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Energy potential and power generation from tidal basin in coastal area of Malaysia

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A B S T R A C T

In order to meet the Malaysia's energy demand by year 2020, sixteen tidal locations located at peninsular Malaysia, Sabah and Sarawak coastal area which are Pulau Langkawi, Pulau Pinang, Lumut, Pelabuhan Kelang, Tanjung Keling, Kukup, Johor Bahru, Sejingkat, Bintulu, Miri, Kota Kinabalu, Kudat, Sandakan, Lahad Datu, Tawau and Labuan are assessed to see the potential of the power generation by using tidal basin to produce the electricity. The study reports the potential of power generation based on the annual tidal data gathered from each of the tidal stations retrieved from Malaysia Metrology Department (MMD) from the year 2007 until 2011. In this study, power generation is calculated by using tidal barrage with double mode generation. The tidal basin area was estimated by approximation to generate sufficient electricity for local community consumption. In this study, the tidal basin area was measured with the help of Geographic Information System, GIS to enhance the result. Result of the feasibility study conducted in study shows that these sixteen locations contribute at least 0.10% of the energy demand for the year 2020.

1. Introduction

Malaysia relies heavily on fossil fuel and in year 2013, the electricity generations from fuel and gas is 50.1%, coal is 42.8%, hydro is 4.8% and from renewable energy is only 2.3%. In Malaysia, petroleum is expected to be depleted in year 2020, gas in year 2058 and coal in year 2066 (Muda and Pin, 2012). Malaysia has around 50 years before the fossil fuel resources depleted. The disconnection of electricity may not be imminent. However, the burning of fossil fuel to generate electricity releases an enormous amount of carbon dioxide into the atmosphere and contributes to global climate change (Jakhrani et al., 2013). Pollution is a major concern in using fossil fuel to generate electricity power. Malaysia populations grow rapidly year by year and this has caused the increasing of the energy demand. As a developing country, Malaysia's population increase over the year with an annual growth rate of 1.8% and it's expected will reach 33.4 million by the year 2020 and approximately 37.4 million in 2030. The energy demand in Malaysia is expected will be increased to 190,000GWh in 2020, causing greenhouse gas emission to multifold (Lim and Koh, 2010).

Renewable energy resources such as wind, tide, solar, wave and biomass should be seriously considered in Malaysia. The ocean which surrounds the country has a lot to offer. The ocean energy can be categorized into three forms, tidal, wave and thermal. However, wave and thermal energies are not commonly available in Malaysia's ocean as the wave power density of Malaysia's ocean is largely lower than 50kW/m and the depth of the water is less than 1,000m (Lee and seng, 2008). This leaves us with tidal energy to harness. Ocean energy is another form of renewable energy available on the earth. The potential and the commercial viability of harnessing ocean energy in Malaysia were not studied thoroughly. Until recently, a preliminary study was carried out to explore the potential of harnessing ocean energy for electricity generation in Malaysia (Xia et al., 2012).

2. Renewables energy development in Malaysia

According to the 8th Malaysia plan (2001 – 2005), government planned to make the renewable energy as the fifth fuel energy and 5% renewable energy in energy mix. While in the 9th Malaysia plan (2006 – 2010), the government targeted renewable energy capacity to be connected to the power utility grid are 300 MW for peninsular Malaysia and 50 MW for Sabah. With the populations' grow up, the CO_2 emissions will increase too, and the target for carbon intensity reduction is 40% lower than 2005 level by year 2020 (Kor et al., 2014).

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Malaysia heavily depends on the fossil fuel for the electricity generation and this situation becomes critical as fossil fuel is predicted going to be depleted by the year 2020. Renewable energy is one the alternative solutions for Malaysia to continue supply the energy due to its increasing in energy demanding. In Fig. 1 shows the trends of the Malaysian population growth and the electricity generation in order to fill the energy demand. The Malaysia population is expected around 33 million peoples which are increased by 8.13% during year 2020.

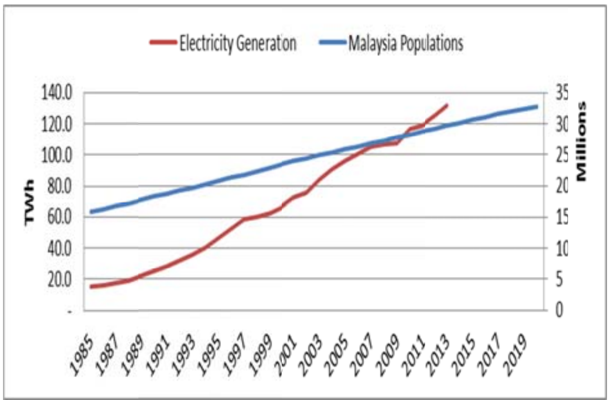

Fig. 1: Energy demands until year 2020

In Fig. 2, shows the trends of CO_2 emissions over the Malaysia population growth. Both CO_2 emissions and Malaysia population growth are proportionally and increase year by year. Besides, burning of fossil fuel to generate electricity releases an enormous amount of carbon dioxide into the atmosphere and contributes to global climate change. This is will make the greenhouse gas emission to multifold.

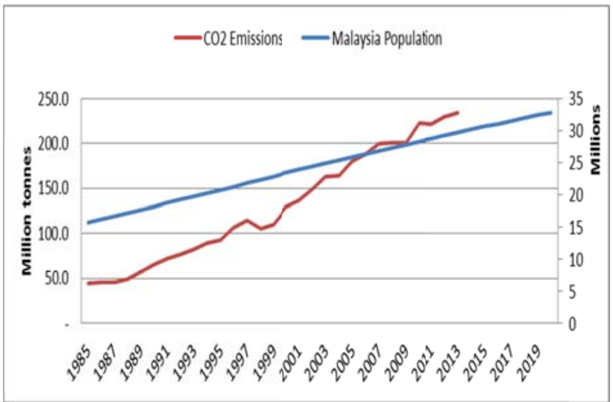

Fig. 2: CO2 emission trends over the number of populations

3. National renewable energy goals

According to the Sustainable Energy Development Authority, Malaysia (SEDA) the goals for National Renewable Energy are targeted 5.4 GWh for power generation by renewable energy source during 2015 and 11.3 GWh during year 2020. Fig. 3 shows the trends of goals for power generated by renewable energy source from National Renewable Energy.

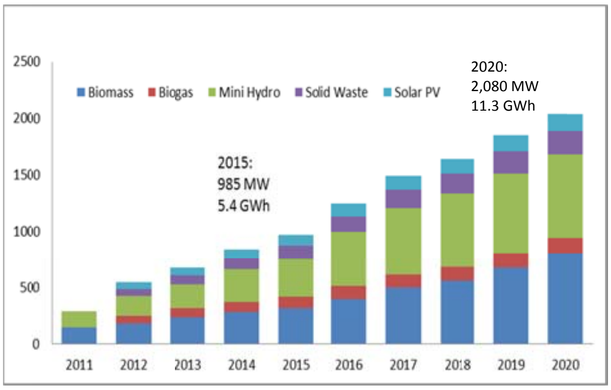

Fig. 3: National Renewable Energy Goals

4. Modes of generations

4.1. Tidal barrage single basin

Tidal barrage is one the technology that commonly used worldwide for harnessing the tidal energy for electricity generation. It is a physically barrier, namely the barrage is created within the sea with sluice gate to control the flow of sea water (Lee and Seng, 2009; Ali et al., 2012). Figs. 4, 5, 6, 7 and 8 shows the diagram of tidal barrage.

There are divided into three approaches which are Ebb-mode generation, Flood-mode generation and Double-mode generation. In this paper, it will discuss about the double-mode operation since the double-mode generation can produce bigger output generation. Double-mode generation operates firstly; sluice gates and turbines are closed until near the end of the flood tide when water is allowed to flow through the turbines into the basin creating electricity. At the point where the hydrostatic head is insufficient for power generation the sluice gates are opened and kept open until high tide when they are closed. When the tide outside the barrage has dropped sufficiently water is allowed to flow out of the basin through the turbines again creating electricity (Shafie et al., 2012).

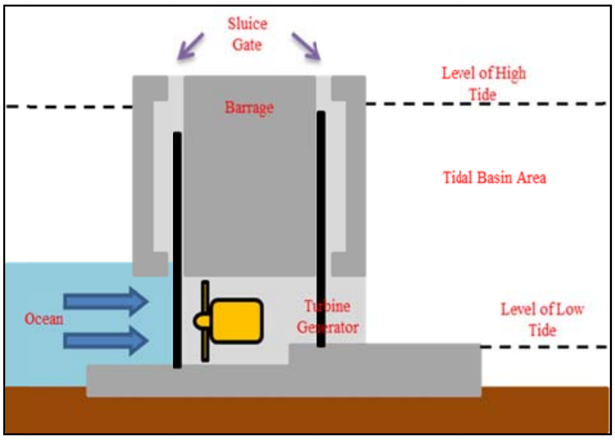

Fig. 4: Double-mode generation diagram

4.2. Tides stations

The data collected from the Malaysia Metrology Department (MMD) shows that the highest tidal range of five meters is located at Sabah and Sarawak. Malaysia has 21 stations of tide gauge as shown in Fig. 9 and tide gauge will be installing near to village or town.

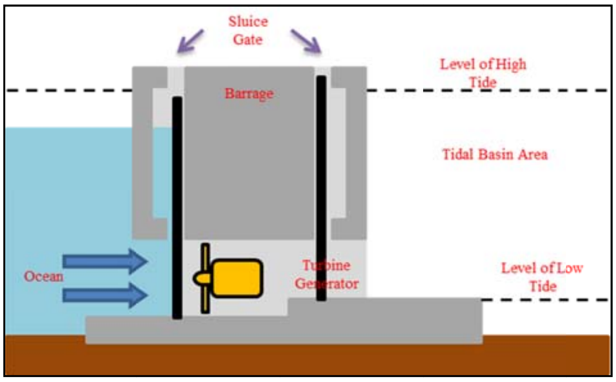

Fig. 5: Double-mode generation diagram

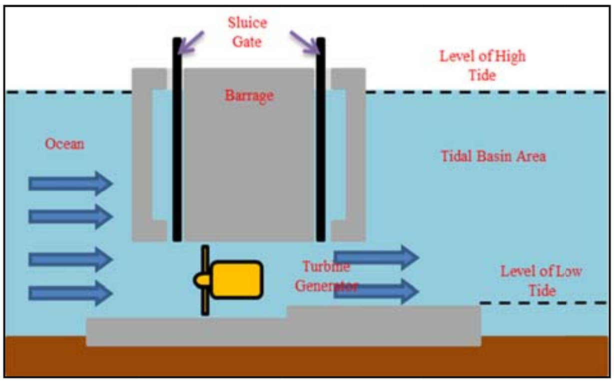

Fig. 6: Double-mode generation diagram

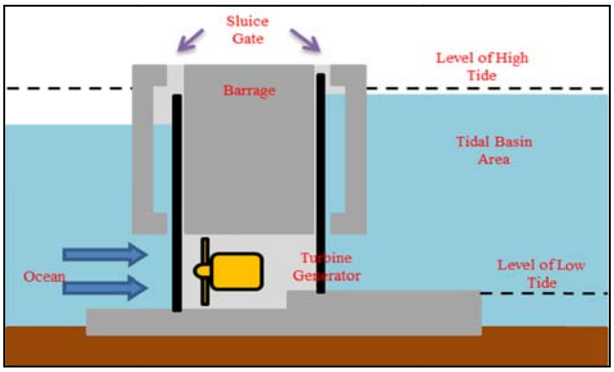

Fig. 7: Double-mode generation diagram

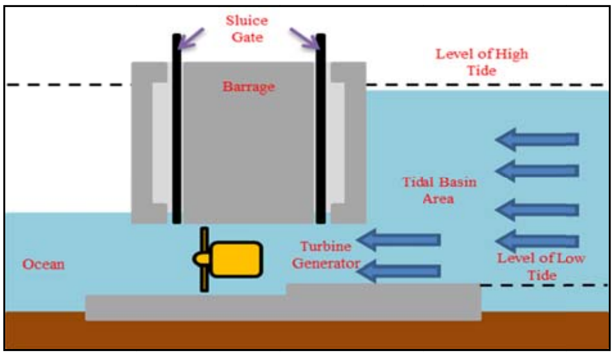

Fig. 8: Double-mode generation diagram

The purpose of tide gauge installation near town or village is to avoid and give warning if there is a change in increasing water level as usual that may cause flood to the nearest region. Since the tide gauge located near and at the coastal area, there will be advantage to make analysis of tidal range at nearest location of tide gauge station. The suitable place to build tidal barrage with high in tidal range will be study more detail into bathymetry at coastal region for more accuracy in finding potential generation.

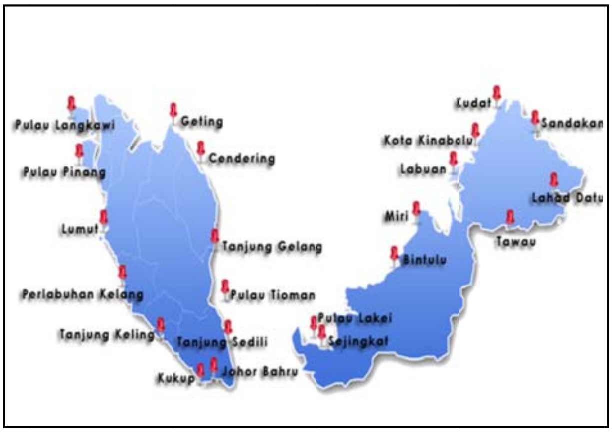

Fig. 9: Tide stations

4.3. Tide range

Tide range is divided into two sections which are ebb generation and flood generation as shown in the Fig. 10 and Fig. 11 and the calculation for these two types of generation are shown in following equation.

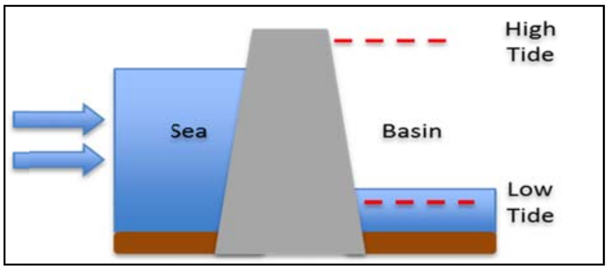

Fig. 10: Flood generation diagram

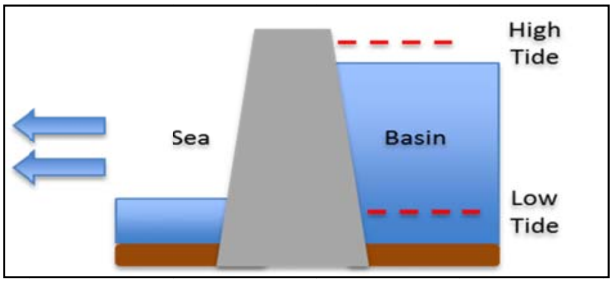

Fig. 11: Ebb generation diagram

$$Flood\ Generation = |Low\ tide - High\ Tide|$$
$$Ebb\ Generation = High\ Tide - Low\ Tide$$

Fig. 12 shows the tide range around the peninsular Malaysia while in the Fig. 13 for Sabah and Sarawak. The highest tide range in Peninsular Malaysia is at Pelabuhan Kelang with three meters height which are passing the minimum requirement for the tidal barrage implementation. In Sabah and Sarawak region the highest tide range is at Sejingkat with the height more than three meters.

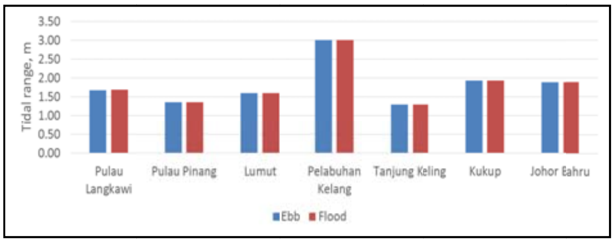

Fig. 12: Tide range for peninsular Malaysia

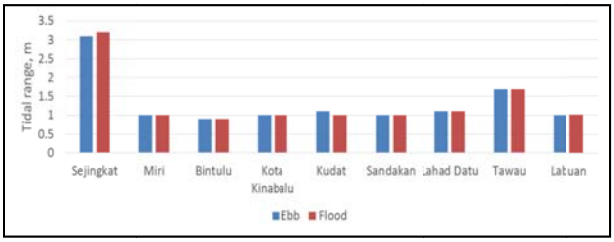

Fig. 13: Tide range for Sabah and Sarawak

4.4. Local electricity demands

The local community was based on the region that the tidal stations were located and data is collected from Statistical Department of Malaysia for the year 2010 (Lee and Seng, 2008). The average electricity consumption in Malaysia is 3966 kWh per household annually (Che and Lam, 2015). Table 1 presents the number of household on that particular area with local community electricity demand. As shown in the table, the demand is relatively proportional due to the number of household; the bigger number of household means that it requires the highest electricity demand.

Table 1: Local community demand

Location	No. of household	Electricity demand (GWh)
Pulau Langkawi	26,000	103.12
Pulau Pinang	64,653	256.41
Lumut	16,591	65.80
Pelabuhan Kelang	3,447	13.67
Tanjung Keling	2,991	11.86
Kukup	1,976	7.84
Johor Bahru	3,703	14.69
Sejingkat	6,636	26.32
Bintulu	35,274	139.90
Miri	11,958	47.43
K. Kinabalu	81,747	324.21
Kudat	16,745	66.41
Sandakan	64,194	254.59
Lahad Datu	34,194	135.56
Tawau	69,656	276.26
Labuan	19,719	78.21

4.5. Tidal basin power generations

The tidal basin area was estimated to approximate the generation of electricity to meet demand of local community per household. Thus, the tidal basin area was manipulated at each tidal station location to generate electricity to satisfy the local community electricity demand per household as shows in Table 2.

Basin area is affected by two factors which are number of electricity demand and the tides range. These two factors give the important information in order to estimate the tidal basin area. Once, the number of electricity demand is bigger for sure it is need a bigger tidal basin area in order to meet the local community demand and also when the tide range is too low but need to produce the bigger output it is require the bigger tidal basin area. But, when the tides becomes too low and still need to produce the bigger output generation it requires the bigger tidal basin area and this will make the cost become increase and expensive.

Table 2: Power generation from tidal barrage

Location	Electricity demand (GWh)	Tidal Basin area (km^2)	Power generation (GWh)
Pulau Langkawi	103.12	3.7	111.25
Pulau Pinang	256.41	15.3	273.45
Lumut	65.80	3.0	74.03
Pelabuhan Kelang	13.67	0.2	17.49
Tanjung Keling	11.86	0.8	12.89
Kukup	7.84	0.3	10.94
Johor Bahru	14.69	0.5	17.05
Sejingkat	26.32	0.3	24.86
Bintulu	139.90	14.0	105.93
Miri	47.43	5.8	41.43
K. Kinabalu	324.21	35.5	289.32
Kudat	66.41	6.5	61.98
Sandakan	254.59	25.5	245.32
Lahad Datu	135.56	12.0	145.45
Tawau	276.26	10.5	291.51
Labuan	78.21	8.0	71.63

5. Conclusion

In this paper, it was attempted to study the potential of harnessing tidal energy for electricity generation in order to satisfy the local demand. The result showed that double-mode generation can produce the power generation that can meet the local demand. However, from the result the sites that have potential for harnessing tidal energy are Lumut (basin area = 3.0 km^2), Pelabuhan Kelang (basin area = 0.2 km^2), Tanjung Keling (basin area = 0.8 km^2), Kukup (basin area = 0.3 km^2), Johor Bahru (basin area = 0.5 km^2) and Sejingkat (basin area = 0.3 km^2). However, it is still a lot of challenging in order to implement the tidal barrage around the coastal area of Malaysia since the tide range itself shows its challenging and there are still a lot of knowledge and characteristic of coastal area around Malaysia that need to be studied thoroughly.

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