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The Potential of Wave Power

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Wave energy – potential and pitfalls



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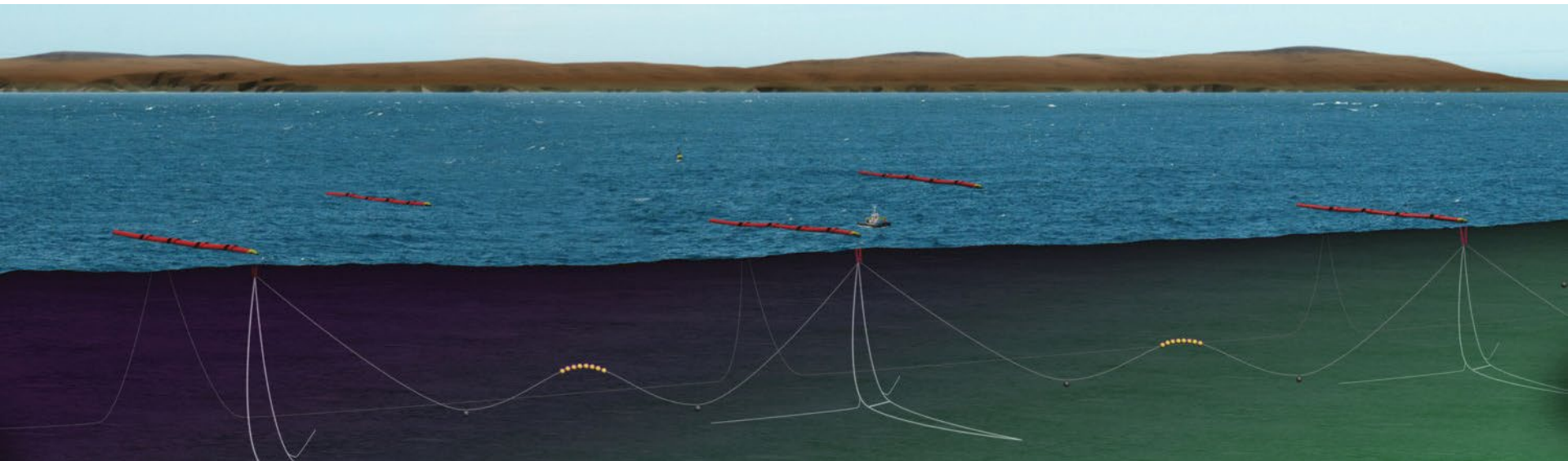
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Introduction to wave power

- Wave energy is a form of hydroelectric energy harnessed from the motion of waves
- Waves rolling through the ocean create kinetic energy which can be used to power turbines
- Wave power has far greater energy density than wind or solar, generating up to 24-70 kW per meter of wave, with peak near-shore power ranging from 40-50 kW per meter
- The global wave resource is estimated to be 2 terawatts (TW) of energy, which is the equivalent of world's electricity consumption.



Setting the scene – how much of renewable energy is recoverable

Resource Resource Recoverable

Solar 90,000 TW 1000TW

Wind 1200 TW 10TW

Tides 3 TW 0.1TW

Wave 3 TW 0.5TW

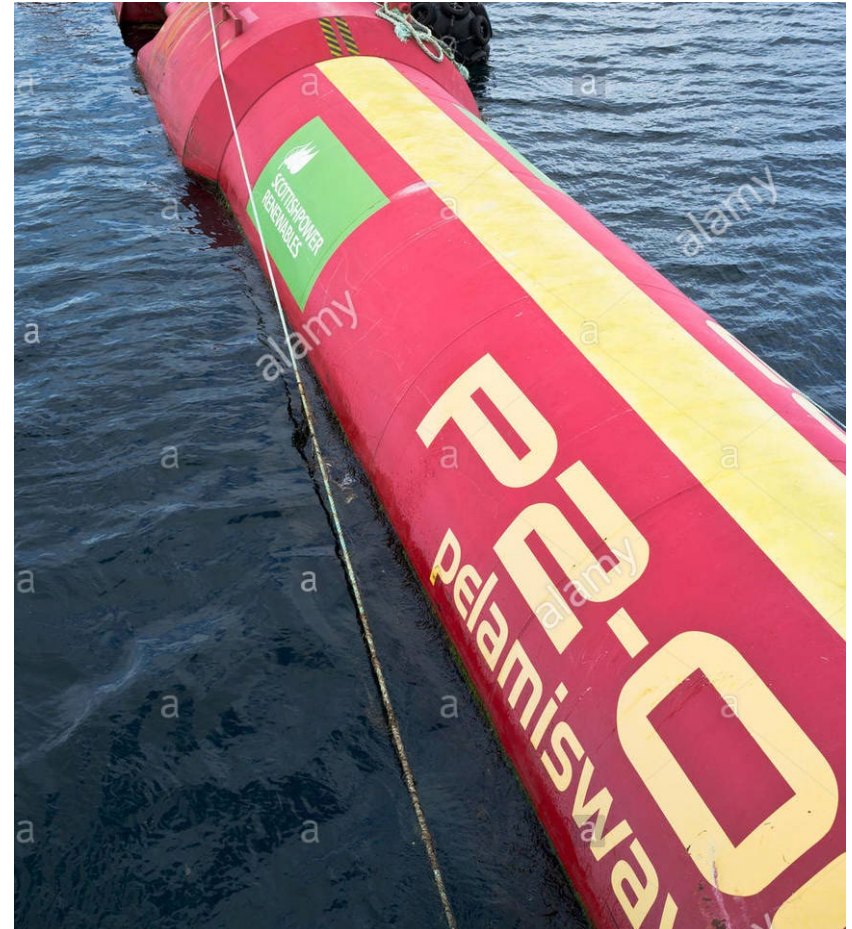
- Primary energy availability - 555.8 exajoules
- However, not all of the available resources can be recovered



Types of wave machines

Some examples

- Wave attenuator - e.g., Pelarmis
- Point absorber
- Oscillating wave converter
- Oscillating wave columns
- Over topping terminators



Wave Power Potential & Pitfalls

A vast resource –
oceans cover 71%
of the earth

Optimal
characteristics –
modular and widely
available

Environmentally
friendly – no waste,
pollution or harmful
by-products

Evolving
technologies

Intermittency
issues

Seasonal
variations and
technology
adaptability

Grid connection

Operating
difficulties

Out of the “valley of death” – Part I

Current wave energy contenders face an uphill struggle from increasingly cheaper wind and solar power

It remains challenging to harness wave energy or convert it into electricity in large volumes

Achieving bankability requires a long and consuming verification and certification process to ensure technology is reliable

As of yet, no single optimal device

Size – current focus on wave energy farms over 20MW

Out of the “valley of death” – Part II

Expensive O&M – operational expenses can account for up to 10% total investment cost

Consistency of supply in sufficiently large amounts remains a challenge

Government subsidies and policies favouring wave energy development will be necessary to support R&D, build demand and drive down costs

Need a clear system governing marine spaces and marine resource management rights allocations

Environmental and aesthetic challenges

Regulatory landscape in the US

- Federal Energy Regulatory Commission (FERC) – regulates marine and hydrokinetic projects as an extension of power under the Federal Power Act to regulate and license hydroelectric projects on navigable waters
- Bureau of Ocean Energy Management (BOEM) – regulates marine projects on the outer continental shelf
- Marine energy projects require FERC authorization unless exempted due to experimental, short-term deployment with no effect on interstate commerce
- Optional preliminary permit to secure first rights to a license application for a specific site for study in state waters
- Progress reports every six months to maintain permitting
- Construction and operation of a project cannot begin until a FERC license is issued, and the FERC will not issue an official license until BOEM has issued a lease for a project
- In February 2021, BOEM issued a lease for the first wave energy research project in federal waters offshore of the US West Coast – PacWave

Funding and R&D



Department of Energy Funding

- In July 2021, DoE announced a USD 27 million funding programme for wave energy R&D
- \$15 million for the testing of wave energy convertor tech;
- Up to \$7 million for wave energy R&D;
- Maximum of \$5 million assigned to the advancement of wave energy converter designs for PacWave.



PacWave

- Oregon State University led project
- The first full-scale, utility-grid-connected wave energy test site in the US.
- Consists of two sites, each located just a few miles from the deep-water port of Newport, Oregon on the Pacific Ocean.
- Eligible projects will be tested at PacWave

Examples of Projects Being Developed



Atargis Energy

- Founded in 2010 after initial research conducted at the US Air Force Academy
- Technology gets 95% or more of the wave energy
- Potential utility-scale generation per system and low LCOE – competitive with wind and solar
- First systems at 2.5MW each



CalWave Power Technologies

- Piloting a wave energy converter technology off the pier of the Scripps Institute of Oceanography in September
- The first-ever in-sea demonstration of a fully submerged wave energy system in California
- Funded by a DOE development contract and lined up for PacWave.

Questions?

Wave Energy – Potential and Pitfalls



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The Potential of Wave Power

by Marcella Burke and Evelina Petraviciute

Wave power is a type of hydroelectric power that relies on the capture of energy held by ocean waves. Like wind and solar power, wave power has the potential to be a valuable part of the energy transition.

The potential of wave power lies in the immense amount of kinetic energy at stake. Wave power has far greater energy density than wind or solar. It generates up to 24-70 kW per meter of wave, with peak near-shore power ranging from 40-50 kW per meter. The world's total wave resource has been estimated to be as much as 2 terawatts (TW) of energy—the equivalent of world's electricity consumption.[1] The annual energy potential off the coast of the United States (US) alone is approximately 2.640 terawatt hours per year, which is equivalent to 65% of US annual electricity consumption.[2]

Ultimately, the question that will determine the role of wave power in the energy transition is how much of it can actually be recovered and harnessed into power. At present, that estimate is understood to be around 0.5TW.[3] The reasons for this include developing a system that can cope with extreme conditions of the open waters, as well as the high costs associated with wide scale deployment. The projections of worldwide installation capacity are also varied. While the Ocean Energy Systems assessments project the worldwide installation capacity of 337 gigawatts (GW) by 2050, International Energy Agency (IEA) estimates a 63 GW installation capacity by the same year.[4]

Wave power energy generation is in a comparative state of infancy to wind or solar. Several different types of wave energy converters are being tested extensively at kW scale. One of the

better-known technologies is an attenuator, which is a floating offshore device consisting of five separate sections with four flexible joints. Ocean waves make the panels flex, which in turn pump hydraulic oil into high pressure accumulators. This turns a hydraulic motor and generates electricity. Pelamis, the first offshore WEC to generate capacity into the grid, is the perfect example of this technology. Although Pelamis did not enjoy commercial success, the peak power of a single attenuator is estimated to be around 750kW (this can vary drastically depending on the location).

Other examples of WECs include oscillating wave columns and oscillating wave converters (with the latter often being shore based), as well as point absorbers and over topping terminators—a plant in Toftestallen, Norway built in 1985 is an example. The Toftestallen plant operated for three years before being destroyed by a severe winter storm in 1988.

PRIVATE SECTOR INVESTMENT

While private sector investment has been largely earmarked for tidal energy and offshore wind farms, there has been a notable increase of activity around wave energy power generation. This includes pilot projects, patents, ocean wave resource assessments and deployment of new WEC technologies.[5] Large utility companies, such as France's EDF and Spain's Iberdrola, along with engineering firms including ABB Group and Mitsubishi Heavy Industries, have recently entered the wave energy market. Indeed, a report by IRENA estimates that installed wave power capacity has reached 2.31MW in 2020 and another 100MW is expected to be added in the coming years.[6]

The US issued its first ever wave energy lease for federal waters off the West Coast in February 2021. The research lease concerns a proposed \$80 million open ocean wave energy test center near Oregon. It is expected to cover approximately 2.65 square miles and will consist of four test berths supporting the testing of up to 20 WECs, with an installed capacity of up to 20 MW. This is a significant development which follows the assessment completed towards the end of last year by the Pacific Northwest National Laboratory, which identified the coastlines of Washington and Oregon as the most promising areas for extracting clean power from the West Coast waves.

The United Kingdom (UK) is also at the forefront of the global wave energy sector. Organizations such as the UK Marine Energy Council, Scottish Renewables and the European

Marine Energy Centre, are aiming to secure revenue support and create a more accessible way forward for the sector. According to a report by Scottish Renewables issued in 2019, the UK now has 23 wave developers.[7] Given its net zero targets for 2050, exploitation of marine energy resources, including wave power, is likely to play a growing role in reducing emissions.

In Europe, developers focus their efforts on piloting wave power technology on a smaller scale, with the aim of pushing it towards greater economic competitiveness. The Swedish company Eco Wave Power, for example, in 2014 launched its trial project in Israel, which generates 100 kW for the country's grid. In 2019, it partnered with EDF and now appears to target future projects in Morocco, Vietnam and Australia.

KEY CHALLENGES

The harnessing of wave power is still an emerging technology. Owing to its optimal characteristics, such as the modular nature of devices, wide availability of resource and low emissions, it attracts interest from both the energy industry and academia globally.

However, due to its complexity, no single device design has emerged as optimal. As such, although wind technology boasts a sustained degree of R&D and investment, wave power continues to lag behind.

Among the core obstacles facing the wave power industry is developing technology which is capable of withstanding harsh environmental conditions and extreme ocean weather, energy storage, and consistency of supply in sufficiently large amounts.

Size density of WEC systems is another challenge. The focus here is on building wave energy farms capable of demonstrating capacity upwards of 20 MW, while utilizing new technology that occupies minimum space yet provides a sufficiently large output.

WECs are also expensive to maintain. In fact, it has been estimated that the operational expenses can account for as much as 10% of the total cost of investment.[8]

Innovation is not just a matter of developing new devices; it also relies on the development of new policies allowing deployment of innovations to the market at a rapid enough speed.[9] To that end, a clear system governing marine spaces and marine resource management rights

allocation is crucial to increase investor confidence and facilitate eventual commercialization of this technology.

WHAT'S NEXT FOR WAVE POWER?

Ultimately, the degree of private sector investment, including debt financing, is going to depend on the bankability of these projects. This in turn depends on a favorable policy landscape, reliable forecasts, demonstrable efficiency and steadiness of supply. While the comparable novelty associated with the sector provides challenges to success, the global efforts to accelerate transition to net zero are giving wave power generation a new lease on life.

Provided that reliable technology, methods of forecasting and cost-efficient operations can be established, the road ahead could be exciting. To that end, companies such as Eco Wave Power are already driving technology innovation, including developing software to monitor wave power generation in real time, which should help enable rapid commercialization.[10]

[1] BARSTOW, STEVE & MØRK, GUNNAR & MOLLISON, DENIS & CRUZ, JOÃO. (2007). THE WAVE ENERGY RESOURCE. 10.1007/978-3-540-74895-3_4.

[2] DOE, U.S., 2015. QUADRENNIAL TECHNOLOGY REVIEW 2015. US DEPARTMENT OF ENERGY, WASHINGTON, DC.

[3] CRUZ, J., 2007. OCEAN WAVE ENERGY: CURRENT STATUS AND FUTURE PRESPECTIVES. SPRINGER SCIENCE & BUSINESS MEDIA.

[4] MWASILU, F. & JUNG, J. 2019, "POTENTIAL FOR POWER GENERATION FROM OCEAN WAVE RENEWABLE ENERGY SOURCE: A COMPREHENSIVE REVIEW ON STATE-OF-THE-ART TECHNOLOGY AND FUTURE PROSPECTS", IET RENEWABLE POWER GENERATION, VOL. 13, NO. 3.

[5] EY: 'OCEAN ENERGIES, MOVING TOWARDS COMPETITIVENESS: A MARKET OVERVIEW' (ERNST AND YOUNG, FRANCE, 2016)

[6] MATTHEW FARMER, 2021, HOW CAN REAL-TIME DATA HELP WAVE POWER DEVELOPMENT?,

[HTTPS://WWW.POWER-TECHNOLOGY.COM/FEATURES/HOW-CAN-REAL-TIME-DATA-HELP-WAVE-POWER-DEVELOPMENT/](https://www.power-technology.com/features/how-can-real-time-data-help-wave-power-development/)

[7] UK MARINE ENERGY 2019, [HTTPS://WWW.SCOTTISHRENEWABLES.COM/ASSETS/000/000/427/UK_MARINE_ENERGY_2019_ORIGINAL.PDF?1579622626](https://www.scottishrenewables.com/assets/000/000/427/UK_MARINE_ENERGY_2019_ORIGINAL.PDF?1579622626)

[8] ASTARIZ, S., IGLESIAS, G.: 'THE ECONOMICS OF WAVE ENERGY: A REVIEW', RENEW. SUSTAIN. ENERGY REV., 2015

[9] GATES, B., 2021. HOW TO AVOID A CLIMATE DISASTER. 1ST ED. NEW YORK: ALFRED A. KNOPF.

[10] MATTHEW FARMER, 2021, HOW CAN REAL-TIME DATA HELP WAVE POWER DEVELOPMENT? [HTTPS://WWW.POWER-TECHNOLOGY.COM/FEATURES/HOW-CAN-REAL-TIME-DATA-HELP-WAVE-POWER-DEVELOPMENT/](https://www.power-technology.com/features/how-can-real-time-data-help-wave-power-development/)

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