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An appraisal of the power density of current profile in the Persian Gulf and the Gulf of Oman using numerical simulation

Mahmood Akhyani [a,*], Vahid Chegini [b], Abbasali Aliakbari Bidokhti [c]

[a] Department of Physical Oceanography, Graduate School of Marine Science and Technology, Science and Research Branch, Islamic Azad University, Tehran, Iran

[b] Iranian National Institute for Oceanography and Atmospheric Sciences (INIOAS), Tehran, Iran

[c] Department of Physical Oceanography, Graduate School of Marine Science and Technology, Science, Research Branch, Islamic Azad University and Institute of Geophysics, University of Tehran, Tehran, Iran

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ABSTRACT

Having more than 2000 km tidal coastline, it's expected that Iran could exploit marine renewable energies. Furthermore, marginal countries around these seas are going to develop their energy resources and marine current energy can be a reliable choice. So, the results of a three dimensional numerical model for the study of circulation in the Persian Gulf and the Gulf of Oman, have been used to assess the power density of ocean currents in these prominent water basins. The calculations are performed regarding converter's dimension and accessibility of the generated power. The results show that the current energy, in the upper 50 m layer increases in two periods of the year, late winter to early spring and late summer to early autumn. It can be asserted that the current energy in the study area increases during monsoon periods. According to the model results, the marine current energy in the Persian Gulf and the Gulf of Oman is rather substantial; but it should wait for harnessing as more efficient power conversion systems are available.

1. Introduction

Nowadays, the nonrenewable energy recourses are dwindling apart from the fact that their ever increasing use has created new challenges for the living environments. Hence, reaching the renewable energy resources is becoming a key objective for many countries. Furthermore, the oil crisis in the 1970s emphasized the requirement to look for other resources to satisfy the growing global demand of energy [1]. Developed countries have implemented some research based on theoretical and practical aspects of marine environment for obtaining energy with lower conversion prices, both nationally and globally [2]. Oceans can be considered a good source of renewable and green energy [3,4]. Countries that are more actively pursuing the application of ocean energy technologies include the European Union, Japan, and China and U.S [5].

One of the renewable energy resources is ocean currents from which; with suitable devices, one can extract energy. A schematic diagram of mechanical energy sources for the ocean circulation is shown in Fig. 1 [6]. Wind stress and tidal force are the most important sources of mechanical energy that drive the oceanic general circulation, because the horizontal flows in oceans are much stronger than the vertical flow [7,8]. The role of other factors such as pure geostrophic currents, internal waves, and so on, can be neglected, especially in large-scale circulation studies. The effect of each factor can be seen in Fig. 2 [6].

In this diagram, one can see that about 3.5 TW (Terawatt) of ocean current kinetic energy is provided by tide and 3.1 TW by Ekman transport (wind). These values are calculated, based on the annual mean of field measurements and theoretical aspects related to each phenomenon. Therefore, as shown in Fig. 2, the main factors for ocean energy are tidal and wind driven currents and waves. This research focuses on the role of ocean currents.

Waves and currents are two famous energy resources in the oceans. Some estimation of wave potential energy in the world's ocean has been prepared; using models, satellites and buoys data [9,10]. The extraction of such energy can certainly be a good alternative for the future energy needs.

Ocean currents are the main heat distributor processes in the world that transfer massive amounts of warm and cold water through the surface and bottom of the oceans [11]. Astronomical forces, thermal gradients and the rotation of the earth (Coriolis effect) are some of the principal factors producing ocean currents.

* Corresponding author.
E-mail address: akhyani@live.com (M. Akhyani).

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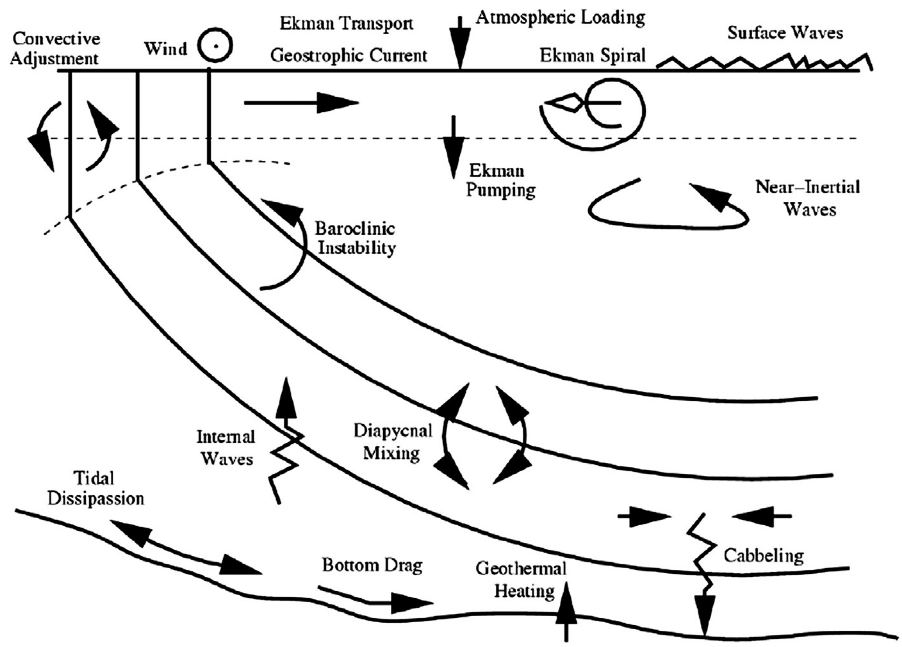

Fig. 1. Mechanical energy diagram for the ocean circulation [6].

In the open seas, gravitational interactions between earth, moon and sun produce tides and tidal currents which can vary due to morphology of seas and gulfs. Although the direction and velocity of tidal currents are changing in a tidal cycle, the net ocean current is almost constant in each season. Other gradients such as regional differences in air pressure, water salinity and temperature and river discharge may have some major influences on the oceanic currents [11].

Marine currents energy has been rarely noticed as a source of renewable energy, but in the near future, it will be one of the important sources for generating electrical energy [12,13]. Converting energy of the marine currents and wind can be quite similar. Various types of open-flow rotors have been designed similar to wind turbines [14]. To compare these two technologies, one can find that ocean currents are slower than winds but as the water density is much greater than that of the air, currents typically have a greater amount of energy (Ocean water density is about 1024 kg/m^3 and air density is about 1.2 kg/m^3). Assuming the same area, current stream with 1 knot speed (0.5 m/s) and winds with speed of 9.3 knot (4.77 m/s) have almost the same amount of kinetic energy.

Such winds (i.e. 4.77 m/s, gentle breeze) can generate about 1 m waves in time and fetch unlimited conditions and sea state will be 3

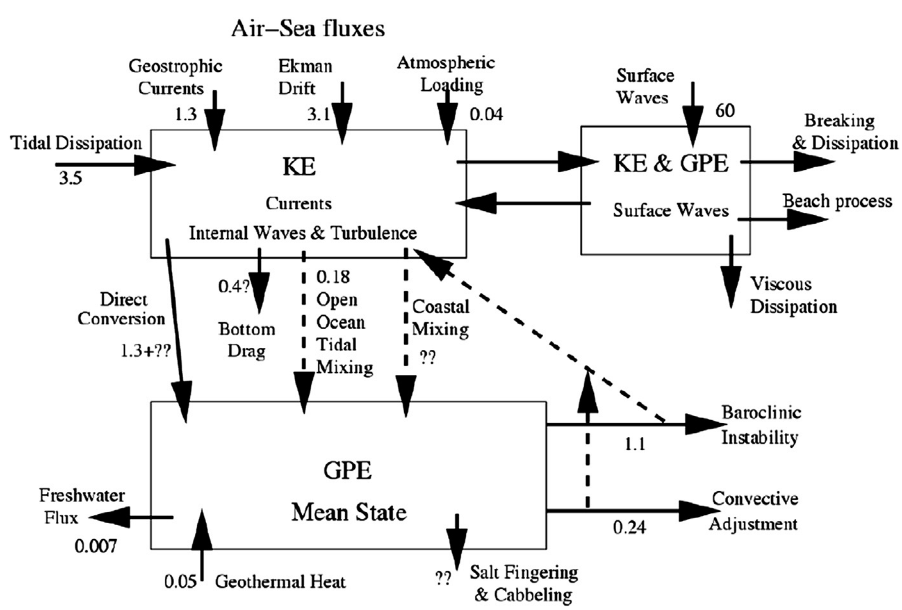

Fig. 2. Mechanical energy balance for the world's ocean (in TW) [6].