

# WAVE ENERGY TECHNOLOGY AND POTENTIAL IN TURKEY

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REFERENCE NO	ABSTRACT
WAVE-01	One of the infinite energy sources in the world is wave energy. European countries are continuously developing energy programmes applied in this area. Turkey; as long as it is cost-effective in terms of location, it should provide the greatest benefit from today's wave motion potential. Turkey reveals the available wave potential, it is important to make the most appropriate decision about the type of wave instruments technology.
<i>Keywords:</i> Potential of wave energy in Turkey	The aim of this study is to determine the rate at which this potential is transferred to the field by revealing the potential of wave energy in Turkey, based on scientific studies and literature information made in the world and in Turkey.

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## 1. INTRODUCTION

History has been one of the most important necessities of the coastal people energy. Energy is very important to meet the demands of rapidly increasing population, especially in industrial and technological developments. New production methods are implemented in the world and in our country to meet the growing need. Research on renewable energy sources increases due to the finite fossil fuel that meets a large proportion of energy needs and leads to heavy environmental problems.

The energy provided by renewable energy sources such as solar, wind, geothermal, modern biomass and small hydraulic resources in today's world meets only 1,9% of the total energy demand. When it joins the production of conventional biomass and large power hydroelectric power plants, the rate rises to 17,7% (3). The remaining part of the demand for energy is provided from fossil fuel sources.

Renewable energy is extremely important in terms of sustainable technology and the need for energy combined with the growing population. At the beginning of renewable energy sources are wind energy, solar energy, geothermal, biomass, hydraulic energy and wave energy.

Archimedes is the great power wave energy that is emerging between the principle and

gravity. Wave energy is one of the most recommended renewable technologies. It is not only a great source of energy, but also more reliable than many renewable energy sources. While the sun and wind can be supplied at 20-30% of the time, wave power is available in 90% of the time. A clean, inexpensive and natural energy source that protects the natural balance, providing breathable fresh air, wave energy, which supports the country's economy, is one of the renewable energy sources that should be benefited in Turkey, surrounded by seas (7).

The idea of electrical production from wave energy has not been interested until 1945 years. In 1945, after the experimental examination of the first vibrating water column from the Japanese scientist Masuda's water tank, the subject began to become interested in several years and has caused many researchers to deal with the issue. The transformation systems that could be used to obtain electricity from the wave energy that lost their popularity in the 1960s began to attract researchers again after the oil crisis. Finally, since the second half of the 1980s, some prototypes have been tried, different systems (2).

Theoretical solutions are often variable in systems that generate electricity from wave energy and are difficult because natural

conditions cannot be clearly determined. For the theory to be healthy, a long-term measurement should be performed. Data such as the average wave period, depth of water and wave height obtained from these measurements must be explained. In order for the results to be more precise, the theories should be considered as three-dimensional velocity potentials and viscous resistance.

The strength of the spleen is proportional to the frame of the amplability and the period of movement. Long period (~ 7-10 s), large amplitude (~ 2 m) consists of 40-50 kW of energy per meter of waves in width (7). As with all renewable energy sources, wave energy does not have a regular distribution. There are regions with high wave power on earth. The wave movement between the latitude of 30 ° and 60 ° in the North and South hemisphere is high with the dominance of the western wind.

### **1.1. WAVE ENERGY**

At the beginning of the biggest factors in the formation of wave energy, the sun comes. The effect of the sun is the pressure difference in the atmosphere. The wave of pressure difference occurs as a result of the wind blowing over the sea. Sağlam and Uyar (2005: s.1) according to the hypothesis, "the power of sea waves is more kesif than other renewable energy sources (10-15 times more)". Wave size; The wind speed is proportional to the wind blowing time and blowing distance.

The history of energy production from waves actually goes back to two centuries. Many inventors have dreamed of hitting the ocean waves of gem. The first samples were constructed in 1799 by mounting the waves on the shore to a floating vessel that would run the pumps, mills and saws. But with the discovery of steam power, the wave power remained only in the drawings. Two centuries later, the oil embargo and wave power came up once again, with the drop of oil prices once again shelved. However, the prices that are

now rising again are pushing scientists to seek low-cost, new and inexhaustible energy (4).

### **1.2. Advantages Of Wave Energy**

- An infinite source of energy.
- It contributes to the reduction of environmental pollution because it partially reduces the use of fossil fuels.
- The installation does not destroy farmland because it occurs on the sea.
- By the task of Dalyan, it contributes to the proliferation of fish generation and ecological balance.
- Resizable according to the amount of energy needed.

### **1.3. Disadvantages Of Wave Energy**

- New systems should be developed for various wave sizes.
- It is quickly affected by adverse weather conditions.
- Initial investment costs and maintenance costs are high.
- It may not be possible to obtain the same amount of energy continuously.

### **1.4. Electric Power Generation Systems From Wave Energy**

Electricity from wave energy is usually obtained by 3 methods. These; Coastal lanes are methods that are close to shore and ashore. In the coastal application, energy production systems are secured or buried on the shore.

#### **1.4.1. Coastline applications**

The maintenance and installation of this app is easier compared to other applications, and the initial investment costs are more appropriate. There is no need for long underwater electrical transmission lines to be delivered to the region to be used. These applications also serve as a wave-breaking task.

The wave regime is higher in the areas where applications near the shore and close to the shore are established. Therefore, the electrical energy produced from the coastline has less power.

#### **1.4.1.1. Oscillating water column**

One end is the sea, the other ends are the structures that have open compartments to the atmosphere. When the water level in the compartment is oscillating with the wave movement, the air in the compartment is continuously pushed out and retracted. The air is used to turn a turbine into the exit and input movement. The movement energy obtained from the turbine is converted into electrical energy with the help of a generator to be included in the system. In such converters, Wells turbines that can rotate in the same direction during both the inlet and exit movement of the air are used (1).

The oscillating water column consists of two phases of electrical production in the wave energy formation system. The first movement enters the water column with the wave movement and rises in the column. The water that enters the column compresses the air, resulting in pressure increases. The increasing air pressure is elastic and the diameter is transmitted to the turbine with the help of a pipe shrinking. With the withdrawal of the spleen, the pressure in the column decreases and atmospheric pressure fills the column contents with air.

If a normal turbine is used in the system, the turbine propeller will return in different directions in the entrance and outlet of the water room. Therefore, energy production will fall due to the continuous stop of the propeller. But thanks to the special structure of the Wells turbine without wasting time, The propeller rotates in one direction, both in the air inlet and outside the column, and thus the energy efficiency is increasing.

The Wells turbine, located at the top of the system, begins to rotate with the air movement and wave energy returns to the movement energy. With the help of the generator at the output of the turbine, motion energy is converted into electrical energy.

#### **1.4.1.2. Oceanlinx**

Oceantinx is an adaptation of the new generation of oscillating water column system. The system operates in the same characteristic as the generally oscillating water column system and electricity production is performed similarly. The system has a parabolic wall and these wall waves are centered on the column (1).

Unlike the column used in the traditional oscillating water column system, a width-shrinking column is used. The air in the width of the shrinking column reaches the highest speed due to the shrinking structure and allows maximum energy to be achieved when passing through the turbine. The essence of the Oceaninx system is based on the column on this shrinking form (1).

#### **1.4.1.3. Tapchan**

The Tapchan system is an adaptation of the traditional hydroelectric power generation system. These systems have a wall height of 3-5 m above the water level, feeding the reservoir built to the edge of the cliff, it's an increasingly narrow channel. The narrowing of the canal causes increased wave height and the rising waves drain into the reservoir from the canal walls. As the water is stored in the reservoir, the kinetic energy of the motion wave becomes potential energy. The stored water is given to the turbine. It has very little harakkets and has a low maintenance cost and high reliability. Energy can be stored until it is needed in this system. However, Tapchan systems are not suitable for all coastal segments (7).

#### **1.4.1.4. Pendular**

Pendular, one side is a rectangular box that opens to the sea. A pendulum lid is hinged on this opening. The lid moves forward-backward with the wave movement. This

movement allows the generator and hydraulic pump to work and generate electricity (5).

#### **1.4.2. Applications near the shore**

These systems are used near the shore and at an average depth of 15-25 m. Proximity to the shore provides an important advantage in terms of maintenance costs.

##### **1.4.2.1. Osprey**

This system is a hybrid conversion system with steel tanks on both sides of the reservoir, which contains a rectangular collector with a 20 m width in the middle. These tanks are positioned towards the direction of the wave, and the collector meets the waves that come towards the reservoir. The reason the system is hybrid is that the wind turbine is integrated into the system (1). The wind with the effect of the spleen is transmitted to the wind rose on the back of the system. Electricity generation from this transmitted wind energy is ensured.

##### **1.4.2.2. WOPS 3500**

It is an offshore structure that incorporates wave oscillation and wind energy. With a 1.5 MW wind energy contribution, the total capacity reaches up to 3.5 MW (5).

#### **1.4.3. Offshore applications**

Offshore applications are established in places where sea depth is 40 m and above. Investment and initial investment costs are high. The cost of maintenance is high because it is established in remote areas of the shore. Long underwater transmission lines are required to move the produced electricity to the mainland. Since it is established in the middle of the ocean, the wave size is high and has a very high potential in terms of energy production. But since they are in the middle of the ocean, they have big waves and heavy working conditions.

##### **1.4.3.1. McCabe wave pump**

This appliance contains 3 rectangular steel (4 m wide) pontoon, which is hinged, neatly sorted and connected to each other. Adding an extra mass increases the inertia of the central pontoon. Energy is provided from the movement at the hinge points through the hydraulic Tulumba mounted between the central pontoon and other pontoon. A sample device was established in Kilbaha, County Clare and Ireland in 40 m long (7).

##### **1.4.3.2. OPT wave energy converter**

The Wave energy Converter (WEC), developed by Ocean Power Technology (OPT) in America, includes a cylindrical structure that is open to the sea with a closed base of 2-5 m diameter. A hydraulic pump was placed between the top of the structure and the floating steel swimmer (7). With the wave of the ocean, the cylinder in the upper part moves up and down. The remaining part of the ocean remains constant, the energy generated by the cylinder up and down movement is converted into electrical energy with the help of a hydraulic pump.

##### **1.4.3.3. Pelamis**

It is a system that consists of connecting the cylinder parts on the water with the hinge. Hydraulic pumps between each cylinder move with the release of water and as a result of this movement, hydraulic pumps operate the power generators.

Pelamis, which is floating on water, can produce energy that can meet the annual electricity consumption requirement of the 500 house (5).

##### **1.4.3.4. Archimedes wave release**

This system includes a cylindrical, air-filled swimmer with a diameter of 10-20 m. The wave passing through the system raises or lowers the pressure of the air in the swimmer. This causes the swimmer's movement to rise

and descend according to the ground, resulting in energy production (7).

### **1.5. The Potential Of Wave Energy In The World**

Although studies on wave energy have accelerated the oil crisis in the 1970s, the interest in wave energy decreased after a few unsuccessful attempts. However, the advancement of technology has increased interest and many new technologies have been developed. Over 1000 patents were taken on wave energy production systems and the facility with many commercial potential has also been released (7).

The first commercial wave energy plant in the world, Limpet 500, was established in the Island of Scotland in 2000 and has been providing power to the UK's network since the late November 2000. Limpet 500 is a facility designed by Wavegen with a capacity of 0,5mw. In addition, Scotland's Edinburgh Ocean Power Distribution Co., Ltd. has built a small (200 house power), offshore wave energy system. Construction finished in 2002. The facility will produce 2.5 million kWh of electricity annually. This company also plans to produce more than 2.5 million kWh/year by establishing 900 devices with a total capacity of 700 MW with support from Scotland (7).

In many countries, OWC was made for demonstration purposes along the shore. In various years in Scotland (75 kW), OWC was applied in India (150 kW), Japan (60 kW at Sakata Port, 40 kW in Sanze, 30 kW at Kujukuri-Cho, 130 kW in Haramachi) and Norway (500 kW) for demonstration purposes. It is used for Energetech OWC and Sri Lanka OWC Testing in Australia (7).

Wave energy programmes are extensively researched in many countries. In particular, European countries have made significant progress in this regard In the framework of these programmes, OWC and Tapchan in

Norway were commercially established in the 1980s. In Portugal, the Coastal OWC application (500 kW) was made on the island of Pico in Azores Swedish houseump in Sweden, also developed Osprey OWC in the UK (7). In addition to these countries, significant developments are carried out in terms of wave energy programmes in Australia, Japan, India and Korea.

### **1.6. The Potential Of Wave Energy In Turkey**

Wave energy is not used in Turkey, which is covered with three seas. In accordance with the use of our coasts, it was calculated that 15, 5 TWh/year-level energy was found (1). There is no wave measuring station and wave data, although the offshore coast of Turkey finds 8210 km outside the sea of Marmara.

Along the shores of the Turkish coast, Wave Atlas can be reached from the wave data needed to calculate the approximate wave energy densities of many points. The approximate wave energy densities calculated at certain coordinates in Turkish waters are shown in the form of equivalent lines on the map of Turkey using the surfer program (6). As a result of some calculations, the approximate maximum and minimum wave energy levels available in Turkish waters can be reached.

Wave formation in the seas in Turkey and the characteristics of these waves can be most suitable for wave energy production systems; Southwest Anatolia, the Aegean Sea and the Mediterranean. This is because the wind potential is 4-17 KW/m annually. The Buddha causes a concentration in the wave power.

The most suitable place to take advantage of wave energy, or to start the work, is the seas that correspond between Izmir and Antalya or Dalaman-Finike to be exact. The regional average wave densities are as follows; Black Sea (1,96 -4, 22 kWh/m), Marmara Sea (0,31 - 0, 69 kWh/m), Aegean Sea (2,86 8, 75

kWh/m), Akdeniz (2,59 8, 26 kWh/m), Izmir-Antalya (3,91 -12, 05 kWh/m) (6). The values we have stated reflect the approximate results. A significant parameter at the beginning of the project is "Wave Energy Development Index" (DEGI) values. The annual average wave of energy flows is the division of wave energy flow in storm dimensions. Thus, the number of units without a unit is obtained, which gives Degi (6).

The Degi values in the seas are not high, but the points that are high in the wave energy level are considered as the best production points. Because high degi values will increase the investment cost of the wave converter/farm, which will be designed to achieve the annual average wave energy potential at a specific point in the sea (6).

In order to achieve the NET results, measurements of the first sample wave energy converter which can be performed in accordance with the values of the seas in Turkey should be carried out.

The construction of the Pilot Wave power plant pioneered by the western Black Sea Development Agency is being conducted. This plant is established in Zonguldak. The test of electricity obtained from the plant will be tested in Magnolia Park next to the plant. The free-to-install facility is expected to produce a 50 kW and meet the electricity requirement of 25 households.

## 2. CONCLUSIONS

Energy production is usually provided from fossil fuels in our country. Turkey will import 72% of its energy needs in 2010, 80% in 2020 (6). In the event of a possible oil crisis in the coming years, Turkey will be one of the countries that will be most affected by this crisis in the world. Unfortunately, Turkey is dependent on energy maintenance. In order to remedy this problem, the energy resources that are in our country's potential to be planned and implemented should be shaped accordingly.

Seas; it should be considered due to its high renewable ability, abundant, use-free, environmental pollution, and a resource that can produce a high amount of electricity.

The information collected from the best wave power sources and estimates for shield vulnerabilities and statistical analyses indicate that the intensity of wave strength is between 6,6 -7,6 kW/m. The wave heights reach 1.21 meters and the wavelength reaches 6.09 seconds (6). The most suitable places to obtain electricity from the production of wave energy; The west of the Black Sea is the north of the Bosphorus and the southwestern shores of the Aegean Sea. In addition, this system is suitable for installation between Marmaris and Finike. Initial trials for starters should be preferred in these areas.

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