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Ocean Thermal Energy Conversion in Indonesia, Malaysia and Philippines

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ABSTRACT

Ocean Thermal Energy Conversion (OTEC) is a process that can produce electricity by using the temperature difference between deep cold around 28 degree Celsius ocean water and warm tropical surface waters around 6 degree Celsius. Malaysia, Indonesia and the Philippines are located on the equator region which has high potential to implement renewable OTEC technology. Indonesia has many potential locations to build OTEC, among them is in Sumatera Utara, Bali, Flores Sea, Makassar Strait. The OTEC is planned under General Plan of National Energy. The 11th Malaysia Plan (2016-2020) aims to manage the 1st Public-Funded OTEC project of Pulau Layang-Layang, Kuala Baram, Gemusut Kakap, and Pulau Bangi. Philippines as located at geographical position near the equator had passed the Renewable Energy Act of 2008 for OTEC project at Pangasinan, Zambales and Quezon.

KEY WORDS: *Ocean Thermal Energy Conversion, Indonesia, Malaysia, Philippines.*

NOMENCLATURE

OTEC	Ocean Thermal Energy Conversion
RUEN	Rencana Umum Energi Nasional
RUED	Rencana Umum Energi Daerah

1.0 INTRODUCTION

1.1 Ocean Thermal Energy Conversion

OTEC technology has been revived through technological capabilities and updates and it is not a new concept, making harnessing the temperature differential of the ocean water [1, 4]. OTEC can provide more energy than the combination of the waves and wind energy [5]. A thermodynamic working fluid were use such as ammonia in a completely closed system where warmer surface water used to evaporate the liquid meanwhile cold deep ocean water condensed the fluid. According to Aydin et al., (2013), the principle of the OTEC system functions is to generate electricity from converting power derived from the movement of a turbine coupled to generator that is linked and solely powered by a working fluid [6].

1.2 Multi Functionality of OTEC

Koto.et.al stated that the potential of OTEC plants to provide not only the clean and sustainable renewable energy but also offers the fresh water desalination, possibility of supporting building air-conditioning system, refrigeration system or agriculture which can be listed as [7-14]:

1.2.1 Freshwater Desalination

Desalination process can be done via OTEC technology which the fresh water can be fashioned in open-cycle OTEC plants when the warm water is vaporized to turn the low pressure turbine [14, 15].

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The water vapour is summarized to make fresh water after the energy was produced. Magesh in 2010 explained that the hybrid OTEC system is capable to generate nearly 2.28 million litres of desalinated water every day for every megawatt of power [16]. Besides, the production of electricity and fresh water at the same time will give benefit for countries which water scarcity [8, 9, 11, 12, 13, 14].

1.2.2 Air Conditioning and Refrigeration

Koto et.al stated that the deep water from OTEC plant can assist to cool buildings in district cooling configuration and provide a large and efficient possibility for overall electricity reduction in coastal regions, assisting to balance the peak demand in electricity as well as overall energy demands [7-14]. A new deep seawater utilization test facility in Okinawa also employs cold seawater air conditioning.

1.2.3 Mariculture

Muralidharan (2012) clearly stated that marine food production is a potential by-product of OTEC power plants [17]. With the alarming loss of topsoil throughout the world our agricultural production will not be able to keep up with increase in demand. Hence, ocean may well become our most important source of food, even more important than the power generated

1.2.4 Hydrogen

The other products of OTEC are hydrogen and oxygen which can be produced from pure water by electrolysis by one of the several industrial processes that have been developed for this purpose [1]. Besides, OTEC plant can be an excellent source of hydrogen production as it can be used as fuel or can be combined with other chemical for other products in future.

2.0 OTEC IN ASIAN COUNTRIES

Southeast Asian countries such as Malaysia, Indonesia and the Philippines located on the equator have their own strategies to implement promising renewable OTEC technology. The potential of OTEC in Indonesia is very large due to availability of deep ocean (Koto et.al, 2016) meanwhile Philippines had passed the Renewable Energy Act of 2008, aimed to harness first ocean energy facility [8]. In line with this deployment of OTEC, Bakar (2013) clearly stated that Malaysia is one of the countries that having potential of this renewable energy harnessing it as an alternative source for stabilizing its grid system [18]. The potential sites of OTEC in Asian countries can be referred in Figure 1 and Figure 2.

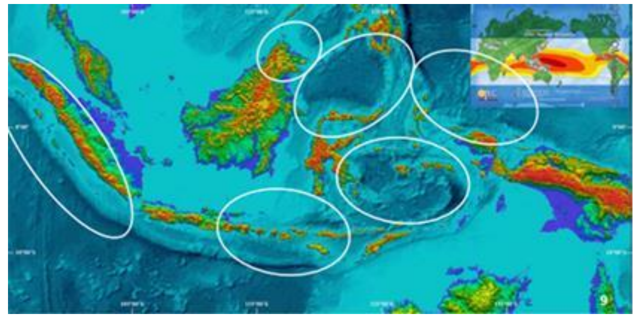

Figure 1: Potential of OTEC in Malaysia and Indonesia [Koto 2017 & UTM OTEC, 2017]

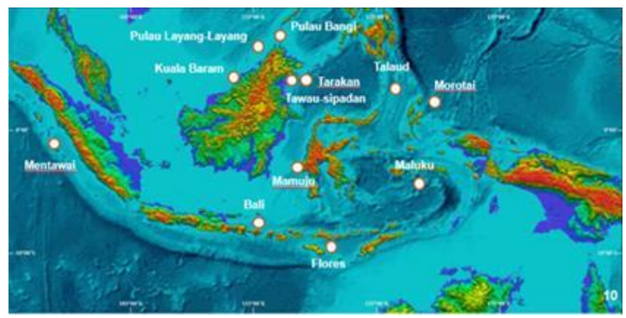

Figure 2: OTEC survey in Malaysia and Indonesia [Koto 2017 & UTM OTEC, 2017]

2.1 OTEC in Malaysia

Malaysia also was among 98 Country listed for OTEC development which include fresh water production [1, 2, 3]. Malaysia is situated in the South East part of Asia which also situated at 2’30’ North latitude and 112’30’ East longitude in the global map. Malaysia has a land area of 334556 km^2 comprising with two medium regions, Peninsular Malaysia and the States of Sabah and Sarawak. As one of the tropical country, Malaysia has tropical weather which is influenced by monsoonal climate. As a result, Malaysia has a hot summer and high humidity level. Besides, the monsoon comes twice a year.

Bun in 2015 explained that there is a high potential to utilize ocean-based energy sources since Sabah is covered by coastal zone of 27549 km² in Malaysia [19, 20 & 21]. Besides, the 11th Malaysia Plan (2016-2020) aims to manage the 1st Public-Funded OTEC project of Pulau Layang-Layang, Kuala Baram, Gemusut Kakap, and Pulau Bangi [21, 22]. On top of that, it requires the ability to attract investments and expansions of similar industries into a high value-added activity in line with the latest 11th Malaysia Plan (2016 – 2020) to ensure the exploration of ocean energy [22].

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Figure 3: Potential sites of OTEC in Malaysia

The location of Sabah trough as depicted in Figure 4 is about 100km off the Sabah coast. The physical continental shelf (shaded in pink) is the offshore areas in which the water depth is generally less than 200 m. This trough is estimated to be about 60km wide and 100km long with a depth of 2500m on average. This study shows the temperature at the bottom of the North-Borneo Trough, at a depth of 2900m, is around 5℃ while the surface water temperature is about 26℃ to 30℃. The graph plotted mean seawater temperature with varies water depth can be refer in Figure 5. The variation of water depth from land can be express in Figure 6.

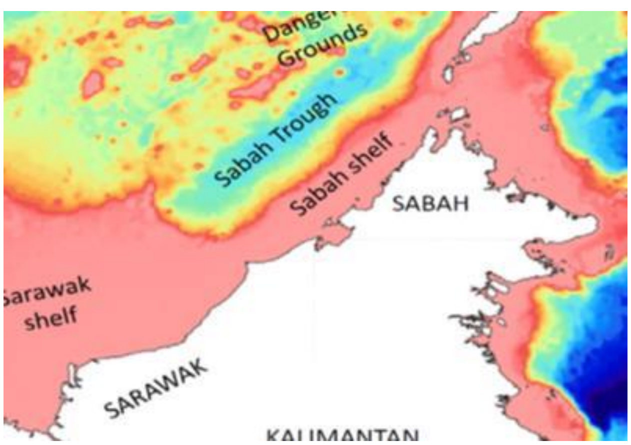

Figure 4: The location of Sabah Trough [23].

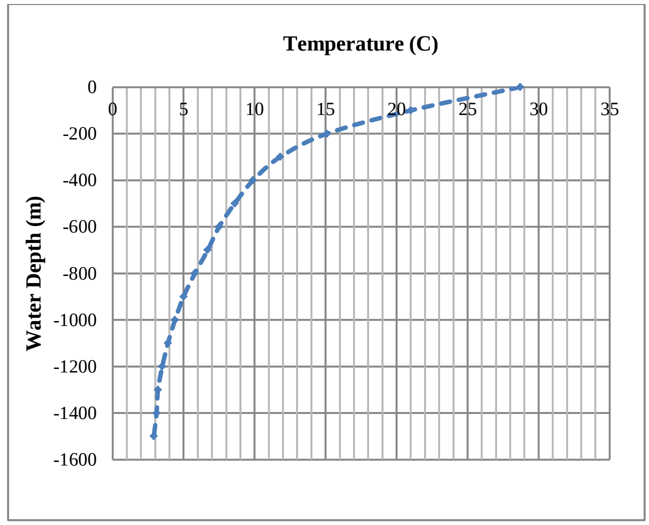

Figure 5: Sea Surface Temperature Data in Layang-Layang, Island, Sabah [1].

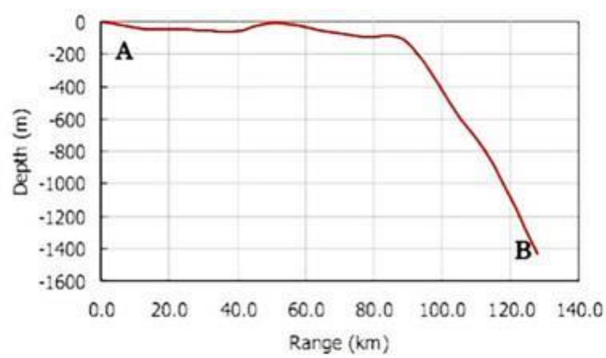

Figure 6: Variation of water depth from land in Sabah Trough [23].

2.2 OTEC in Indonesia

Indonesia is an archipelago island nation along the equator and tropical areas, lies between the Indian Ocean and the Pacific Ocean. Achiruddin, et.al (2010) has mentioned in their study that OTEC plants can be applied in the regions of along southern Sumatra, Java, Bali, Nusa Tenggara archipelago and Eastern Indonesia [24]. Donny (2015) proposed a strategy to develop OTEC in Indonesia by taken economic and environmental issues [25]. He stated that Indonesia has excellent ocean thermal energy conversion technology resources, especially along southern Sumatra, Java, Bali, Nusa Tenggara archipelago and in eastern Indonesia.

Adrian (2015) stated that OTEC could be a solution to produce electricity and also can produce fresh water and cold water for agricultural and cooling purposes especially in the tourist area in Bali [26]. Fanny et.al (2016) and Koto.et.al (2017) studied potentially of OTEC Installation as Power Plant in West

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Sumatera, Indonesia [7, 10, 27]. They proposed three potential locations for OTEC application as follows: Pesisir Selatan, Padang and Mentawai Islands. Delyuzar (2016) has conducted sites seawater temperature measurement in Indonesian waters by MGI Team at the following locations: Mamuju located in the Makassar Strait, Tarakan, Flores Sea, North Bali and Lembata, Nusa Tenggara Timur [28].

Koto et.al has studied feasibility of OTEC in Indonesia such as Mentawai, Karangkelong, Maluku and Morotai [7-14]. They respectively designs and analyses SWOTEC in Banda, Maluku, Halmahera, Maluku Utara, Mentawai, Sumatera Barat, Karangkelong and Sulawesi Utara. The sustainable issues, economic impact on tourism industry, cold agriculture, fishery, electricity and fresh water, equitable national development, politic stability and national defense caused by SWOTEC in Indonesia.

Figures 7 and 8 show measurement and profile at different water depths at Siberut island, Sumatera Barat, respectively. The temperature different between surface and seabed was more than 20 ^{o} Celsius.

Siberut, Sumatera Barat-Indonesia [7].

Figure 7: Experiment of surface and deep sea water in Indonesia [7, 29, 30].

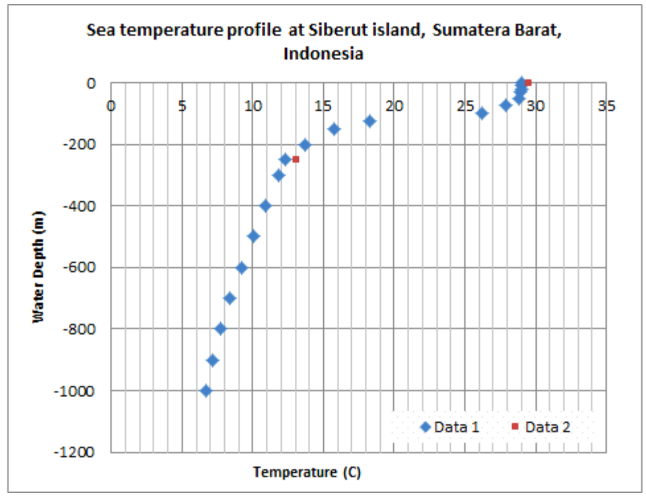

Figure 8: Sea temperature profiles at Siberut Island in Sumatera Barat, Indonesia [7].

Renewable Energy is regulated according to the General Plan of National Energy (RUEN). RUEN is a guideline to direct national energy management to realize energy independence and national energy security in supporting sustainable national development. The RUEN is also a reference in the preparation of the Regional Energy General Plan (RUED).

2.3 OTEC in Philippines

The use of ocean thermal energy can be very interesting in the seas and streets of the Philippines due to its geographical position near the equator such as at Pangasinan, Zambales and Quezon. According to the Uehara et.al (1988), in order to determine suitable OTEC power plant sites in the Philippines, an extensive temperature reading were obtained [30, 31]. The surface seawater is in the range of 25 to 29 C throughout the year meanwhile deep water at 500 to 700 m depth remains at a low temperature of 8 to 4 C, respectively. Uehara et.al (1988) stated that there are 14 potential sites for OTEC within the Philippine seas [30, 31].

Currently, a 10 MW closed-cycle OTEC facility in Cabangan, Philippines was constructed by the UK Company Energy Island Bell Pirie Ltd. as a pilot project [30, 31]. Philippines had passed the Renewable Energy Act of 2008 (or R.A. 9513) as it was signed into law on December 16, 2008, aimed to develop a "strategic program" to increase renewables' usage stating that the law would develop the 'first ocean energy facility for the country'. This also shows that the Philippines government's commitment to accelerate the exploration and development of renewable energy resource.

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Figure 9: Current projects and OTEC research in Philippines [1].

CONCLUSION AND RECOMMENDATION

The main purpose of this paper is to review the potential of Ocean Thermal Energy Conversion in South East Asian region. It was founded that East Malaysia such as Pulau Layang-layang, Kuala Baram Gemusut Kakap, Indonesia such as Mentawai, Karangkelong, Morotai Seram, Selat Makassar and Nusa Tenggara and Philippines such as Quezon, Zambales and Pangasinan were very high potential for Ocean Thermal Energy Conversion.

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