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Research Paper

Persian gulf: Important resource of tidal energy for electrical power generation

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ABSTRACT

Renewable energies, such as energies of wind and river flow, are systems originating intermittently from solar energy and are generally considered as nonpolluting fuels. It should be mentioned that these energies are renewed by sun and are unlimited. Due to the fact that there is no tide in the Caspian Sea in the northern part of Iran, the researchers focus on the southern Coast of Iran: the Persian Gulf. Tidal generation has a significant advantage over many other forms of renewable generation as it is almost perfectly forecast able over long time horizons. Thus, incorporating tidal generation into an electricity system should be less challenging than other forms of renewable generation which are relatively unpredictable. In this paper, we discussed about the capacity benefit of tidal generation in the Persian Gulf.

Key words: Persian Gulf, renewable energy, tidal energy, current energy, Iran.

INTRODUCTION

Since the fossil fuels will be finished in the world, usage of other sources of energy such as renewableenergies is very important. One of the most important sources of the renewable energies is tidal energy that has thehighest energy density among the other sources.

Tidal energy is the energy dissipated by tidal movements, which derives directly from the gravitational and centrifugal forces between the earth, moon and sun. The gravitational force of the moon, due to it being closer to the earth, is 2.2 times larger than the gravitational force of the sun (Mazumder and Arima, 2005). These forces cause the rhythmic rising and lowering of ocean waters around the world that result in Tide Waves. The moon exerts more than twice as great a force on the tides as the sun due to its much closer position to the earth. As a result, the tide closely follows the moon during its rotation around the earth, creating diurnal tide and ebb cycles at any particular ocean surface. The amplitude or height of the tide wave is very small in the open ocean where it measures several centimeters in the center of the wave distributed over hundreds of kilometers (Owen and Trevor, 2008).

Tidal energy has been exploited on a significant scale since the construction of the La Rance tidal barrage in France in 1967. A tidal barrage utilizes the potential energy of the tide and has proven to be very successful, despite opposition from environmental groups. Kinetic energy can also be harnessed from tidal currents to generate electricity and involves the use of a tidal current turbine. This is the more desired method of capturing the energy in the tides (Rourke et al., 2010).

The rise and fall of the sea level can power electric-generating equipment. The gearing of the equipment is tremendous to turn the very slow motion of the tide into enough displacement to produce energy. Tidal barrages, built across suitable estuaries, are designed to extract energy from the rise and fall of the tides, using turbines located in water passages in the barrages. The potential energy, due to the difference in water levels across the barrages, is converted into kinetic energy in the form of fast moving water passing through the turbines. This, in turn, is converted into rotational kinetic energy by the blades of the turbine, the spinning turbine then driving a generator to produce electricity. Comparing with wind power energy and solar energy, tidal power seems not a big sustainable resource, but it is doing a fast-rate progress in recent decades. Nowadays and in the coming years, increased attention is being given to the tidal current energy development all over the world. Because of the climate protection, the shortage of oil in future and the increasing demand for electricity the use of renewable energy source for electricity generation is of great importance. The classical hydro power is with approximately 20% of the worldwide electricity generation the most important renewable source (Etemadi et al., 2011). In the search of other sources recently tidal currents obtained an increased importance. This technology seems to be ecologically suitable as well as economically feasible. The aim of this paper is to present the distribution of tidal current energy and the future potential of tidal energy in Persian Gulf.

TIDAL ENERGY

Factors such as the predictability of tidal currents, the relatively large resource estimated in coastal waters, and the advanced development of similar turbine and component technologies have contributed to the significant growth in the development of tidal current concepts over the past decades. Tidal energy is vastly distributed all over the world, such as Rance River in France.

The first large-scale tidal power plant in the world was built in 1966 at La Rance in France. It generates 240 MW using 24 low-head Kaplan turbines. A number of small tidal power plants have also been built more recently in order to gain operational experience and to investigate the long-term ecological and environmental effects of particular locations. The Rance Tidal Power Station in France is the world's first and largest tidal power plant with the capacity of 240 MW and the annual output of 600GWh and it has been operating since 1966. North America's only tidal power plant, the Annapolis Royal Generating Station with the capacity of 20MW and the annual output of 30 GWh, was opened in Nova Scotia, Canada in 1984. Also, two small tidal plants were installed in Russia and China with the capacity of 400 and 500 kW in 1968 and 1966, respectively (Ghobadian et al., 2009).

Traditionally tidal energy has been harnessed using a barrage system to establish a head of water, which can in turn power a turbine, much as in a hydroelectric dam. The basin is filled through the sluices and freewheeling turbines until high tide. Then the sluice gates and turbine gates are closed. They are kept closed until the sea level falls to create sufficient head across the barrage and the turbines generate until the head is again low. Then the sluices are opened, turbines disconnected and the basin is filled again.

Tidal barrages have the benefit of using well-known technology, but on the other hand they require quite a bit of civil engineering work, the local environmental impact can be considerable, and the number of suitable sites is limited. An example of such a scheme can be seen at the La Rance tidal barrage, Brittany, France. Another way to harvest the tidal current energy is to extract the kinetic energy from the free flowing water, in a sense similar to wind energy conversion. Recent developments in tidal energy devices, TED, have focused on harnessing the tidal stream rather than the potential rise in sea level. Tidal streams are fast moving currents, the speed of which can be magnified by local topographical features such as head- lands, inlets and between islands (Denny, 2009).

Maximum electricity output is thought to be achievable by operating a tidal barrage or lagoon in ebb generation mode, possibly with flood pumping. Generation times could be expected to occur around three hours after high water and continue for around four hours. As a result, a total generation time of just less than eight hours per day could be expected.

Rather than using a dam structure, tidal current devices are placed directly "in-stream" and generate energy from the flow of the tidal current. There are a number of different technologies for extracting energy from tidal currents. Many are similar to those used for wind energy conversion, i.e. turbines of horizontal or vertical axis. There are several ways of categorizing tidal stream devices, with overlap between categorizations. Probably the most obvious design element is the rotor configuration, of which there are three main categories:

- Horizontal axis
- Reciprocating hydrofoil
- Vertical axis.

In addition to rotor configuration, tidal stream devices can be categorized by their placement method, which can be fixed to the sea floor, weighted to sit on the sea floor, or floating (usually through the use of cables attached to land anchors). They can also be ducted, which is a way of concentrating the tidal flows from a larger amount of sea water into a smaller rotor area.

Most Tidal currents technologies rely on the horizontal or vertical axis turbine concepts. Turbines may be suspended from a floating structure or fixed to the sea bed. In large areas with high currents, it will be possible to install water turbines in groups or clusters to both drag and lift turbines have been investigated, although the lift devices offer more potential. The concept of installing a number of vertical axis turbines in a tidal fence is being pursued in Canada (Roddier et al., 2007.

Tidal currents are experienced in coastal areas and in places where the seabed forces the water to flow through narrow channels. These currents flow in two directions; the current moving in the direction of the coast is known as the flood current and the current receding from the coast is known as the ebb current. The current speed in both directions varies from zero to a maximum. The zero current

Table 1. The tidal power values per square meters for 6 selected location of south coast of Iran.

Location of south coast of Iran	Tidal Power Values (W/m^2)
Khor-e-Musa Estuary	1.1
Bushehr	0.38
Kangan	1.1
Bandar-Abbass	2.35
Jask	0.82
Chabahar	1.93

speed refers to the slack period, which occurs between the flood and ebb currents. The maximum current speed occurs halfway between the slack periods (Boyle 2004).

TIDAL ENERGY IN IRAN

Tidal energy is unique as a renewable technology since it has the capability of providing predictable, firm power contributing to security of supply. Iran is a country endowed with abundant tidal current energy resources. The tidal flows are favorable in southern coasts of Iran such as Chabahar, due to the bay form of the region.

Additionally, electricity can be generated from tidal flows and their kinetic energy by helical turbines in some parts of Chabahar bay such as "Teiss port", "Ab-Shirinkon" and "Kenarak port", and as mentioned above, the generated electricity has diverse usages. Furthermore, it is possible in Chabahar bay to develop the fishery industry with Mashta method making use of the tides. Obtaining energy in a traditional way from tides was initially achieved in Germany in 1580 where using barrages and height difference of the tide, they stirred large water wheels. In its advanced form, acquiring energy from tidal flows has been studied in many countries since 2000. However, no complete and applied research has been carried out in Iran regarding this subject (Lari and Rahmani, 2012).

Iran has a considerable tidal power resource that could be exploited to produce renewable electricity. Although the data is somewhat uncertain, current estimates suggest that its total resource is divided roughly equally between tidal stream and tidal range potential, with a combined output equal to around 5% of Iran electricity supply.

For Iran, it seems that the simplest and most economical scheme is the single-pool ebb tide system, because it requires less hydro-mechanical equipment and the turbine is simpler. On the other hand, since Iran's dam construction industry has improved considerably during the 90s, tidal power plants can be developed mainly based on the domestic technology and resources (Zabihian and Fung, 2011)

According to Khalilabadi and Dehghani (2007), the tidal power values per square meters for six selected location of south coast of Iran is illustrated in Table 1. Thus, The Bandar-Abbass port, Chabahar port and Khor-e-Musa Estuary respectively are the best locations in the south coast of Iran to establishing a tidal power plant and obtaining energy from tide. Additional establishing a tidal power plant require a large reservoir, and a short and shallow dam closure. In the selected locations, Khor-e-Musa estuary is a natural reservoir but establishing a tidal power plant is impossible, because its inlet need to be dammed-adverse impact on fishing and shipping. In the other selected points establishing a tidal power plant need creating an artificial reservoir (Hopner and Maraschi, 2000).

Conclusions

Tidal energy is one of the most available energies of the seas. The main benefits of tidal energy as a renewable energy is presented as follows:

1. It does needs fuel for maintainance, and is free.
2. It produces no greenhouse gases or other waste, totally no pollution, unlike fossil fuels.
3. Predictable source of energy (compared with wind and solar), it is independent of weather and climate change and follows the predictable relationship of the lunar orbit.
4. More efficient than wind because of the density of water.
5. It will protect a large stretch of coastline against damage from high storm tides.

Due to the fact that there is no tide in the Caspian Sea in the northern part of Iran, the researchers focus on the southern Coast of Iran: the Persian Gulf. In this paper, the distribution of tidal current energy and the future potential of tidal energy in Persian Gulf were presented.

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