Determination of Tidal Energy Resource Location in East Coast of Peninsular Malaysia Using Geographical Information System

KHAIRUL NIZAM ABDUL MAULUD, OTHMAN A. KARIM, KAMARUZAMAN SOPIAN & SITI NUR FARHANA ABDUL AZIZ
Department of Civil and Structural Engineering
Faculty of Engineering & Built Environment
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor
MALAYSIA

Solar Energy Research Group
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor
MALAYSIA

knamukm@gmail.com

Abstract: - The need of national development is to emphasize sustainability factor in every single development. Beyond 2020, the demand of energy resource will increase two times higher than current demand. The continuous usage of conventional energy resource such as mixed fuel will effect to the increment of cost and economy. Furthermore, this kind of energy resource will decrease and gives negative impact to the environment as well as create other problems if it not well-managed. In a few more decades, renewable energy resource will become the major contribution to the nation because of the increment of global fuel prices as well as environment rehabilitation cost. Therefore, the purpose of this research is to determine the potential area to generate renewable energy from tidal wave at east coast of Peninsular Malaysia covers Kelantan and Terengganu. Data that was used in this research are from Malaysia Meteorology Department, Department of Mapping and Survey Malaysia and National Hydrographic Centre, TLDM. These data has been analyzed and present in GIS to show the potential area to generate electricity. As a result from the research conducted, one potential area was determined where almost 203kWatt energy can be generated in Tanjung Berhala, Terengganu.

Key-Words: - GIS, Tidal Energy, Renewable Energy

1 Introduction
Sustainable economy progress today shows that our country was prepared to face the competition in globalization era. As an addition, the increment of industrial sector and generation of new product will increase the energy usage in Malaysia. It is very essential to assure that energy resource is enough and have quality.

Industrial sector is the major energy user which is 38.2 percent of energy usage equivalent to 650 Petajoule (PJ) from the final demand of commercial energy in year 2005, follow by transportation sector (37.8 percent equivalent to 642.5 PJ) and residential and commercial sector (12.5 percent equivalent to 165.2 PJ).

Dependencies on the conventional energy resource contain mix fuel such as natural gas, coal, pure fuel and petroleum from electric generation neither effective nor consistent anymore. It is disadvantage if continuous usage will contribute to the decreasing of energy resource in the future and gives negative impact to social life and the environment. As an example, combustion of coal will lead to air pollution, global warming and the increment in the cost of energy resource.

The 8th Malaysia Plan shows that the increment between electric generation and variety sector are parallel to each other. Regarding to the previous 8th Malaysia Plan report of energy resource usage in the country, national electricity demand had increased from 10,673 MW in 2000 to 16,834 MW in 2005. As a result today national electricity demand has been expected to increase two times
higher beyond 2020 and extra energy is needed in 2008. Therefore, it is a challenge to prepare the sustainable energy resource to increase national competencies and immunity.

In connection with that, government has implemented a strategic development project for renewable energy as a 5th fuel to evaluate its potential.

Below are parts of the strategic guideline energy from 2006 to 2010:-

(i) To ensure the energy is adequate, guaranteed, having quality and economical,
(ii) To promote the usage of renewable energy in generating electricity and industry usage,
(iii) To stimulate the initiative of energy performance in industrial sectors, transportations, commercials and government buildings,
(iv) To reduce the dependencies of petroleum product with the increment of alternative fuel usage

This is a way to ensure the energy resource is adequate, guaranteed and economic, besides to promote powerful energy usage and to minimize negative impact to the environment.

2 Tidal Energy

2.1 Introduction

A tidal phenomenon is a sequence movement of sea water as a result of celestial body. Tidal and its wave are different as their relationship is hard to determine. A Tidal involved sea water increment and decrement, while its waves show the movement of its flow horizontally. The occurrences of tidal are because of gravitational force from solar system.

Hence, tidal energy is a hydrological energy which exploited the increment and decrement of sea water level as a result of tidal wave. Although the usage of tidal power is not yet widespread, its potential to generate electricity is easy to predict compare to wind energy and solar energy.

2.1.1 Tidal energy and the principle

The increment and decrement of sea water level is influence by gravitational force of solar system. Magnitude of gravitational force for an object depends on its mass and distance. Moon has the biggest gravitational force compare to the sun even though it is smaller. It is because of the distance between moon and earth is shorter than the sun.

This force affected to the increment about 71% to the ocean level. The condition lead to an enormous movement of sea water consist biggest amount of energy. Tidal energy has been expected to solve many problems regarding to the inadequate energy source, if tidal water power could be change to useful energy.

There are two basic theories in transforming the tidal energy to electricity. First theory involves the transformation of water movement horizontally to electricity. The second theory involves the output energy from the increment and decrement of sea water level. According to the advanced technologies which have been implemented to electric hydro dam, the transformation of tidal to electricity is easier and favorable.

2.1.2 How it's work – enormous dam of water tidal

It has almost the same operation with electric hydro frame but it more bigly. An enormous dam will be built pass by the river estuary. Water will flow in and flow out through the tunnel and rotate the turbine naturally or when forces apply to it as shown in figure 1.

![Tidal Energy Diagram](image)

Fig. 1: Basic Method of operation for enormous tidal dam

2.1.3 Power generated from tidal wave

Energy from tidal dam is influence by water volume. The potential energy in one volume of water is:

\[
\text{Energy (E)} = hMg
\]

(1)

Where;
- \(h\) = height of tidal water
- \(M\) = water mass \((1025 \text{ kg/m}^3)\)
- \(g\) = gravitational force \((9.81 \text{ m/s}^2)\)

The above formula will be calculated with barrage area and ocean tidal 4 times a day. The derived formula is use to calculate the generated energy:

\[
\text{Power (W)} = (E \times (A \times H) \times 4) \quad (2)
\]

Where;
- \(E\) = Potential energy (Joule)
- \(A\) = Barrage area \((\text{m}^2)\)
H = Difference of tidal height
T = Duration in one day (second)
The most suitable location to build barrage dam is at high amplitude tidal wave. The performance of tidal energy is 80% to change water energy to electricity.

2.2 Technology of tidal wave converter

2.2.1 Barrage tidal energy
Tidal lagoon and dam have to be build to apply this method but then it will give environmental impact to large area and high cost of construction.

2.2.2 Offshore turbines
Offshore turbines look similar to the wind electric generator under the sea. The cost of construction is cheaper than the tidal barrage. It also causes no harming to the environmental compare to the barrage system which blocked the flow of river estuary and cause of flood phenomena.

3 Result and Analysis

3.1 Tidal water energy
There are four identified areas to perform tidal water research. The involved areas as shown in the table 1 and its spatial location as shown in figure 2:-

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanjung Berhala,</td>
<td>04° 15’N</td>
<td>103° 28’E</td>
</tr>
<tr>
<td>Kemaman Terengganu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jeti Petronas, Kerteh</td>
<td>04° 35.5’N</td>
<td>103° 27.5 E</td>
</tr>
<tr>
<td>Terengganu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chendering, Terengganu</td>
<td>05° 16’N</td>
<td>103° 11’E</td>
</tr>
<tr>
<td>Getting, Kelantan</td>
<td>06° 14’N</td>
<td>102° 6’E</td>
</tr>
</tbody>
</table>

The river widths of the site are assumed to approximately 200 meters. In this study, calculation was made using the tidal barrage technology and has been applied to generate tidal water to the research area. The used tidal barrage area is approximately 200m x 200m. It is assumed according to Department of Irrigation and Drainage Malaysia.

According to the data in tidal table (2006 and 2007), the height of either inward movement of tide or outward movement of tidal. The graphs show the result from the spatial calculation. Histogram graph of water energy differential versus its location have been plotted from the values show, to identify the area where the water tidal energy is maximum and consistent throughout the year.

According to figure 3 to 12, data have been analyzed by month where maximum daily power is taken as monthly value involved. It is to determine maximum value achieved at a certain location. According to figure 4, the energy generated from Tanjung Berhala area is between 90kWatt to 203kWatt. As for energy generated from Petronas Jetty in Kertih, the energy interval is quite big which is 31 kWatt to 168 kWatt. Energy value is not consistent due to the increment and decrement of tidal wave drastically in the middle of year 2006.

The highest energy generated at Chendering is 136kWatt, while the lowest energy is 60kWatt. Kuala Terengganu had generated energy between 67kWatt to 107kWatt and Getting areas have the smallest energy interval which is 15kWatt to 31kWatt. These areas could generate a consistent energy as shown in the graphs.
Fig. 2: Location of the Tidal Station

**Fig. 3** Graph of optimum height limit of power generated vs time (month) for 2006 at Tanjung Berhala, Terengganu

**Fig. 4** Graph of optimum height limit of power generated vs time (month) for 2007 at Tanjung Berhala, Terengganu.
Fig. 5 Graph of optimum height limit of power generated vs time (month) for 2006 at Jeti Petronas, Kerteh, Terengganu.

Fig. 6 Graph of optimum height limit of power generated vs time (month) for 2007 at Jeti Petronas, Kerteh, Terengganu.

Fig. 7 Graph of optimum height limit of power generated vs time (month) for 2006 at Chendering, Terengganu.

Fig. 8 Graph of optimum height limit of power generated vs time (month) for 2007 at Chendering, Terengganu.
Fig. 9 Graph of **optimum height limit of power generated** vs time (month) for 2006 at Kuala Terengganu, Terengganu

Fig. 10 Graph of **optimum height limit of power generated** vs time (month) for 2007 at Kuala Terengganu, Terengganu

Fig. 11 Graph of **optimum height limit of power generated** vs time (month) for 2006 at Geting, Kelantan

Fig. 12 Graph of **optimum height limit of power generated** vs time (month) for 2007 at Geting, Kelantan
Figure 13 shows the difference between 2006 and 2007 and generating energy between these periods is almost the same except for Petronas Jetty at Kerteh. The condition is probably due to the monsoon season which increases the water level in the early of 2006. In 2007, the highest energy generated from Tanjung Berhala is 207kWatt and the lowest is 107kWatt. While in Petronas Jetty, the energy interval is 90kWatt to 179kWatt. There are a few changes of value than the previous year. Chendering have generated almost the same energy with the previous year which is 67kWatt to 126kWatt. Same energy interval generated from Kuala Terengganu; 60kWatt to 107kWatt. These show that tidal energy is stable throughout the year. Geting area shows almost the constant energy with the highest energy is 31kWatt and the lowest is 15kWatt.

The histogram graph shows the different of generated energy for 5 areas involved in the research. Clearly, Tanjung Berhala is the potential area to generate electricity. The highest value of generated energy throughout year 2006 and 2007 which is 203kWatt comes from Tanjung Berhala. While the lowest energy which is 31kWatt has been generate from Geting area. Petronas Jetty and Chendering have been generate intermediate energy where energy generation at Petronas Jetty is 168kWatt (2006) and 179kWatt (2007). Energy generation at Chendering is 136kWatt (2006) and 126kWatt (2007).

There are two factors influence tidal energy. The first one is height differential between inward movement and outward movement. For Tanjung Berhala, achieved height differential is 3.3 meters where the highest inward movement is 3.6 meters compare to other related areas (not more than 3.3 meters). Energy could be generating although the level of the wave is 0 meters.

The second factors in generating energy are barrage area. In the research, barrage area that was used in the calculation has been standardizing to evaluate the comparison between each area. The generated energy will increase as the barrage area increase.

4 Conclusion

Tidal energy in the future has a very bright potential to be used due to its environmentally friendly and its ability as a renewable energy. This energy could be applied to the tourism area especially an island because it does not need huge amount of energy. The cost increment and resource decrement of natural gas and petroleum give a way to development of renewable energy. Tanjung Berhala area is identified as a potential area to generate electricity with maximum amount of 203kWatt. The final volume of the energy generated was depending on the specification and design of the barrage size and converter (Turbine).