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Feasibility Study on Renewable Power Plants: Tidal Power Plants

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Abstract

Nowadays, the widespread use of fossil energy has created many problems in the world such as gradual splitting of Ozone layer, increasing greenhouse gases, increasing environmental pollution, global warming, and etc. Today, decreasing the effects of these resources is one of the main priorities in energy management. In addition to efforts for optimal consumption, we should look for some other alternatives such as renewable energies for these resources. One of the main renewable energy is the sun. Almost 70% of this energy is stored in the sea. Several different methods are proposed to extract this energy from seas such as wave power plants, temperature difference, difference in salt concentration, etc. One of the methods of electricity extraction from seas is tidal power plants. In this paper, we also explain origin of tidal energy and the energy amount that can be extracted by this method, different methods of usage, production, advantages and disadvantages of these power plants and feasibility of them in our Iran.

Keywords: Gravity between the moon and the earth, renewable energy, tidal energy, tidal power plants, tidal turbines

Introduction

One of the most important and the most applicable renewable energy resource is using tidal energy from seas and oceans. The use of tidal energy dates back to many years ago. Tidal mills have been used from 11th Century in France, England and Spain. The water went in a pool when the tide came in (flood tide), trapped there and moved the blades of mill for several hours in ebb time. For instance, Rhode Island mill was built in 18th century and had a wheel with diameter of 11ft, width of 36ft and weight of 20 tons. In 1965, the first facilities were built in France for electricity production from Rance River. This station had 24 turbines, each of which produced 10Mw electricity and 240 Mw in total. In 1967, a station (400Kw) was built in Kislaya Guba, Russia. In 1984, a station with output capacity of 200Mw was built on Annapdis River in North America. Developing and installing tidal power plants has been continued till now. There are near 26 areas which are suitable for tidal power plants, in 14 of these areas tidal power plants are built and have been used. The total potential energy of 200Twh has been calculated for these stations. For technical reasons, tidal power plants can only use 25% of their output capacity. Therefore, the maximum accessible capacity of tidal energy in the world is almost 3000Gw. This is only 2% of the whole energies which can be used to produce electricity. Until now, near 166365Mw of this energy capacity is used by tidal power plants in the world (Anvarkhatibi , Mohammadi , & Mohammadi , 2013). In this paper, we describe the tidal energy. Then, various methods available for the use of tidal energy are introduced. Finally, advantages and disadvantages of tidal power stations is discussed.

Description of tidal energy

Tides are caused by gravity of the sun and the moon on water of the earth's level. The moon and the earth revolve around their common center of mass with sidereal period of 27.3 days. The

gravity force between two objects is equal to their centripetal force. In figure1, centripetal power is towards outside and it causes water ridge (flood tide) in those 2 areas. The earth rotates around its axis each 24 hours. Therefore, flood tide happens twice a day in any region. The areas which have the most power are located in 45, 135, 225 and 325 degrees of the earth. However, there is a gravity between the sun and the earth which is weak.

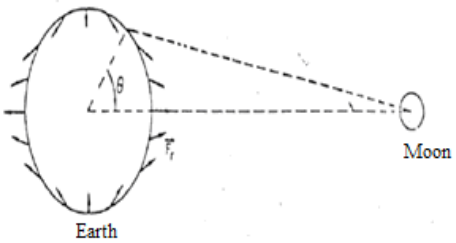

Figure 1: The Moon's Effects on the Earth

Every 7 days, the moon and the sun make an angle of 90 degrees and they neutralize each other's gravity effects. In this case, a little tide happens. The average of weak tides is 1.3 of the average of strong tides. These changes are quite recurring. Normally, each 24 hours and 50 minutes, tides happens 2 times. For economical use if tidal energy, a difference of 5 to 10 meter is needed. 27 areas have the suitable conditions for building tidal power plants (as shown in figure 2).

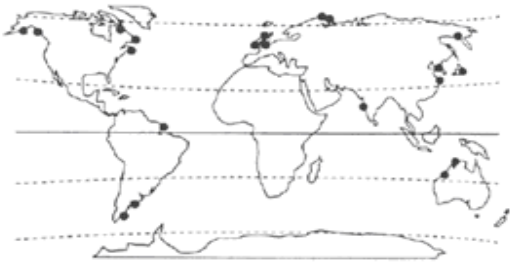

Figure 2: Ideal Places for Tidal Power Plants

Table 1 shows the tidal difference in current power plants. Generally, 3 cycles can be considered for this process. Half-day cycle which is created by the earth's rotation with the moon's gravity field. 14 days cycle happens by gravity of the moon and the sun. Half-year cycle which is caused by the moon's rotation around the earth (Samani and Naseh, 2012). Table 1 shows the tidal difference in current power plants. Generally, 3 cycles can be considered for this process. Half-year cycle is caused by the moon's rotation around the earth (Samani and Naseh, 2012).

Table 1: Tidal Difference in Tidal Power Plants

Country	Geographical location	height difference (ft)
France	Rance River and Saint Malo	27.8
United States and Canada	Hopewell and Passamaquoddy	18.1
England	Servern River	35
United States	Annapolis River	24
White Sea Russia	Murmansk	20
Argentina	San Jose	20

The total distributed tidal energy on the earth is almost. The energy which can be produced by tides can be calculated by this formula:

$$E = dgAH^2$$

In this formula, H is the height of the tides, A is the area, d is density of water and g is gravitational acceleration. The first factor for building tidal power plant is to find a suitable area. The minimum height of water for producing economical electricity is 5 meters. The second factor is volume of water which flows.

$$P_e(t) = \frac{1}{2} pA_0 V^3(t)$$

In this formula, P is the density of water, A0 is initial surface area (square meter) and V is speed (meter per second). Almost in every plan, a gulf or a canal or an entrance is needed.

Different methods for using tidal energy

There are different methods for using tidal energy. The most economical method is to build a dam on sea water. The flow of the water is used for moving turbines. This method is shown in figure 3. A hydraulic unit with low height is the most applicable plan which is installed on rivers.

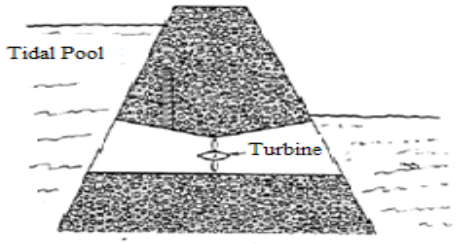

Figure 3: A sample of tidal unit

. One of the effective factors in selecting a method for using tidal energy is combining surrounding areas and the costs of each plan. Different methods of plans are:

1- Construction of a pool for flood tide
2- Construction of a pool for ebb tide
3- Construction of a pool for ebb and flood tides
4- Construction of 2 pools, one for ebb tide and one for flood tide
5- Construction of 2 pools, one long and one short with a one-way system

In above plans, one or two pools are created by building a dam on water canal or gulf. Turbines and bypass sluices are installed inside the dam. Turbines can be used for one-way flow and two-way flow

Technology of tidal energy

Tidal energy has a long history. Tidal energy was used by mills in seashores of France, England and Spain 1100 years ago. For obtaining tidal energy, different methods are applied such as water wheel, air compressor, etc.

In new form of this system, the pond of water storage is equipped with lifting and falling sluices and a water turbine with a low height is used instead of the old water wheel. Operating cycle of this system is divided into the following parts:

- Filling the source with water during flood tide

- Keeping water in the source until the flood tide is complete and the maximum height of water is acquired.
- Emptying the water of the pond to sea by water turbine and giving the essential energy to the turbine.
- Waiting until the next complete flood tide and repeating the above 3 steps.

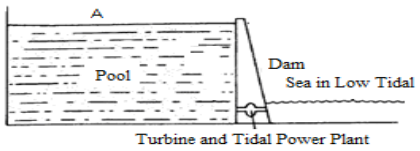

Figure 4: Energy Production during Level Changes in a Single Pond System

This method is called generation in ebb tide because in this step the energy is acquired. This cycle can be reversed. Therefore, the energy can be acquired during water flow from sea to the pond. Because of steep coasts, usually energy generation is more effective and more economical during ebb tide. Two way energy production (in both ebb tide and flood tide) is possible. This method is popular by the name of Double-Effect Single Pond System. Tidal power plants are designed and built to produce to produce electricity. However, in special cases their power can be used to pump water. A single pond tidal power plant produces one or two staggering rate of energy by each tide. Nowadays, there are a few tidal power plants in the world. La Rance, the first and the biggest tidal power plant, is built in France and is using the technology of single pond system and double effect(Zou Fan, 2012).

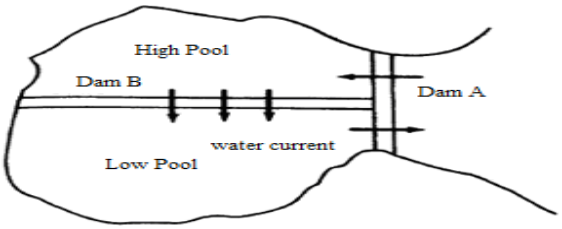

Figure 5: Double Effect- Double Ponds System

Feasibility of exploiting tidal power plants in Iran

In Iran, there are strong tides in south coastal regions especially in north of Persian Gulf like Arvand River. Therefore, the feasibility of exploiting tidal power plants in Iran can be studied and applied seriously. The height difference of tides in east of Oman sea is 3 meters and it reaches to 5.5 meters in Strait of Hormuz. Therefore, the possibility of building tidal power plants exists. Electricity energy can be extracted from seas by other methods such as by waves, temperature difference and difference in salt concentration. Ministry of Energy of Iran has done a research in this regard which is shown in table 2.

Table 2: Waves Projects of Ministry Of Energy

	Start Year	End Year	Investment Done($)
Wave power plant models (OWC)	1977	1977	100.000
Wave power plant models (Pumping)	1976	1978	50.000

20 areas in South Coast of Iran were studied by Ministry of energy. Table 3 shows the results of this research. Currently, we are using lots of fuel fossils in our power plants. If we use renewable energies, we can use fossil fuels for creating derivatives and create a high income for the country(Darron Scott, 2007).

Table 3: **Annual Average of Tidal Energy in One Tidal Period (Watt Hour/Square Meter)**

Row	Location	Average years energy potential
1	Arvand River	8.946
2	Mosea Khor	5.416
3	Gulf Khor Moses	9.430
4	Mahshahr Port	22.800
5	Hendijan	4.837
6	Dylm **Port**	5.403
7	Imam Hussain **Port**	4.116
8	*Kharg island*	2.715
9	Bushehr	2.041
10	Sea camp Bushehr	2.319
11	Halylh	2.319
12	Lavar	2.920
13	Knkan	3.096
14	Asalooye Port	2.740
15	Lavan island	1.737
16	Faroe Islands	2.829
17	Sirri Island	2.064
18	Bstanvo	3.995
19	LENGEH Port	4.451
20	Kong	4.312

Conclusion

Fossil power plants have a good efficiency especially when they are combined with the wheels which reduce losses. But, we faced environmental problems and unstable fuel prices. To solve this problem, we looked for a power plant such as a combined cycle which creates less pollution. These power plants again were dependent on fuels. The problem of fossil fuels is only solved by using renewable energies. Renewable power plants were not economical at the beginning. But, with the increase in fuel costs and optimizing the cycles of these power plants, they could compete with the other power plants. Tidal power plants are considered as renewable power plants. Since decades ago, developed countries have started plans to develop their renewable power plants. In order to reach a consistent development, our country should also continue to develop renewable power plants.

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