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Reviews Existing Technologies and Proposes 'E8-PowerBuoys' Nano-Scale Generator Of Tidal And Wave Energy For River And Ocean

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***Abstract*—The installing and generating capacity of sustainable energy dramatically increasing since 2009. It can be noted that none a single sustainable energy technology will be able to achieve the carbon reduction independently. The simultaneously developed of many sustainable energies still needed. The recent growth in sustainable energy, especially tidal and wave energy is shown that the nano-scale generators for the river and ocean are still required. This is due to the most country in the world have the river and the ocean covers approximately 70 % of the surface of the earth.**

In practice, the tidal energy is the interaction between the gravity of the sun, earth, and moon, and hence it results the rise and fall of the tides. Whereas, the wave energy is the water movement due to the frictional drag of wind over the water surface. Despite these advantages, tidal and wave energy continued to face challenges in achieving a high efficiency output to generate the electricity, Moreover, some standards and regulations of grid connected are needed to revise in order to ensure its operations and safety. These allow small-scale distributed generator such sustainable energy resources to cooperate with the exiting power network.

Therefore, the paper reviews and proposes the nano-scale generator of tidal and wave energy for river and ocean. The proposed generator can support at the riverbank, in the middle of river, bays, shoreline, coastal estuaries, and in the middle of ocean. The generator should be easy to install and maintenance, while the chosen material structure of generator has the corrosion resistance of the saline water. The generator must follow the standards and regulations in order to ensure its safety.

Keywords—Distributed generator, Nano, Small-scale, Tidal energy, Wave energy

I. INTRODUCTION

According to the electricity demand continually growing, over 200 GW of sustainable energy was dramatically installed in 2019 as can be seen in Fig. 1 [1]. As can be seen, the growth rate of sustainable energy resources is well above over the previous 5 years. Because the changing in the power market regulations could support the participation of sustainable energy. This lets more electricity operators participate in the electricity market, which allows more flexible operations. A contract between two parties or more than two parties, one who supplies the electricity (the seller) and one who consumes the electricity (the buyer) can be easily established the Power Purchase Agreement (PPA).

These sustainable energy resources are mostly included hydropower, wind power, photovoltaic (PV), bio-power, geothermal, tidal and wave energy as shown in Fig. 2 [1]. It is known that approximately 70 % of the surface of the earth is covered by the river and the ocean. In practice, the primary energy such as tidal and wave energy can be directly used by supplying without any prior conversion into the other forms of useful final energy. It is just converses from the primary energy to electricity with the mechanism systems. Therefore, the nano-scale generator of tidal and wave energy will play a significant source of modern sustainable energy.

Fig. 3 shows the deployment of tidal and wave energy for the global in 2020 [2]. As can be seen the development of the energy conversion are continually increasing in the Europe and Asia. Because these 2 continents have a lot of island and the longest coast. Hence, the paper reviews the limitations of existing design, which include floating, middle-water column and seabed mounted devices. These assessments have the variety of moving-parts, and hence it results the unique performance for each device.

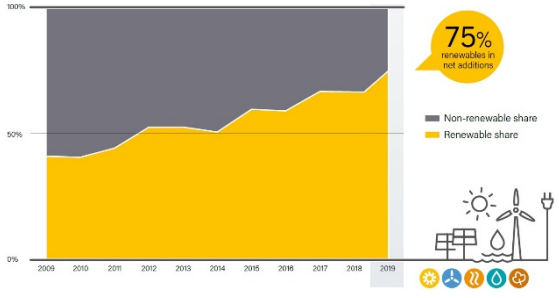

Fig. 1 Annual share of renewable and non-renewable energy during 2009-2019 [1]

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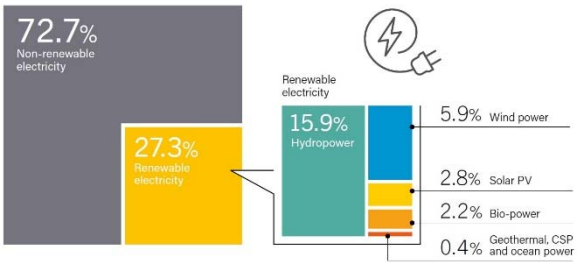

Fig. 2 Approximate power generating capacity share of renewable energy in 2019 [1]

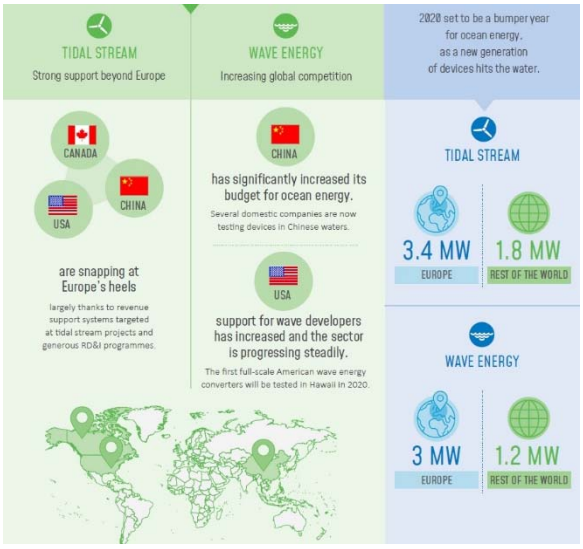

Fig. 3 Tidal and wave energy conversion deployment till 2020 [2]

II. Reviews Exisiting Technologies of Tidal and Wave Energy Conversion

In the past, many Wave Energy Conversion systems (WECs) have been continually developed and implemented. It can be divide into 3 main types, which are the Oscillating Water Columns (OWC), the Wave Surge or Focusing Devices (or TAPCHAN) and the Floating or Pitching Devices [3, 4].

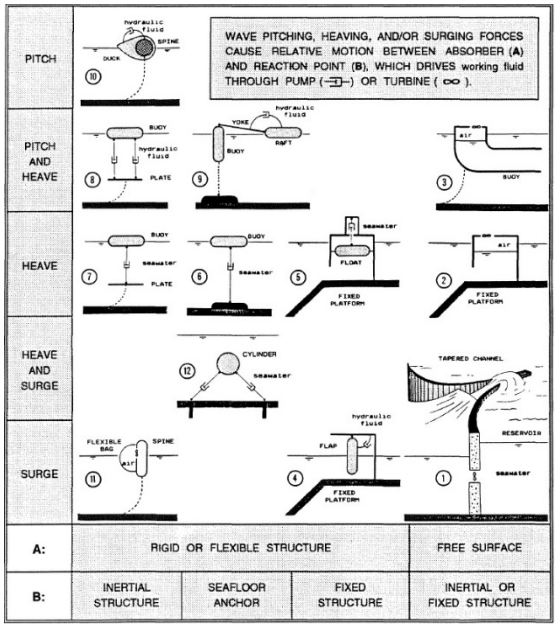

Fig. 4 Tidal and wave energy conversion in the past [3]

In the Fig. 4, the OWC devices can generate the electricity from the rise and fall of the wave. Theses driven wave can drive the shaft of device and/or power the turbine. However, the TAPCHAN devices had most likely installed at the shoreline in order to concentrate the water flow out of its reservoir, and hence drive the shaft and/or the turbine, which is similarly to the standard hydropower technologies. Last, Floating or Pitching Devices had mounted at the seabed and used the movement action of floating device to allow the bobbing or pitching action, and thus these action drive the shaft and/or the turbine as well. However, The European Marine Energy Centre LTD. (EMEC) has currently classified the existing types of WECs into 8 specific technologies as follows [5, 6]:

A. Attenuator or Wave Actived Bodies (WABs)

The floating device that convert the kinetic energy with the moving arms from the oscillation of the wave during the wave rides through them. The device directly operated parallel to the wave direction. For instance, the 'DEXA' device has implemented and patented by DEXA Wave Energy that uses an aqua gear, which has a low pressure power transmission in the water and supports the angular oscillations [7]. While, the 'Wavestar' device had been stationed in the ocean or near the shoreline in order to converts the wave energy through the floating arms. According to the rise and fall of the movement arms, the kinetic energy had been transferred the energy via the hydraulic shaft, and hence it drives the generator [8].

B. Point Absorber

The device absorbs kinetic energy from the movements of the wave at/near the water surface. Type of structure device depends on the configuration of displacers/reactors, and then it converts the buoyant part to drive the generator. For instance, the 'PB3 Powerbuoy' device develops with the floating system, which uses rise and fall or heaves motion of the wave. The buoyant part of the device has installed in the vertical axis direction. This allows the thrust rod system to drive the generator. While, the 'Searaser' device comprises with a cylinder attach to a piston in vertical axis. It can convert the kinetic energy from the buoyant part at the surface water [9-11].

C. Oscillating Wave Surge Converter (OWSC)

The OWSC extracts the energy from the wave surge. The system implements by buoyant flap, hydraulic arm and mounted hinge at seabed in order to response the movement of the water. For instance, the 'Oyster' device uses the wave surge component in the water to drive the flap. The flap pumps the water at high pressure level through a combination of pipeline, hydraulic accumulators, adjustable outlet valve, and drives the generator. However, the 'Langlee' device utilises the horizontal wave movement, which has more kinetic energy and easies to convert the wave energy via the 2 arms swing back and forth to drive the generator [9-11].

D. Oscillating Wave Column (OWC)

The OWC is a semi-submerged device that uses the rise and fall of the wave surge in order to compresses and decompresses the air in the enclosing column (cooperates between the cylindrical and piston). This allows the trapped air in the column to flow and drive the generator. For instance, the 'CETO' device is a semi-submerged point absorber (the buoyant part is under a few meters from the surface water), and hence supports the orbital motion drive system and drives a Power Take-Off (PTO) system (converts the movement of the wave into electricity) [9-11].

E. Submerged Pressure Differntial

The device is typically installed near shoreline and attached to the seabed. The rise and fall levels of the wave induces the different of pressure in the device, and then the pressure moves the fluid through a system to drive generator. For instance, the 'Archimedes Waveswing Submerged (AWS)' device has the point absorber and/or buoyant part that fully submerge under the surface water. It is reacted to the sub-sae water pressure, which causes by the wave surge. The device uses the direct drive technology to drive the generator [9-11].

F. Overtopping or Terminator

The device seizes the wave into a storage reservoir, and then, it returns the water to the sea by passing the water column wave power device. This connects to the conventional low-head turbine that generate the power. The 'collectors' may use to concentrate and reservoir the wave energy. For instance, the 'Limpet' device uses the shore based energy conversion system by installing water column wave power device and rotating well turbine for generator [9-11].

G. Bulge Wave

This technology has a rubber tube filled with the water, moored to the seabed heading into the waves. Then, the wave enters through the stern and causes the pressure variations along the length of the tube, creating a 'Bulge'. This travel bulge will be continually growing as same as gathering the kinetic energy, which drives a low-head turbine that locate at the bow during the water returns back to the sea. For instance, the 'Pelamis' device develops with the complete the electro-hydraulic power system (operates with four segments, with hinged joints connected) that attach a single cable to the seabed. The device operates at semi-submerged level in order to catch the wave energy [9-11].

H. Rotating Mass

The device uses the wave movement to excite the movement of the gyroscope, and hence the power absorption is a function of the rotation and inertia weight of the gyroscope. This technique supports the influence of the wave from multi-directional. Two forms of rotation are used to capture energy by the movement of the device heaving and swaying in the waves. For instance, the Gyroscopic Wave Generator and the Inertial Sea Wave Energy Converter (ISWEC) devices have been used the internal reaction from the movement of gyro to harvest wave energy without exposed the mechanical part. The gimbal of gyro has the capability to convert wave energy from multi-directional [12-14].

Fig. 5 Typical existing technologies of tidal and wave energy

III. Proposes 'E8-PowerBuoys' device the nano-scale generator of tidal and wave energy

The 'E8-PowerBuoys' device is mainly considered the Enthusiasm for innovation with ethic and integrity, Enhancement of power generation efficiency with smart design, Easy installation and preventive maintenance, Endurance device with Environmental friendly and support scenery, Energy on demand with endless power generation, Expand economic growth to community and Envision to extend the energy market.

The proposed design, development and implementation has been verified the effectiveness with the prototype of 'E8-PowerBuoys' device (develops from Rotating Mass and 3D Gyroscopic wave generator). The Double Axial Permanent Magnet (PM) Generator and Helix Turbine were also chosen to combine the system and supported the direct-drive of the generator in the vertical and horizontal axis. The structure of buoy was developed from Superlene Nylon plastic (Polyamide; PA6), Acrylonitrile Butadiene Styrene (ABS) plastic and/or High-Density Polyethylene (HDPE) plastic, which prevents the oxidation and corrosion, respectively. The proposed device was generated the electricity up to 0.9 kW (each segment unit generate at least 0.3 kW) as shown in Fig.6 to Fig.8. The proposed buoys have considered as the light weight (around 30 kg) due to its approximate sizing of each segment unit is 0.5m x 0.5 m 0.5m.

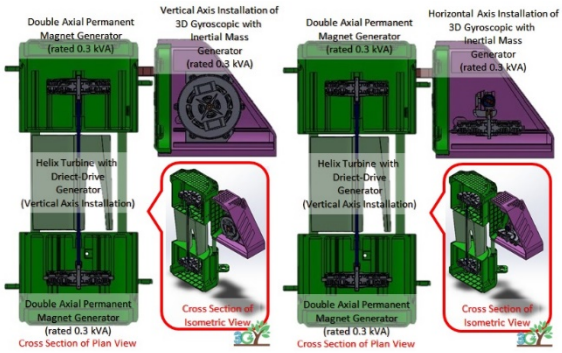

Fig. 6 'E8-PowerBuoys' device mounts in vertical axis

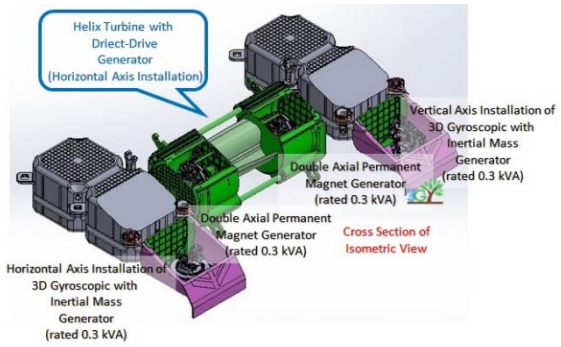

Fig. 7 'E8-PowerBuoys' device mounts in horizontal axis

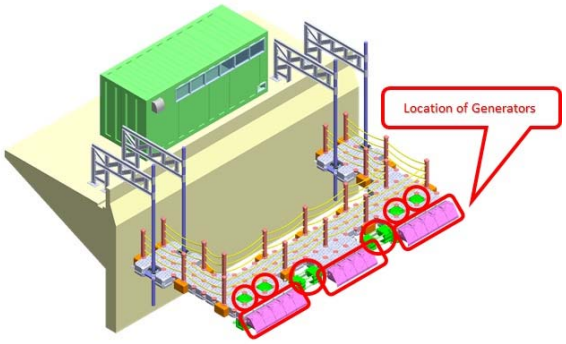

Fig. 8 Typical installation location of 'E8-PowerBuoys' system at the river bank.

IV. Conclusion

In order to design and develop the 'E8-PowerBuoys' nano-scale generator of tidal and wave energy conversion, it is necessary to consider the location of installation such river, ocean etc. as same as the installation position of device for instance floating, in the middle of water and seabed. Theses ensure the suitable type of materials and structure are chosen. To implement and analyse the characteristic of turbine, the Power Coefficient (CP), Tip Speed Ratio (TSR), Drag Force, Lift Force and Rotor Wake Vortex equations are required. Thus, the most and commonly design is based on the oscillation of water movement.

The potential of 'E8-PowerBuoys' nano-scale generator of tidal and wave energy will be dramatically increasing due to it can install in the river and ocean, and hence the total power generating capacity contribution from devices would be large. The approximation of energy conversion can also estimate from the yearly periodical of tidal and wave. The impacts of environmental degradation, the grid connected standards and regulations are needed to revise in order to ensure its operation performance and safety.

In the future, the trend of tidal and wave energy conversion, which is currently pricing may become a reality. As can be seen, the development of conversion technologies and materials could allow the suitable and easy installation at the riverbank, in the middle of river, bays, coastal estuaries, and in the middle of ocean. Then, the cost of the tidal and wave energy may decline sufficiently to use.

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