Numerical Estimation for Tidal-current Energy Resources in Indonesia

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ABSTRACT

Knowledge of flow characteristics and spatial variations of tidal-current energy has been strongly required for locating a power plant. In this research, a numerical approach was presented using Princeton Ocean Model (POM) with topography data and tide prediction data as initial condition. The water elevation results were compared with the real time data. The validations shows a good agreement for the water elevation phase and an acceptable agreement for the amplitude of water elevation. More than 100 MWh in the kinetic energy of the tidal current was estimated at several locations. Nusa Tenggara islands could be one of the most preferable location in Indonesia to install a tidal power plant in the intermediate water depth and narrow straits. Considering a suitable site in examinations, an optimized tidal turbine has been proposed and designed.

KEY WORDS: Tidal-current energy; Ocean Circulation Model, POM, Nusa Tenggara; Tidal turbine; Indonesia.

INTRODUCTION

Indonesia (see Fig.1) is an archipelago country located on South East Asia. Indonesia consists of 17,508 islands (Lee, 2003), including about 6,000 inhabited islands (Lamoureux, 2003). The total area of Indonesia is more than 77.7 million square kilometers, including water are surrounding the islands, and the total shoreline of all islands is approximately 54,556 kilometers (Lamoureux, 2003). Therefore, in the vast territory, development of infrastructures in Indonesia has not been evenly distributed, especially, electrification which is the most important lifeline, is scarce for many people without any light. The electrification ratio currently reaches 96% (World Bank, 2015). In other words, there are 10 million people living without any light. Uneven distribution of electricity is mainly found at small islands. To meet energy shortage, the Indonesian government has set the Master Plan for the Acceleration and Expansion of Indonesia's Economic Development 2011-2025 (Coordinating Ministry for Economic Affairs and Ministry of National Development Planning/National Development Planning Agency, 2011), which supports development of a renewable energy and the innovation. Quirapas et al. (2015) mentioned that the ocean energy potential in Indonesia could theoretically reach up to 57 GW generated from ocean thermal, 160 GW from tidal-current, and 510 GW from ocean wave. However, ocean wave is unpredictable and inconsistent. On the other hand, tidal current could be another promising marine energy resource. It can be perfectly predicted by location between earth and moon in astronomy. Considering many narrow straits and channels between islands, Indonesia has a great potential to harvest energy of tidal-current. However, the tidal prediction in Indonesia is the most complex among the world. Because the complexity of coastal geography, uneven topography, and strong tidal elevation and the charge from the Pacific and Indian Ocean current can make a complex ocean circulation system (Ray, Egbert, and Erofeeva, 2005). The semidiurnal tidal can be influenced by large tidal power derived from Indian Ocean, while the diurnal tide can be derived from tidal power of Pacific Ocean through Makassar Strait and Maluku Sea. Both of them can generate the semidiurnal tidal type in Nusa Tenggara islands. The tidal input from Pacific Ocean and the Indian Ocean is also called Indonesian Through Flow (ITF) mentioned by Schmitz (1996), as shown in Fig.1.

In recent years, several researches on estimation of current energy in Indonesia have been conducted. Masduki (2011) has investigated the potential energy of current for electric power generation in coastal areas of east Florest, East Nusa Tenggara Province. Based on the field measurements, the current velocity at Larantuka Strait can be up to 2.83 m/s with semidiurnal type. Blunden (2013) has numerically estimated on the initial tidal current power for the Alas Strait using numerical model. The two scenarios have been examined with and without a maximum water depth limitation of 40m. The first scenario estimation has been acquired from the field observations and mostly with semidiurnal type. The second scenario would be nearly twice, 640 GWh in practical use. The first scenario estimation of annual energy generated from the Alas Strait is approximately 330 GWh in practical use. The second scenario would be nearly twice, 640 GWh. Purba et al. (2014) has conducted the preliminary research on utilization of ocean energy such as current and wind energy in order to support a lighthouse in several small islands of Indonesia. The estimation has been acquired from the field observations and mostly from the satellite data. The highest ocean current velocity could be 0.835 m/s in Miangas Island (small island at south of Halmahera Island). Base on the above mentions in the background, to effectively utilize