OCEAN ENERGY: A PRIME SOURCE OF RENEWABLE ENERGY

Abstract

Since the beginning of time, Earth has been warning mankind to find safer alternatives to burning fossil fuels, which would emit harmful chemicals into the atmosphere, in order to produce power. It is projected that global power consumption will rise dramatically in the coming decade. There will be a day when pure air is no longer available if current environmental negligence persists. We are constantly made aware of the enormous threats that conventional energy generation methods bring to the environment. Therefore, producing independent, clean energy is essential. The possibility of using wave energy as a clean energy source to create electricity exists. Despite the fact that this method is still extremely new and very competitive economically, the government and corporations are growing more interested in it. An essential quality of these waves is that they perform better than other renewable energy sources in terms of energy density. This chapter enlighten about how ocean waves are efficiently used to produce electric energy and how to store using different short and long-term storage systems. This chapter also deals with how the WEC's are eco-friendly in producing the energy and what are the benefits and limitations of this system.

Keywords: Wave power, Sustainable energy, Hydropower, Environmental effect.

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I. INTRODUCTION

In terms of renewable energy sources, ocean waves are one of the potent energy transporters since they exhibit abundant energy reserves throughout the world. According to researchers, 2 Terawatt (TW) of electricity can be produced globally each year by ocean waves. According to theoretical calculations, the annual global wave energy is equivalent to 8 X 10^6 Terawatt hours (TWh), or around 100 times the plant's entire hydropower capacity (Rodrigues, 2008). Fossil fuels release 2 million tonnes of carbon dioxide into the atmosphere if this energy were to be produced. Fossil fuels account for around 80% of the world's gross primary energy. International Energy Agency (IEA) projects that this percentage will remain constant through 2030 despite a 1.6% annual rise in global energy consumption (Salter, 1974).

In accordance with the Kyoto Protocol, wave power can aid in reducing air pollution (Rodrigues, 2008). Therefore, it is strongly advised to utilize this technology to the utmost. According to Kempner and Neumann (2014), the world contains 8 x 10^5 km of coastline that has wave power densities of more than 30 KW/m. Additionally, India has a potential of roughly 14 KW/m on average and 7500Kilometers of coastline. The energy produced might be between 3750 KW and 7500 KW even with just 10% usage. The first investigation into large-scale tidal waves began in 1924 on a number of islands employing powerhouses, ship locks, and electric stations (Karim *et al*., 2015). The methods of wave energy convention development have been ongoing for a long time. Different versions and sizes of created gadgets are available.The details of the devices are given below.

- **Pelamis:** It is an offshore, floating device with a hollow steel cylindrical segment with a diameter of 3.5m. It has around 120m length and three power modules which are rated at 250 KW. It can be operated at a depth of about 50m.
- **Wave Dragon:** It is another floating slack-moored WEC. Its physical dimensions such as width of body, length of wave reflectors, number, size and weight of the turbines, etc. are altered according to the wave climate of the stationing site. Size of the main body would be about 140 x 95m in a 36 kW/m wave climate.
- **Sperboy:** Sperboy is another floating WEC device developed by Embley Energy. This can be deployed at a greater depth. The size and dimensions of this device vary according to sea conditions at the site of installation. The maximum diameter is about 30m, a height is about 50m and a draft is 35m.

However, the cost of building, maintaining, setting up electric lines, building grain storage facilities, purchasing scales, equipment and managing projects is not based on the capacity of the wave energy converter (WEC). Therefore, larger, more energy-efficient gadgets which produce more energy are preferable over smaller devices. Along with producing more energy, they are also highly efficient in converting wave energy into electricity.

Compared to wind energy, we can boost energy output by developing swept areas, only a small number of WECs can improve their energy generation. This is because WECs have an optimal size from the beginning of their development, making it challenging to further develop (Murray, 2013; Holmes, 2009; O'Sullivan *et al*., 2011; Kofoed and Frigaard, 2009; Bjerke *et al*., 2011). Wave motion is extremely random, as far as we can understand. There is a need for a device that can take unpredictable input and convert it into a steady and reliable electrical output. The wave forces are absorbed by an absorber, possibly a buoy. The absorbed energy can be converted directly into electricity using an alternating current generator or it can be done gradually using mechanical and hydraulic transducers. Considerations for these converters should include things like endurance, durability, dependability, efficiency, etc.

The main advantage of implementing WEC is that it does not emit GHG (Green House Gases). As mentioned earlier, there is an enormous potential in wave energy which can be utilised to produce electricity with no environmental pollution. More over the waves are available abundantly and it also a reliable energy source as the waves is always in motion. WEC can supply more and ecofriendly electricity in the future. The production cost of electricity with the help of these WEC’s is very low. So, the WEC’s are highly cost effective, resilient and productive way of producing green electricity. By keeping the above benefits and mentioned advantages in mind there’s a need for implementing WEC.In order to possibly improve the effectiveness of the entire system, research on the WEC's generating system is still ongoing. When constructing a WEC, it is important to consider the location where it will be used because specific requirements and constraints must be addressed there.

II. CLASSFICATION OF WECs

Wave energy converters can be categorized in a variety of ways. Depending on location the devices are used as WEC.

- **Shoreline Devices:** These devices are found on the coast. These devices have the benefit of being simple to set up and maintain. To improve power generation, they should be deployed at hotspots. The implementations of these devices are constrained by factors such as coastline geology, tidal range, and coastal landscape preservation.
- **Near shore Devices:** Within a kilometer of the beach, these devices are positioned in deep waters of up to 20 meters. Electrical cables are used to transmit the generated power to the shore's grid.
- **Off Shore Devices:** These devices exist in more than 40 meters in deep water and are subject to stronger wave regimes. Based on the operating circumstances, the offshore devices are as follows,
  - Floating devices
  - Partially submerged devices

- Fully submerged devices

III. TRANSDUCERS

Electrical energy can be produced in a variety of ways. They use mechanical, electrical, and hydraulic transducers in various combinations.

1. **Mechanical Devices:** Gear configurations, Pelton turbines, wells turbines, etc. are some mechanical devices. These have the disadvantages of being big and having low efficiency. Additionally, flywheels are employed to supply a constant rotational output.

2. **Hydraulic Devices:** Since hydraulic devices are more dependable and long-lasting than others, they are used. Pumps, reservoirs, hoses, pipelines, piston configurations, incompressible fluid, etc. make up a typical hydraulic system. Also employed are hydraulic motors. The drawback of hydraulic devices is that they are expensive, big, and take up much more space.

3. **Electromagnetic Devices:** The advantage of using these devices is that they directly transform linear motion into electricity. The linear generator is a well-known electromagnetic apparatus. It has a converter with alternate-polarity permanent magnets attached to it. The iron core and windings of this translator are housed inside a fixed enclosure.

IV. POWER STORAGE

Using a proper storage mechanism, the process's energy must be kept in reserve. The storage units can be either long-term or short-term relying on their purpose. Short-term storage technologies include capacitors, super capacitors, and magnetic energy storage with super-conductivity. Electrolytic capacitors, film capacitors, and ceramic capacitors are a few of the methods that use capacitors for energy storage. Ceramic capacitors age poorly, despite having low equivalent resistance and high-frequency applications. Electrolyte capacitors, which have a higher capacity than regular capacitors (non-super capacitors), are widely used to store enormous quantities of power.

In direct current link programs on power converters, electrolytes are widely employed to maintain bus voltage and control power fluctuations. Due to the high-power variances that can be detected when producing wave energy, electrolytes can be employed as electrical energy devices for this purpose. Super Capacitors excel in quick discharge and have the capacity to instantly release all of their stored energy. It should be mentioned that supercapacitors are capable of achieving capacitances in the kilo Farad range, but the costs are currently prohibitive. Superconducting magnetic energy storage, a type of short-time storing device, is comprised of a coil made of a superconducting substance that can super conduct when its temperature is decreased below a particular temperature. Due to the current flowing through the coil, the power is stored in the magnetic field. Energy can be held in reserve indefinitely, and the current won't start to weaken unless the temperature is kept below a certain level. Superconducting magnetic energy storage is more expensive than other energy storage devices and is still in the early stage of development. It contains significant components, such as a refrigerator, which will make it more susceptible to storms, as well as requiring more room and mechanical upkeep. These factors prevent small and medium-sized businesses from being categorized as ocean-dependent energy applications. A cylinder is utilized with a shaft that revolves in a sturdy housing for flywheel energy storage. The magnet levitates the cylinder to lessen frictional losses. The motor or generator is then connected to this system. In flywheel energy storage, the motor converts the electric energy so that the shaft's rotational speed can be accelerated. Long-term storage systems include batteries, gasoline storage, compressed air energy storage and injected hydroelectricity.

A hydrogen-based fuel cell with an electrolyser made of hydrogen gas and kept in high-pressure tanks is the best method for storing extra energy. The fuel cell can then be sent out as needed. Further investigation has been conducted in recent years, and it has been determined that, with the technology currently in use, losses during storage and distribution are too great and the optimism around the use of hydrogen appears to have decreased. Batteries are another type of long-term storage device that is utilized widely. Over the past few decades, batteries have gained a lot of popularity. At least two electrochemical cells make up an electrochemical battery. Two electrodes plus an electrolyte substance make up a cell. Electric current is produced during the oxidation-reduction process as a result of the chemical reaction occurring at the electrodes (Lerch, 2007). The goal of a compressed air energy storage system is to compress and store air using extra or cheap energy. Smaller plants may be able to store air in tanks, while larger plants typically store it in underground caves. When there is an increase popularity or when prices rise, the energy is released. Compressed air is fed into a turbine that powers a combustion generator system to generate energy.

V. IMPACT ON ENVIRONMENT

The environmental benefits of wave energy are that it requires less harmful gas emissions to produce the same amount of energy as the WEC. Fadaeenejad*et al.* (2014) claim that because offshore islands have constant development and high-quality surroundings, using wave energy there has a favourable effect on tourism. The Institute of Electrical Power Engineering added that certain water sports can be performed in WEC's safe water. WECs will therefore have a significant and favourable effect on tourism and recreational activities. If wave transmitters are set up in the sea, effective agricultural zones will not vanish. According to Bedard's assessment (Bedard, 2007; Boehlert *et al.*, 2008), the installation, operation, maintenance and discharge of these wave energy converters will also have the extra benefit of being the most eco-friendly technology. The ecological and financial effects of wave energy, like those of other forms of energy, must be considered when developing a new facility. Similar environmental concerns surround maritime wind power projects as they do wave energy. Designing to reduce the environmental impact of wave energy can benefit from learning from offshore oil, wind and other marine-based sectors. According to many studies (Boehlert *et al.*, 2008; Frid *et al.*, 2012; Inger *et al.*, 2009; Linley, 2012; Simmonds *et al.*, 2010), there are two types of environmental interactions between WECs and the maritime environment. A lot of research has been done on the potential effects on living organisms and other things by Frid *et al.* (2012), Inger *etal.*(2009), Linley (2012), and Simmonds *et al.* (2010). To assess the negative effects of such wave farms, they noted the potential for habitat loss or weakening marine invertebrates. They also mentioned the risk of colliding with deep noise emissions and electromagnetic fields, as well as the capacity to function as an artificial reef and rehabilitate damaged ecosystems (Frid *et al.*, 2012; Inger *et al.*, 2009). The project's environmental impact varies with its size and is influenced by the area's ecosystems and geography. The life cycle of a transducer is largely determined by the system for monitoring the environment, which must be established through a successful EIA investigation (Solaun*et al.*, 2003). Due to variations in currents and waves, coastal and near-coast plans may have an impact on coastal erosion. Wave amplitude, water flow, and pulse velocities can all be related to array size. When installing wave energy, this could harm the device. The ocean floor is held in place by many rods, concrete blocks, anchors, and chains. Depending on the seabeds, land preparation may involve washing the seafloor to install electrical cables. The rate of ocean degradation is influenced by the quantity of mounted devices and the anchoring techniques. When producing electricity, wave energy does not release GHG or other air pollutants, but development, transportation and other phases of its life cycle do cause emissions. Additionally, there are consequences when hydraulic rams and other objects leaks into the ocean. Local fishing may be impacted, with the exception of the marine installations' region. In addition to limiting access to fish catching grounds and to network, power cables, floats can be used to provide priority to certain species of seafood and habitats. Fishing activities, however, might be outside the installation's scope, just as they are in the seas. The phyto and zoo benthos of the seabed may be harmed by marine mammals that are prone to submerged structures or that operate as seagoing and migratory barriers. Anchor lines can be dangerous for some species, especially large whales because many offshore wind projects are fixed directly to the seabed. Another factor that may inspire mariners to employ structures as temporary rafts is liquid microwave technology. Due to its low profile and potential for complicated visual or radar identification, WEC may present a navigational risk for carriers. In the event that wave energy devices malfunction at night or disintegrate during a storm, this could have an influence on night time traffic. Additionally, increasing ship movement for maintenance and repairs may have an impact on water quality due to the possibility of oil spills. When used in severe environments, the sound produces from these devices may harm whales and dolphins that hunt using echoes. Operating noise levels for coastal and coastline equipment contaminate nearby noise on the beach or shore. However, when it is working properly, no sound can be produced because the wind and waves ambient noise acts as a mask. Some swimming and water activities that use floating surfaces may be impacted by offshore waters and neighbouring infrastructure. These facilities offer protection for water sports like water skiing and diving, but surfing and sailing may suffer. Large installations may have a negative aesthetic impact on tourism, and some close devices may require water depths that are several hundred yards from the seashore. The movement of water and sand around the building can be altered by installations on land, such as platforms, anchors and cables. Changes in water velocity have an impact on coastal erosion, sediment and stones. Sludge deposition is accelerated by restricted or slow water flow. These environmental issues are nothing more than challenges and people must create pure energy without harming the environment.

Moreover, the wave energy does not generate any GHG, waste and other pollutant as the fossil fuels does. The wave energy can be directly converted in to electricity and can be used to power plants and generators. The WEC's are ecofriendly as they generate energy from a natural, sustainable and predictable source of energy.

1. **Benefits :** The following benefits of this technology are listed

   - In contrast to other renewable energy sources, waves have a high-power density.
   - In comparison to other kinds, wave energy is predictable and more regular.
   - Wave energy is the most environmentally friendly form of energy available and has no negative effects on the environment.
   - Waves can cover great distances with little energy loss.
   - Decreased reliance on nonrenewable energy sources.
   - Affordable method of electricity generation.

2. **Challenges:** The difficulties that could be encountered are

   - It is challenging to absorb the forces that exist in waves since they are emitted in arbitrary directions.
   - Storms and the ocean's salinity must be withstood by the WEC.
   - A WEC has a high initial cost to construct, and regular maintenance is essential.
   - It is challenging to transform high-force, unpredictable and slow-moving wave-action into continuous output.
   - Electricity transmission from underwater devices to the onshore system has issues.
   - Large WECs might be considered disruptive to marine life.
   - These technologies are still expensive, thus additional development is required.

3. **Limitations:** Wave energy converters (WECs) are devices designed to harness the energy from ocean waves and convert it into electricity. While they hold great promise as a renewable energy source, they also come with several limitations, some of which include

   - **High upfront costs:** The initial investment required to design, construct, and deploy wave energy converters can be significant. This cost is often higher than other renewable energy technologies, such as wind or solar.
   - **Environmental impacts:** Depending on the design and location of WECs, there can be potential environmental impacts. For example, they may disrupt marine ecosystems, affect fish migration patterns, or alter sediment transport.
   - **Intermittency and variability:** Wave energy is inherently variable and

depends on weather conditions and the ocean's state. This intermittency can make it challenging to integrate wave power into the grid reliably.

- **Corrosion and maintenance:** Being exposed to harsh marine conditions, WECs are prone to corrosion, which can increase maintenance costs and decrease their operational lifespan.
- **Location dependence:** The effectiveness of wave energy converters is highly dependent on the location's wave characteristics. This means that not all coastal areas are suitable for efficient wave energy extraction.
- **Energy transmission:** Offshore wave energy farms require efficient transmission systems to transfer the electricity generated to the onshore grid. This can be logistically complex and add to the overall costs.
- **Storm resistance:** WECs must be designed to withstand extreme weather conditions, such as storms and high waves, which can further add to the complexity and cost of their construction.
- **Visual impact and public perception:** Wave energy converters located near the coast can be visible from shorelines and may face opposition from communities concerned about their visual impact on the landscape.
- **Energy storage:** As with other renewable energy sources, energy storage is essential to compensate for the intermittent nature of wave energy. Developing effective and cost-efficient storage solutions remains a challenge.
- **Technological immaturity:** Compared to other renewable energy technologies like wind and solar, wave energy converters are still relatively new and undergoing continuous development. As a result, the technology might not be as mature or commercially available as other options.

Despite these limitations, ongoing research and development in the wave energy sector aim to address these challenges and improve the viability and efficiency of wave energy converters as a clean and sustainable energy source.

VI. DISCUSSION

Ocean wave energy is a sustainable and environmentally friendly type of energy with enormous potential to contribute to the global energy mix and reduce carbon emissions. The vastness of the world's seas offers an endless supply of wave-based kinetic energy and even a small portion of this energy might have a substantial impact on our energy requirements. This chapter examines the main elements of ocean wave energy, including its benefits, drawbacks and potential contribution to the transition to a sustainable energy future. The details have made an effort to give a comprehensive review of the ocean energy, which underlying the process by which the energy held by ocean waves is transformed into one that is more beneficial to humans. This chapter provided a thorough explanation of the instrumentation and techniques used to estimate the wave energy resource. Prior to making a final choice about where to install a wave farm, site-specific measurements and surveys are required when analysing potential locations for a wave energy project. There are a few crucial areas where knowledge gained from allied businesses, such the offshore and wind energy sectors, might be applied.

Guidelines and brief documentation detailing processes and approaches are immediately needed, especially during the consultation and project monitoring phases. A promising step toward a more sustainable and diverse energy portfolio is provided by ocean wave energy. We can lessen our reliance on fossil fuels, slow down climate change, and ensure a cleaner energy future by harnessing the power of waves. However, for this renewable energy source to be widely used, it will be essential to overcome the technological, environmental, and economic obstacles. Ocean wave energy has the potential to play a significant part in our transition to a greener and more sustainable planet with continuous study, innovation, and supportive policy.

VII. FUTURE PROSPECTUS

The wave energy appreciation is given to competitors who can create wave conversion devices more effectively. The goal is to develop a system that would cut the cost of using ocean waves for power production in half. Although the creation of new wind turbines has made wind power successful thus far, and the solar industry is aware of what a solar panel looks like, the wave sector lacks similar development opportunities but is always working to convert ocean energy into usable electricity. When you take a look at the emerging wave industries, it makes sense. The development of solar and wind energy over the years has led to most wave energy companies being just a decade old, some being even younger. Around the world, just a few select wave energy companies have been able to exert control over the network, and essentially no one has advanced to the stage where they can provide the promised electricity. It's incredibly challenging to try to gather energy in the ocean since it's not simply salty water, oppression, or major blows. Unlike the wind or sunlight, the water simply does not radiate. The oceans are expanding; their surface, their waves, and their vast variety of patterns show their unexpected nature. One could conclude that the businesses' challenging competition will be entertaining and improve energy efficiency.

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