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A Brief Account of the Latest Developments in Wave Power Generating

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ABSTRACT:

Earth has been telling mankind for decades that there are other methods to generate power than burning fossil fuels, which emit hazardous chemicals into the ecosystem. Energy usage is expected to increase significantly during the next decade. We are transitioning to solar and wind power for energy generation to address this issue. However, both have significant limitations, including little possibility for continuous power generation. Wave energy may be viewed as a viable clean energy resource with considerable potential for continuous power output. The paper provides an overview of wave energy conversion. The study goes on to describe the most recent advancements in wave energy converters (WECs), design optimization, and hybrid systems that aim to improve durability, lower prices, and boost energy capture efficiency

Keywords: Archimedes Wave Swing, Water Surge Converter, General Hydraulic System.

1. INTRODUCTION

The development of green energy and the extension of new energy supplies has become a global goal for addressing environmental pollution, global warming, and energy depletion issues caused by the use of traditional fossil fuels. Wind and solar the two most common renewable energy sources, have been widely developed across the world as an alternative to traditional fossil fuels. Marine renewable energy has emerged as a new development focus due to its environmentally friendly, low-carbon, and clean qualities. Making full use of marine renewable energy can assist in addressing not just environmental problems but also other challenges. Sea waves are the most potent energy carriers in renewable energy sources since they show a wealth of energy sources throughout all geographical regions. Scientists think that ocean waves can generate 2 Terawatts (TW) each year over the planet. Wave energy is estimated to be 8 × 106 Terawatt hours (TWh) per year, or 100 times the plant's entire hydroelectric capacity. In addition, with around 7500 km of shoreline, India has an average potential of 14 kW/m. Even with 10% utilization, the energy output might be anywhere between 3750 × 103 and 7500 × 103 kW [4]. The first investigation of large-scale tidal waves began in 1924 on many islands, using electric stations, ship locks, and powerhouses [5]. The development of wave energy conventions has been ongoing for many years. The produced gadgets come in a variety of kinds and sizes. This frequently results in expensive processes for big and complex devices. Larger gadgets that generate a lot of energy perform better than smaller devices. There are just a few WECs that can improve their energy generation, as opposed to wind energy, which can be increased by increasing the swept area. This is because WECs have an ideal size from the start, making further product development difficult [6-13]. As we all know, wave motion is quite arbitrary. As a result, there must be a system that utilizes and converts the unpredictable input into a consistent and steady output in the form of electricity. The forces of the waves are absorbed by an absorber, potentially a buoy. This absorbed energy can be transformed immediately into electricity using a Linear Permanent Magnet Generator or in stages using Hydraulic and Mechanical transducers. These converters should be chosen based on parameters such as life, durability, dependability, efficiency, and so on. The WEC's generating system is the subject of continuing study, to increase the overall System efficiency. Another significant thing to consider while developing a WEC is the site of implementation, as needs and restrictions must be met.

1.1 Energy Storage

The energy generated throughout the process should be stored in an appropriate storage device. Storage devices can be short-term or long-term, depending on their intended function. Storage devices include capacitors, supercapacitors, and superconducting magnetic energy storage. Capacitors for energy storage include electrolytic, film, and ceramic capacitors. Ceramic capacitors, despite their high frequency and low equivalent resistance, exhibit poor aging characteristics. Electrolyte capacitors (SC) are commonly employed for storing significant amounts of electricity due to their high capacity compared to other capacitor types. Electrolytes are commonly used to stabilize bus voltage and reduce power fluctuations in DC-link programs on power converters. Electrolytes are suitable for wave energy generation due to their ability to generate significant power variations. Super Capacitors discharge their stored energy quickly and completely. Supercapacitors may attain capacitances up to kilo Farad but at a considerable cost. Superconducting magnetic energy storage is a short-term storage system that uses a coil built of superconducting material. When cooled below a threshold temperature. To display superior conduct. Current flowing through a coil stores energy in its magnetic field. Energy may be stored for all time, and the current remains stable until the temperature falls below a certain level. Superconducting magnetic energy storage is still under development and is more costly than other energy storage methods. The refrigerator is a key component that contributes to the susceptibility of the strong wave climate. It also requires more room and mechanical maintenance.

1.2 Benefits

Using waves for renewable energy provides multiple benefits over other techniques of energy generation, including

- Sea waves have the highest energy density among renewable sources. Winds and solar energy combine to create waves. Solar energy intensity is generally 0.1- 0.3 kW/m2 horizontal surface yields an average power flow intensity of 2-3 kW/m2 in a vertical plane perpendicular to the direction. propagation just below the water's surface.
- Wave energy fluctuates seasonally and connects with power consumption in cooler climates.
- Wave power devices may create electricity up to 90% of the time, whereas wind and solar power devices only produce 20-30%.

1.3 Challenges

To realize the benefits listed above, several technical challenges need to be overcome to increase the performance and hence the commercial competitiveness of wave power devices in the global energy market.

1. Converting slow (~0.1 Hz), unpredictable, and high-force oscillatory motion into a generator with adequate output quality for the utility network is a considerable issue. Waves' power levels fluctuate based on their height and time.
2. To collect the energy of offshore waves, wave devices must be symmetrical due to their extremely changing direction. Wave paths near the beach are typically predictable due to natural reflection and reflection.
3. The Wave energy converter has to survive storms and the salinity of the ocean.
4. The high initial cost of fabricating a WEC and proper maintenance is key.
5. Large WECs may be seen as a disruption to marine animals.
6. Still these technologies are of high cost and more development is necessary.

2. LITERATURE REVIEW

2.1 POWER TAKE-OFF METHODS

Energy capture methods vary by device, although typical high-speed rotary generators are the most common way to generate electrical power (excluding linear electrical production, which is covered later) [19]. WECs present an enormous problem in driving their generators. To connect heaving- and nodding-type devices to traditional rotating electrical machines, a transmission system is necessary [20]. This section introduces several types of rotary generators and provides an overview of energy transmission mechanisms. This covers turbine transfer, hydraulic conversion, and direct electrical linear generators. which could be considered as a competing technology. These different PTO mechanisms are shown in Fig 1: power take-off (PTO) Mechanisms.

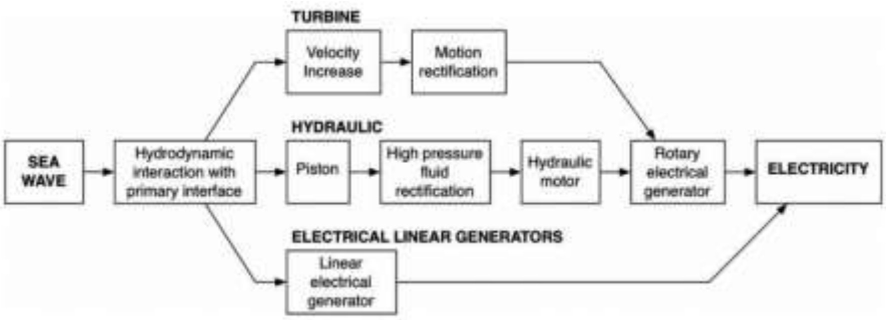

Fig 1: PTO Mechanisms

2.2 Rotor generator types

On-line synchronous generators (SGs) in traditional power plants operate at a steady speed to match the grid frequency. Depending on the conversion mechanism, wave energy producers may need to handle fluctuating speeds. Generators are classified into four types: doubly fed induction generators (DFIG), squirrel cage induction generators, permanent magnet SGs, and field would SGs. Generators in oscillating water column (OWC) systems generally work at varying speeds. This application has parallels with well-established wind turbine technology. Wind turbine generators, such as DFIG with a gearbox and direct drive low-speed SG with specific power electronics, may be suitable for usage in OWC WECs. According to O'Sullivan and Lewis' analysis, SGs are the preferred alternative owing to their higher energy yield, weight, and controllability, despite the need for a complete frequency converter between the generator and the grid. The DFIG has a big drawback in that it requires maintenance and is not brushless, which is a serious concern in offshore wind energy projects.

Ear SG allows for the direct conversion of mechanical energy into electrical energy. The electric direct drive PTO, as shown in Fig. 8, is a simpler alternative to hydraulic systems since it eliminates intermediary stages between the primary interface and the electrical machine. Conventional electrical machines require high-speed rotating motion for operation. These machines have high airgap speeds (up to 60 m/s) that enable quick flux changes. Linear oscillatory motion from a WEC is projected to peak at roughly 2 m/s [15]. The wind power sector is focusing on direct drive generators to replace large and inefficient gearboxes. The direct drive generators have an airgap speed of 5-6 m/s. Developing linear electrical generators necessitates ongoing study into slow-speed machinery. shown in Fig 2: a linear electrical generator based on a permanent magnet generator.

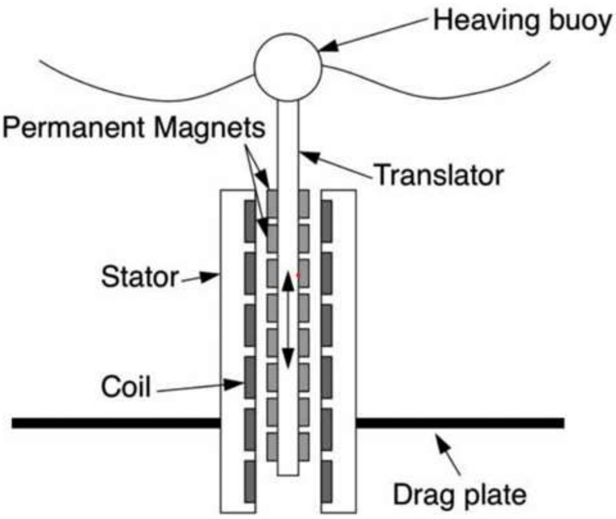

Fig 2: A linear electrical generator based on a permanent magnet generator

3. Modes of operation

Within the categories identified above, there is a further level of classification of devices, determined by their mode of operation. Some significant examples are given below.

3.1Submerged pressure differential

The submerged pressure differential device absorbs waves by using the pressure difference between their crests and troughs. The system consists of two parts: a fixed air-filled cylindrical chamber on the seabed and a moving top cylinder. When a crest passes over a device, water pressure compresses the air within, causing the top cylinder to move downward. When a trough passes over, the water pressure on the mechanism decreases and the top cylinder rises. The device has the benefit of being submerged, which protects it from severe slamming forces and lessens its visual effect [2]. The gadget may require maintenance. These devices are typically found nearshore since they are partially connected to the seabed. Figure is an artist's concept of the Archimedes Wave Swing. Shown in Fig: Submerged pressure differential: the Archimedes Wave Swing

3.2 Oscillating wave surge converter

An oscillating wave surge converter consists of a hinged deflector (a terminator) that travels perpendicular to the wave path, utilizing the wave's horizontal particle velocity. It is widely assumed that hanging the paddle at the bottom would better match the velocity of the water particles due to the exponential decline in water particle motion with depth of submergence (Scher 1985).

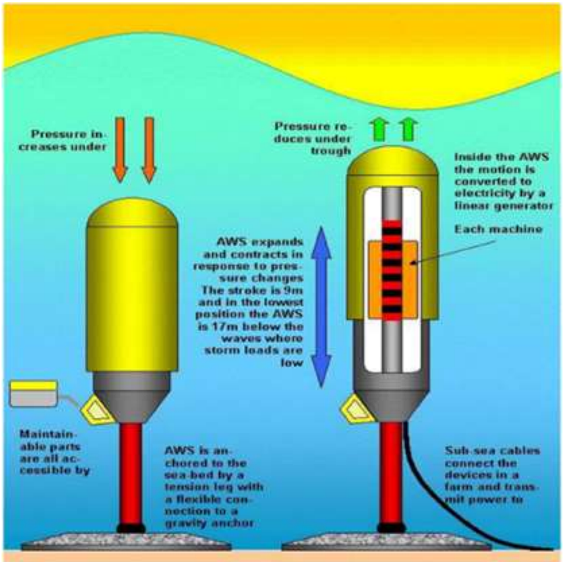

Fig 3. Submerged pressure differential: the Archimedes Wave Swing

However, in "shallow" water, horizontal water particle motion remains substantial at the seabed, but the horizontal motion of the paddle at the hinge is nil. Alternatively, if the hinge was situated some distance above the water's surface, it may be able to more accurately determine the average horizontal velocity of water particles. Hinging the paddle above the water surface offers two extra advantages. For starters, the bearings and power take-off would be far more accessible than in a bottom-hinged paddle. Second, the upper-hinged the paddle suffers. no “end-stop” problems and could feasibly swing through a full 360 degrees. Fig Oscillating Wave surge Converter

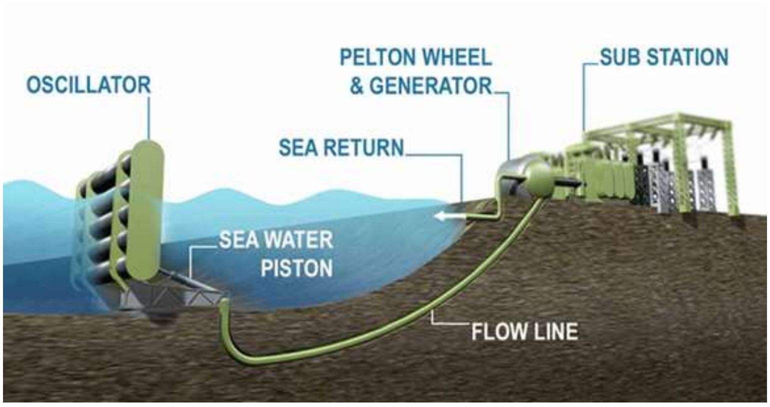

Fig 4. Oscillating Wave Surge Converter

The OWSC's back wall is necessary for carrying out several duties. Primarily, the back wall and paddle produce a simulated water column that affects the device's tuning. It is vital to shape this water column such that it is perfectly matched to the incident wave environment. The back wall must also be designed to prevent the creation of turbulence, which affects device performance, with horizontal water particle movements efficiently transferred into an elevation of the water column surface. Finally, when the OWSC is built with a caisson, the sloping rear wall can serve to stabilize it by pushing the foundation into the bottom of the ocean as water runs up it.

3.3 General Hydraulic System

The primary WEC interface's low-speed oscillations are converted via a hydraulic mechanism. Hydraulic devices may effectively absorb energy from slow-moving waves [51]. Hydraulics at 400 bar provide a distinct advantage for particular types of WEC, especially where space and weight are a concern [42]. These pressures generate far more force than the greatest electrical machines. A basic hydraulic PTO system for a WEC. A floating buoy pushes the hydraulic cylinder's rod up and down, causing fluid to flow through check valves and into a hydraulic motor. The generator might be a constant-speed device, while the hydraulic motor has variable capacity to drive it at close range. Shown in the Fig 5. Typical hydraulic circuit for WEC

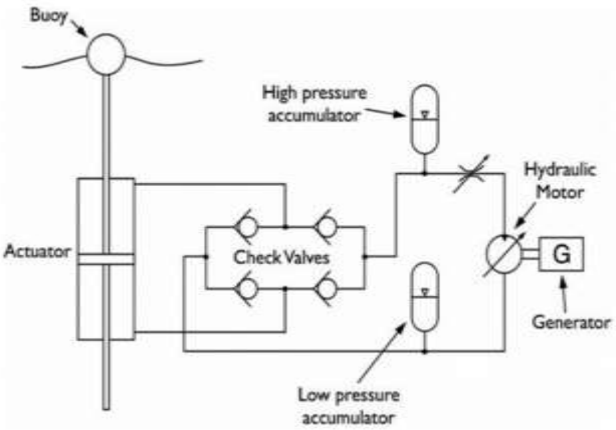

Fig 5. Typical hydraulic circuit for WEC

Despite varying flow rates, the pace remains constant. The motor capacity may be controlled using measured or forecasted sea conditions surrounding the WEC, as well as fluid flow data in the system. A throttling valve can regulate the flow to the motor. Accumulators are used in the circuit to store energy and provide consistent flow to the hydraulic motor. Additionally, the low-pressure accumulator adds a tiny boost pressure to prevent cavitation on the low-pressure side. If the incident waves are near to sinusoidal, the flow from one port of the actuator is shown in Fig. Rectification using check valves produces the flow The accumulator would smooth the output, with the variable-capacity motor driving the generator. shown in Fig 6. Rectification using check valves produces the flow.

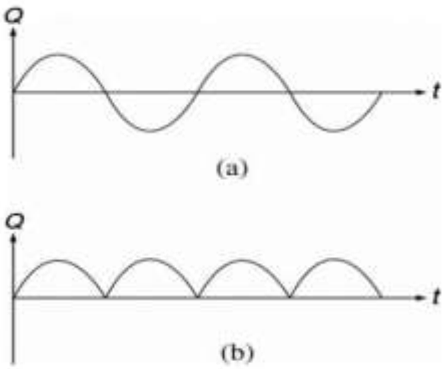

Fig 6. Rectification using check valves produces the flow

Fluids must be compatible with components and seals. While using seawater as a working fluid is ecologically benign, it has limits such as leakage, sealing, temperature, pressure, speed, size, cycle, solids deposition, biological development, lubrication, and corrosion.

The Pelamis WEC utilizes biodegradable hydraulic fluid in the maritime environment. Flexible rubber bellows provide two egress/intrusion protection levels, preventing water ingress and fluid escape to the outside environment. The practically implemented hydraulic System was developed by the Eco Wave power shown in below Fig7. Hydraulic System

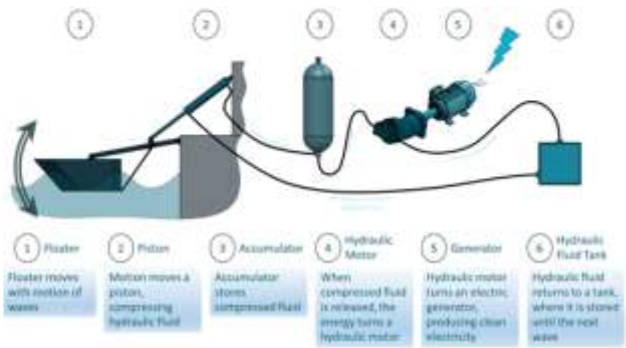

Fig 7. Hydraulic System

3.4 Dragon 12 Wing Wave Energy System

Dragon 12 is propelled by the wing's use of hydrodynamic lift generated by the underwater current. The turbine shaft drives the generator, transmitting electricity to the grid via a cable and an underwater hose cable to the shore. According to the design, the underwater kite should move in the opposite direction to the main flow, developing a relatively sufficient speed to generate electricity.

The control system controls the trajectory of the "sea kite" by manipulating the rudders and elevators at the rear of the structure. The cable holds Dragon 12 and is also a communication and power line, it is attached to the seabed using a simple mechanism that locks in place when the kite is set up and then easily detached [21-23].

The wing propels the kite using the hydrodynamic lift force generated by the underwater stream. With an onboard control system and rudders, the kite steers itself in a programmed figure-eight pattern, propelling the turbine through the water. As a result, the turbine receives a water flow that is many times faster than the real stream speed. Fig 8. Dragon 12 wing

Fig 8. Dragon 12 wing

The turbine transfers power to the generator, which produces electricity via the power wire in the tether. The seabed umbilical transmits electricity to the onshore connection. Dragon 12 makes it possible to generate energy in low-flow locations while still being cost-effective, with a flow rate of just 1.2 m/s. Engineers claim that their kite weighs up to 15 times less per MW than competitive technologies. Compared to a stationary turbine, such a "kite" and rotor, which are necessary for energy production, are quite cheap.

CONCLUSION

All the selected papers in this Special Issue, entitled ‘Advances in wave energy conversion systems’, have shown recent improvements in wave energy technology across the fields of wave analysis

The potential for generating electricity from wave energy is considerable. The ocean is a huge resource, and harnessing the energy in ocean waves represents an important step toward meeting renewable energy targets.

Possible PTO systems are categorized as hydraulic, linear electrical generator, or turbine-based. A hydraulic PTO system converts reciprocating motion to rotational motion, making it ideal for collecting energy from high force, slow oscillations, and driving a generator. There are several design problems, including efficiency and reliability. A linear electrical generator is a viable alternative, although the technology is still in its early stages.

The hydraulic system and Dragon 12 wing are cost-effective and maintenance is a bit easier to maintain as compared to other renewable sources like wind, and solar.

Despite much study, there is no consensus on a better approach for converting a slow, high-force, reciprocating motion to generate energy.

Choosing the right concept, optimizing performance, and controlling a system are all important considerations. Future studies should employ a systems engineering approach, as individual subsystems in a WEC are interconnected and should not be optimized without considering the other subsystems. Individual wave energy converters (WECs) are typically part of a wave farm, therefore future systems analysis should consider their interaction.

REFERENCES

[1] L. Rodrigues, Wave power conversion systems for electrical energy production, RE&PQJ (2008).

[2] A.Z. Karim, M.M. Rahman, S. Karmoker, Electricity generation by using the amplitude of ocean wave, in 2015 3rd International Conference on Green Energy and Technology (ICGET), IEEE, 2015, pp. 1-7.

[3] D.L. O'Sullivan, A.W. Lewis, Generator selection and comparative performance in offshore oscillating water column ocean wave energy converters, IEEE Transactions on energy conversion 26 (2) (2011) 603–614.

[4] I. Bjerke, E. Hjetland, G. Tjensvoll, J. Sjolte, Experiences from field testing with thebolt wave energy converter, in Proceedings of the 9th European Wave and Tidal Energy Conference (EWTEC11), Southampton, UK, volume 59, 2011.

[5] C. Frid, E. Andonegi, J. Depestele, A. Judd, D. Rihan, S.I. Rogers, E. Kenchington, The environmental interactions of tidal and wave energy generation devices, Environmental Impact Assessment Review 32 (1) (2012) 133–139.

[6] H. Polinder, M. Scuotto, Wave energy converters and their impact on power systems, in 2005 International conference on future power systems, IEEE, 2005, pp. 9–pp.

[7] Z.M. Yusop, M.Z. Ibrahim, M.A. Jusoh, A. Albani, S.J.A. Rahman, Wave-activated–body energy converters technologies: A review, Journal of Advanced Research in Fluid Mechanics and Thermal Sciences 76 (1) (2020) 76–104.

[8] J.P. Kofoed, P. Frigaard, M. Kramer, Recent developments of wave energy utilizationin Denmark, in Proceedings of the Workshop on Renewable Ocean Energy Utilization: the 20th annual conference, Korean Society of Ocean Engineers, 2006.

[9] H. Titah-Benbouzid, M. Benbouzid, An up-to-date technologies review and evaluation of wave energy converters, International review of electrical engineering-IREE 10 (1) (2015) 52–61.

[10] Thorpe, T. W. An overview of wave energy technologies: status, performance, and costs. In Wave power Moving towards commercial viability, 1999 (Wiley, Chichester UK).

[11] Ackermann, T. and Söder, L. Wind energy technology and current status: a Review Renewable Sustainable Energy 20004.

[12] Salter,S. H.Taylor,J. R.M.,and Caldwell,N. J. Power con-version mechanisms for wave energy. Proc. IMechE, PartM: J. Engineering for the Maritime Environment, 2002,216(M1), 1–27. DOI: 10.1243/147509002320382103.

[13] Design and Fabrication of Power Generation by Combined Wind and TidalTurbine:P.Naveenkumar.,M.E1,Ajai prakash.V2, Hariharan.S3, Hari Ganesh Singh.K3 Department of Mechanical Engineering Hindusthan Institute of Technology

[14] Wave Energy for Desalination Plants –A Review: N.Babu1,

K.Karthik Balaji2, S.Nishal, Assistant Professor, UG Scholar 2,3

Department of Mechanical Engineering Sri Krishna College of

Engineering and Technology, Coimbatore.

[15] Ocean Energy Systems (OES), also known as the Technology Collaboration Programme (TCP) on Ocean Energy Systems, functions within a framework created by the International Energy Agency (IEA). Views, findings and publications of the OES do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

[16] Baker, N. J. and Mueller, M. A. Direct drive wave energy converters (in French). Revue des Energies Renouvelables, 2001, 4(2), 1–7.

[17] Mueller, M. A. Electrical generators for direct drive wave energy converters. IEE Proc. Gener. Trans. Distrib., 2002, 149(4), 446–456.

[18] Scarr, D. Kollek, R, and Collier, D. Wave energy: technology transfer & generic R&D recommendations, Technical report ETSU V/06/00187//REP, Arup Energy, Ove Arup & Partners International, Report carried out under contract as part of the Sustainable Energy Programmes, managed by ETSU on behalf of the DTI, 2001.

[19] SuperGen Marine Energy Research Consortium. Available from http://www.supergen-marine.org. uk (access date 4 September 2008).

[20] Mueller, M. A. Electrical generators for direct drive wave energy converters. IEE Proc. Gener. Trans. Distrib., 2002, 149(4), 446–456.

[21] Ackermann, T. and Söder, L. Wind energy technology and current status: a review. Renew. Sust. Energy Rev., 2000, 4(4), 315–374.

[22] B. Drew, A. R. Plummer, and M. N. Sahinkaya. A review of wave energy converter technology. Power and Energy, 223:887–901, 2009.

[23] https://www.oedigital.com/news/505477-minesto-s-dragon-12-project-powers-forward-with-cable-installation-completion.

[24] Sea kite Dragon 12 - a new technology for generating electricity has appeared (focus.ua).

[25] How it works - Eco Wave Power from the Eco Wave Power.