Study of Wave Energy Potential in Tonekabon (N Iran)

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Abstract: Wave energy is produced when electricity generators are placed on the surface of the ocean. The energy provided is most often used in desalination plants, power plants and water pumps. Energy output is determined by wave height, wave speed, wavelength, and water density. In many areas of the world, the wind blows with enough consistency and force to provide continuous waves. There is tremendous energy in the ocean waves. Wave power devices extract energy directly from the surface motion of ocean waves or from pressure fluctuations below the surface. Tonekabon on the north of Iran is subjected to a very wave climate; in this work its potential for energy production is assessed based on data from covering the period 2000–2007. The transformation of the offshore wave field as it propagates into this area is computed by means of a near shore wave model in order to select the optimum locations for a wave farm. Zones emerge as those with the highest potential for wave energy exploitation. Wave power, along with renewable energy-generating sources like tides and streams, is underestimated considering its advantageous physical properties and predictability. This paper examines possible examples of wave power installations in the Tonekabon . The mean power within 50 km of the shore is determined to be (∼3 kW/m), whereas higher power (∼ 9 kW/m) is available further offshore.

1. Introduction

Waves are a result of the effects of wind on the oceans and seas. This wind originates from the major influx of energy to this planet: solar energy from the sun. The energy contained within waves is around the world is huge; in some places values of 70MW/km of wave front are experienced. In theory it could then be said that huge generating stations could be built which would capture all this energy and supply all or most of our needs. But there are many factors affecting this kind of deployment becoming a reality. Identifying area of suitable wave height is something that has to be done before deployment can start. The highest concentration of wind power is found in the windiest areas, which are mainly between latitudes 40 and 60 in both northern and southern hemispheres. We are lucky in the Scotland to have an abundance of Wave Energy available, mainly on the west coast. The technology must be able to withstand the freak wave heights that can be experienced, in rough and remote locations where access can be difficult. There are three main categories that wave power can be split into, these are Near Shore, At Shore and Off Shore. There are obvious environmental and social considerations to go with both of these conditions. Near Shore operations have to consider the aesthetic influence they will have on what could be a picturesque area, they also will have a definite impact on shipping and marine life but again this will be no greater than current offshore installations. It has been suggested that a distance of 12 miles from shore is the distance within which a device is said to be near shore.
The issues discussed previously will also obviously be experienced by off shore wave installations. It has been suggested that a depth greater than 50m will constitute an offshore device. On shore wave power will have a marked effect on the area it is deployed. There are ways of incorporating it into existing structures to minimize the effect, such as harbor walls. At present, the main stumbling block to deployment of wave energy devices is funding. The Government has a very important role to play if this industry is to be given the chance to fulfill its potential. The capital costs are the problem, as it is hard to get companies to invest in technologies that have not yet been completely proved.

2. How Much Power Can Get from Wave?

If the height a deep-water wave is h, the density is ρ and the wavelength is λ, then the total energy, E, of the wave will be

$$E_{pot} + E_{kinetic} = E = \frac{\rho g h^2 \lambda}{8} J/m. \qquad (1)$$

Per meter of wave front, where g is the gravitational constant. In term of the time period, T, of the wave we have:

$$E = \frac{\rho g^2 h^2 T^2}{16\pi} J/m \qquad (2)$$

Dividing by T, then gives the power, P, per unit length of wave crest:

$$P = \frac{\rho g^2 h^2 T}{16\pi} W/m \qquad (3)$$

Using the values, $g = 9.8$, $\rho =- 1000$, and $\pi = 3.14$ allows us to write equation (3) as

$$P = 2h^2 T` kW/m \qquad (4)$$

In reality, the state of the sea will not be a continence wave of wavelength λ and period T, but a complex amalgamation of waves off varying λ and direction of travel. In order to get an accurate idea of how much power there is over a reasonable length of time, measurement becomes the only option. A typical result [1] is that:

$$P_{measurd} = 0.55h^2T`kW/m \quad (5)$$

The power, P_{elec}, which can be extracted and converted to electricity by any wave machine, is likely to be even less, possibly only third so:

$$P_{elec} = 0.55h^2T/3$$

i.e.

$$P_{elec} = 0.18h^2T`kW/m \quad (6)$$

Dividing equation (6) by equation (4):

$$\frac{P_{elec}}{P} = \frac{0.18h^2T}{2h^2T} \cong 0.1$$

Which demonstrates that will only be able to extract 10 per cent of the total power indicated by Equation (4).

Linear wave theory assumes that the motion of the water past a point is sinusoidal. The period (T) for one wave to pass this point can be expressed by:

$$T = \sqrt{\frac{2\pi\lambda}{g}} \quad (7)$$

Interestingly, equation (7) implies that the larger waves travel faster than the smaller ones.

Near the shore in shallower waters, $d < \lambda/4$, and:

$v = \sqrt{gd}$, i.e. the velocity is independent of the wavelength or period.

3. Wave Energy Technologies

A variety of technologies have been proposed to capture the energy from waves. Some of the more promising designs are undergoing demonstration testing at commercial scales. Wave technologies have been designed to be installed in near shore, offshore, and far offshore locations.

3.1 Buoyant Moored Device

This type of device floats on the surface of the water or below it. It is moored to the seabed by either a taught or loose mooring system. One example of this type of device will be discussed, the Edinburgh or Salter Duck. The Duck team is led by Professor Salter at Edinburgh University. The Duck is shown in the figure below. Ducks work by independently rotating about a long linkage; this maintains its stability by out spanning wave crests. The front edge of the duck matches the wave particle motion. In moderate seas, the more cylindrical back portion creates no stern waves but when the weather is bad these parts shed energy through wave making to the rear. The device requires a depth of at least 80 meters and uses a system of weights and floats to give almost constant tension in the mooring cables.

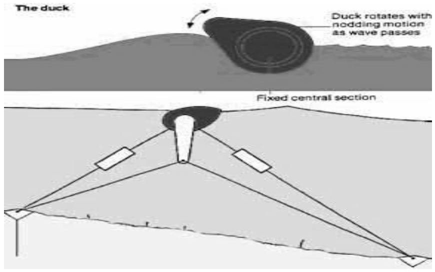

Fig. 1 The Duck

3.2 Hinged Contour Device

This type of device follows the motion of the waves; it creates power using the motion at the joints. It is commonly moored slackly to hold it in place. One example of this type of device is the Pelamis WEC that is being developed by Ocean Power Delivery. As the Pelamis moves with the waves, the motion is resisted at the joints by hydraulic rams that pump high-pressure oil through hydraulic motors via smoothing accumulators. These motors are used to drive generators to create power. It has been said that a 750kW device would be 150m long and 3.5m in diameter and comprise five sections.

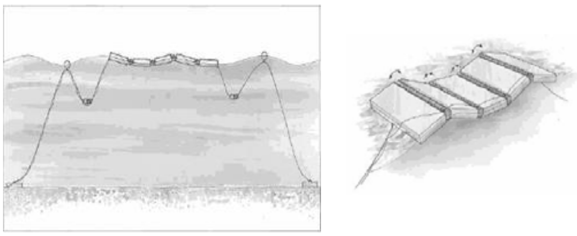

Fig. 2 Pelamis

4. Tonekabon Beaches

Tonekabon in north of iran is located on the south of Caspian sea. The wave power potential along the southeast the Caspian Sea isn`t investigated. The available data from National Data meteorology Center wave stations in the given area are examined. Power calculated from hourly significant wave heights and average wave periods is compared to power calculated using spectral wave density.

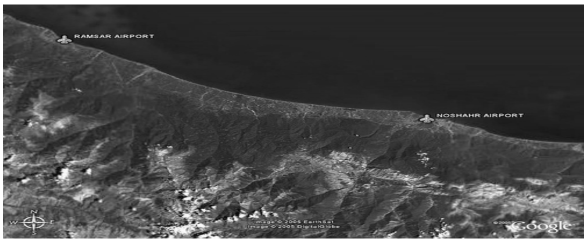

Fig. 3 A map of the area

5. Methodology of Case Study

In this work its potential for energy production is assessed based on daily data covering the period 2000–2007. Taking into account the results of this assessment along with other relevant considerations such as the location of ports, navigation routes, and fishing and aquaculture zones, an area is selected for wave energy exploitation. The transformation of the offshore wave field as it propagates into this area is computed by means of a nearshore wave model (SWAN) in order to select the optimum locations for a wave farm. The study is based upon linear generator technique, placed on the seabed using point-absorbers arranged in arrays of up to several thousand units. Temporal trends of the wave heights, wave periods and the wave power are analyzed for a time scale of weeks. Power calculated from hourly significant wave heights and average wave periods is compared to power calculated using spectral wave density.

Fig. 4 Experimental dike for evaluation of wave power

6. Data Analysis

Measurements in this area, Tonekabon domain, were done in 2000- 2007 for wave properties in coastal dike. Wave power values in coasts of this region have been studied. With this Wave power results determined the potential of wave power in this region. Figure- 4(a, b, c & d) shows illustrate wave power during year months in 2002, 2003, 2004 and 2007.

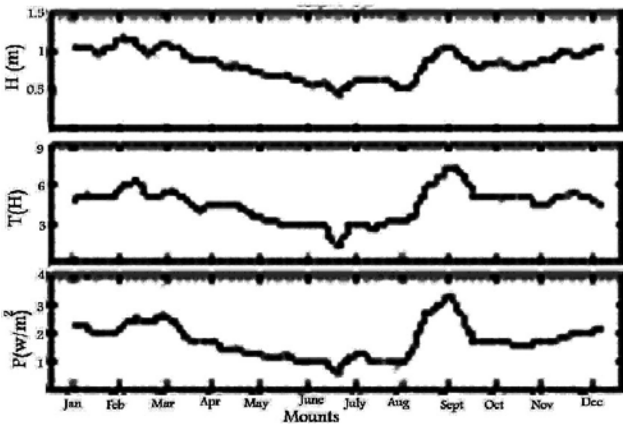

Fig. 5 Wave height, average wave period and power averaged over the years, for the waves observed at study region

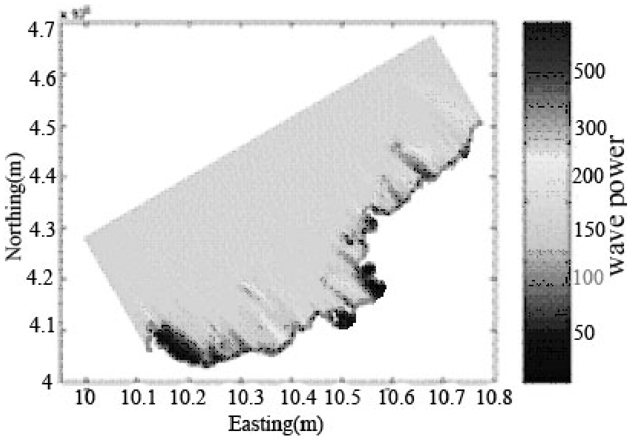

Fig. 6 Wave power in this region

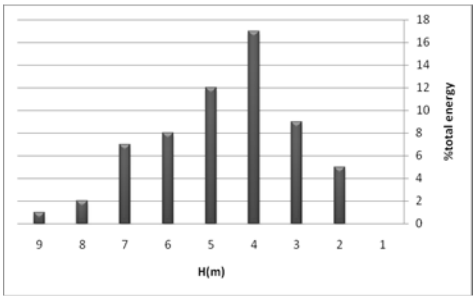

Fig. 7 Percentage of total wave energy significant wave height

7. Conclusions

According to the experiment and result of computing we could see:

a) The mean power within 50 km of the shore is determined to be (~3 kW/m), whereas higher power (~9 kW/m) is available further offshore.

b) With this study determined one zone emerges as those with the highest potential for wave energy exploitation.

c) In this region wave energy electric conversion is an option that needs more attention and which has several advantages compared to conventional renewable sources.

References

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