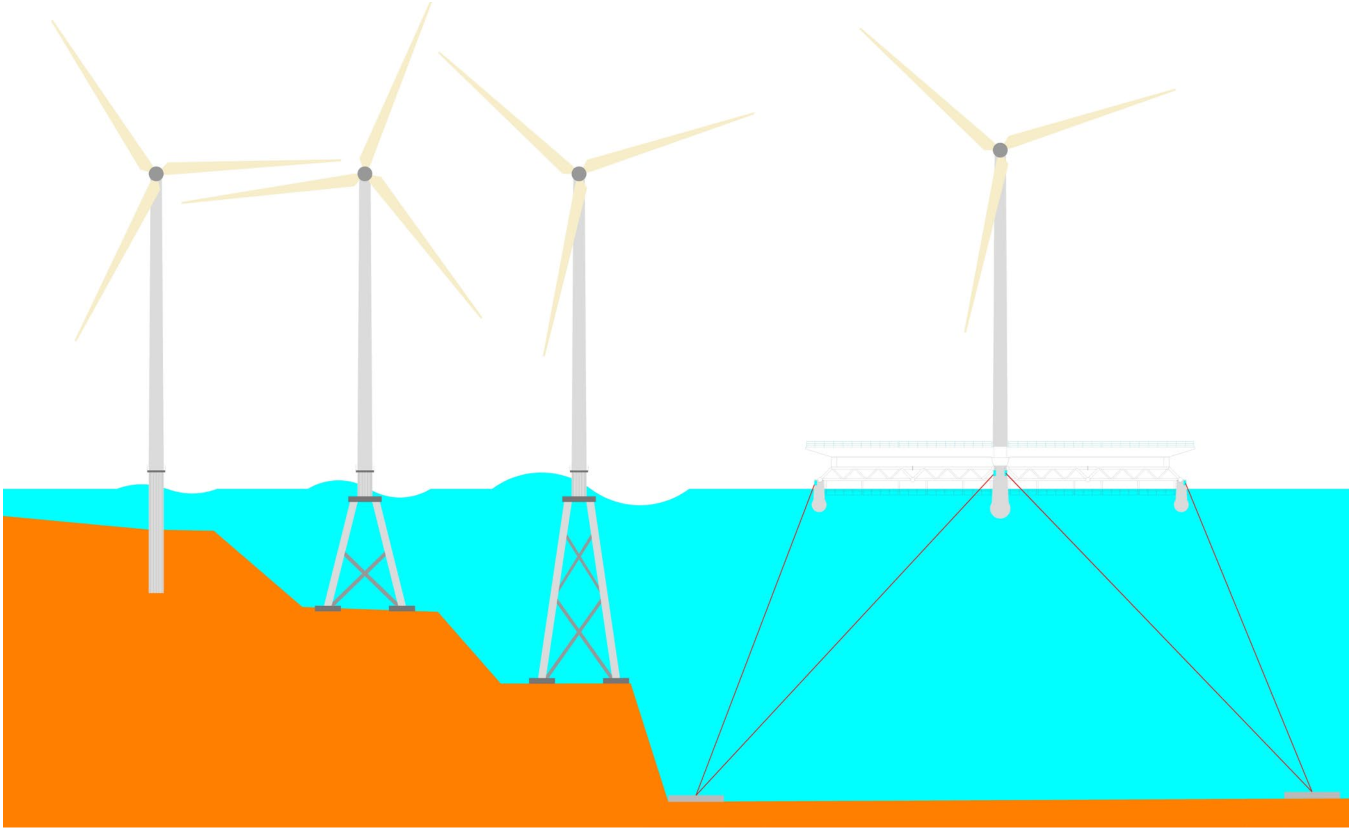

Advantages of floating technology