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Tidal current turbines glance at the past and look into future prospects in Malaysia

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ABSTRACT

Periodic changes of water levels, and associated tidal currents, are due to the gravitational attraction forces between the Earth, the Sun and the Moon. These changes can be transformed to a renewable energy resource called Tidal Current Energy. A number of resource quantization and demonstration studies have been performed throughout the world and it is believed that offshore ocean energy sector will benefit from this emerging technology. In this study, a set of basic definitions which are relevant to this technology are presented with an overview on the main tidal turbine schemes and the mooring methods that in use. A review of the current development and their fields of applications are outlined. The Blade Element Momentum BEM method and the Computational Fluid Dynamics CFD are discussed. The last section highlights the importance of this technology and its applicability in Malaysia. Other renewable energy resources in Malaysia are highlighted and discussed as well.

Contents

1. Introduction

Tidal energy is the only type of energy which comes from the relative motions of the Earth–Moon system, and to a lesser extent from the Earth–Sun system. The tidal movements are cyclic variations in the level of the seas and oceans [1]. The tidal forces produced by the Moon and Sun, in amalgamation with Earth's rotation, are responsible for the generation of the tidal movements (Fig. 1), [2]. The magnitude of the tide at a given location is the result of the changing positions of the Moon and Sun relative to the Earth, the effects of Earth rotation, and the local shape of the sea floor and coastlines [3]. Because the Earth's tides are

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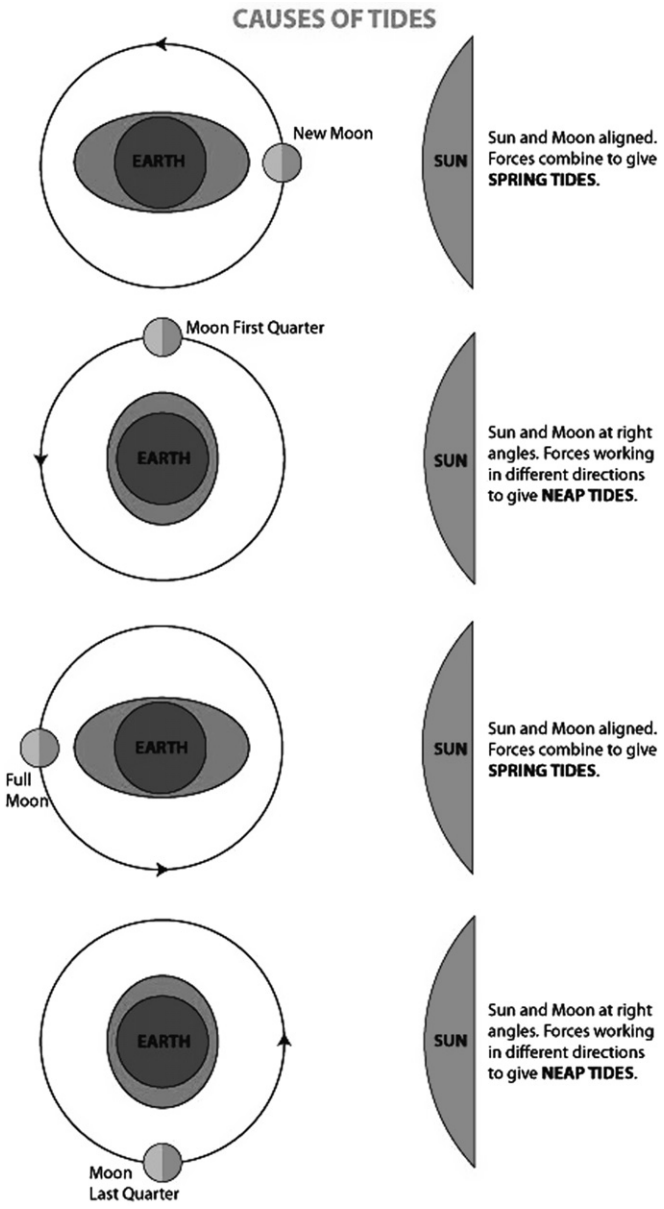

Fig. 1

caused by the tidal forces due to gravitational interaction with the Moon and Sun, and the Earth's rotation, tidal power is basically never-ending and can be classified therefore as a renewable energy source. Tidal energy extracting devices use this phenomenon to generate energy. The stronger the tide, either in water level height or tidal current velocities, the greater the potential for tidal energy generation.

Land-based renewable energy technologies are already facing limitations due to conflicts over land-use, so the seas and oceans offer enormous open spaces where prospect new energy technologies could be deployed on a magnificent scale, without impact on either the environment or on other human activities [4]. Debatably, unless we develop and use offshore renewable energy resources we will not be able to meet our future energy needs without continuing to consume escalating quantities of fossil fuels; this is the main argument for investing in these innovative and so far little-developed renewable energy technologies [5]. However, offshore renewable energy resources are generally more expensive and difficult to harness than the on-land resources, which is why experience up to now with them is quite limited [6]. There is a vicious circle at work in that the expenses of harnessing offshore energy technologies will only be reduced once they are perfected and then deployed on a large scale, so that the high costs involved can be shared by a large deployed generating capacity, but while costs and risks are high there is no incentive for large scale deployment [7].

Tidal energy technologies under development have its roots in investigational work that started in the 1970s after the first surge of interest in renewable energy alternatives following the oil crisis of that era. The common factor between these eras is that the development of renewable energy technologies was supported politically; but of course today the apprehension is for the damage to the environment from greenhouse gases if we carry on to burns even the known reserves of oil in their entirety [8].

There are basically two methods of generating electricity from tidal movement: by building a tidal barrage across an estuary or a bay in high tide areas, or by extracting kinetic energy from free flowing tidal current
[9–11].

Tidal barrages make use of the potential energy in the difference in height between high and low tides. Tidal barrages are a deep-rooted, technically-proven concept which fundamentally involves a structure with gated sluices and low-head hydro turbines (Fig. 2), [12]. This system has been in operation at "La Rance" on the northern French coast for more than 40 yr. Barrages are essentially dams across the full width of a tidal estuary, and suffer from very high civil infrastructure costs, a worldwide shortage of viable sites, and environmental issues [13].

Tidal current systems make use of the kinetic energy of moving water to power turbines, in a similar way to windmills that use moving air. This method is gaining in popularity because of the lower cost and lower ecological impact compared to barrages. Most of the proposed tidal current turbines resemble submerged wind turbines but there are also substantial differences in appearance stemming from the much larger structural loads these devices are subjected to [14].

Modern advances in turbine technology may eventually see large amounts of power generated from the ocean, especially tidal current using the tidal current designs. Tidal current turbines may be arrayed in high velocity areas where natural tidal current flows are concentrated. Such flows occur almost anywhere where there are entrances to bays and rivers, or between land masses where water currents are concentrated [15]. Many tidal sites are relatively bi-directional; however, some sites can have flow reversal of 20° or more away from 180° such as the flow around islands [16] and headlands [17]. This paper discusses the background to the development of a unique and novel technique for renewable energy generation using the kinetic energy of tidal currents.

2. Background of hydrokinetic energy conversion

The process of hydrokinetic energy conversion involves utilization of kinetic energy contained in river streams, tidal currents, or other man-made waterways for generation of electricity. This emerging type of renewable energy technology is being strongly recognized as an exceptional and unconventional solution that falls within the areas of both in-land water resources and offshore energy resources. In contrast to conventional hydroelectric plants, where an artificial hydraulic head is created using dams or penstocks, for large-hydro and micro-hydro, respectively, hydrokinetic converters are constructed without significantly altering the natural path of the water stream [18]. With regard to ocean power exploitation, these technologies can be arranged in