International Journal of Renewable Energy Resources 3 (2013) 1-7

STUDY OF RENEWABLE ENERGY POTENTIAL IN MALAYSIA

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ABSTRACT

Malaysia has many renewable energy sources that can be developed such as solar, wind, biomass, hydro, geothermal and tidal wave. However, it is not yet widely developed. Since, energy is important, a national center for renewable energy resources database should be setup to bring together designers, engineers, architects and policy makers to use the actual data for implementing renewable energy projects. The objective of this study is to determine the most suitable renewable energy generation to be implemented in Malaysia from four obvious options available which are solar, wind, biomass and tidal wave. A study has been conducted in several contributing factors namely geographical distribution, technology involved and economic analysis. The analysis has been done by gathering the related information and data from previous studies as well as and visits to sites and related authorities. The result of these analysis shows that biomass energy generation has the most encouraging potential to be developed in Malaysia as shown by evidences from the comparative study being made in this paper.

Keywords: Renewable energy, Geographical, Economy.

1. INTRODUCTION

Energy has always been a most important thing for the development of economy and social growth in country. It is no longer viewed as affluence as it used to be but it has become a compulsion in our everyday life. Malaysia is gifted with renewable energy resources such as hydro, wind, solar, geothermal and tidal wave but most of these renewable energy resources are not fully utilized. More development of these resources will be needed concentrating various views and big challenge. Presently, Malaysia is still very much sustained by fossil fuels as its dominant source of energy. According to the current rising trend of fuel prices, especially crude oil prices in the world market, the Malaysia Government comprehended the potential of renewable energy as an another option to ensure the sustainability of energy resources. As we covering energy resource shortages around the world, there is critical need to expand a more sustainable energy system to accommodate for development.

2. GOVERNMENT ACT & POLICY

The Malaysian government is seeking to intensify the development of renewable energy, particularly biomass, as the 'fifth fuel' resource under the country's Fuel Diversification Policy. The policy, which was set out in 2001, had a target of renewable energy providing 5% of electricity generation by 2005, equal to between 500 and 600 megawatt (MW) of installed capacity. The policy has been reinforced by fiscal incentives, such as investment tax allowances and the Small Renewable Energy Programme (SREP), which encourages the connection of small renewable power generation plants to the national grid (BMI, 2008).

The Small Renewable Energy Program allows renewable projects with up to 10 MW of capacity to sell their electricity output to TNB, under 21-year license agreements. Numerous applications for the program have been received, mainly involving biomass, and of these over half are for palm oil waste. In 2005 there were 28 approved biomass projects involving the installation of 194 MW of grid-connected capacity. There were also four approved landfill gas-based projects, with 9 MW of capacity, and 18 mini hydro-electric projects offering 69.9 MW of total capacity (BMI, 2008).

3. RENEWABLE ENERGY IN MALAYSIA

The study only covers solar, wind, biomass and tidal wave which are the obvious option of renewable energy resources available in Malaysia. Although the hydro is one of the renewable energy but the disadvantages are building a large dam will flood very large area upstream, causing problems for animals that used to live there. The impact on residents and the environment may be unacceptable. The next section will discuss about each renewable energy resources in terms of geographical distribution, technologies and economic analysis.

A. Solar energy

Solar energy is an alternative energy source that involves harnessing the radiant light energy emitted by the sun and converting it into electrical current. Since the middle of the 20th century, the ability to harness and utilize solar energy has greatly increased, making it possible for homes and businesses to make use of the renewal energy source rather than rely on more conventional means of generating power.

By the world standards, the solar radiation in Malaysia is among the lowest in the world. Fig. 1 below described that Malaysia only have the value of solar radiation about 4.0 – 4.9 kWh/m2/day compared to the other location all over the world that are most potential of solar energy about 6.0 – 6.9 kWh/m2/day (Sopian et al. 2005). Chuah et al. (2007) have performed statistical analysis of solar radiation data for three cities namely Kuala Lumpur, Penang and Kota Baru. The analysis shows those days with low radiation occur scarcely in Penang and Kuala Lumpur. Of these two, days with high solar radiation occur more frequently in Penang than in Kuala Lumpur. However, Kota Baru experiences a larger variability of total radiation, extremely low solar radiation for long periods occur during the north-east monsoon season, while high radiation for long periods occur during the south-west monsoon. Estimates for the urban areas are important for building integrated photovoltaic applications. It can be seen, that the region Klang valley (Kuala Lumpur, Putrajaya, Seremban) has the lowest irradiance value. Around Penang (Georgetown, north-west coast) and Kota Kinabalu were the highest values. Fig. 2 below shows the annual average daily solar irradiation in Malaysia (Chuah et al. 2007).

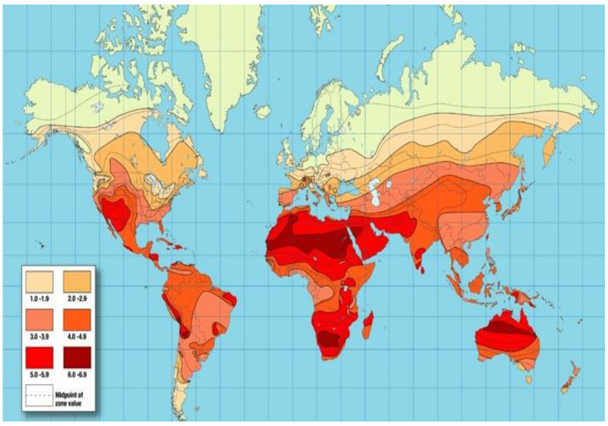

Figure 1 World daily solar radiation map (sopian et al, 2005).

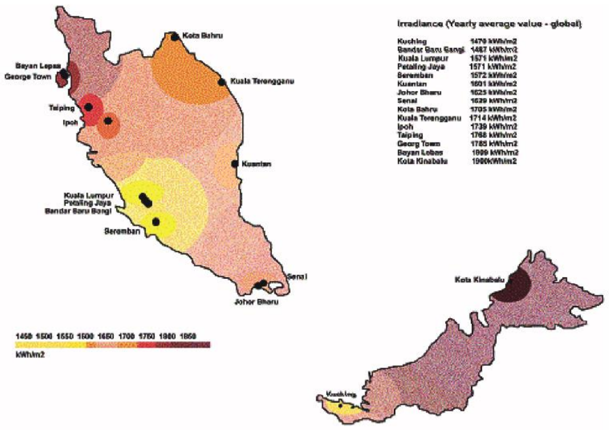

Figure 2 Annual average daily solar radiation in malaysia (chuah et al, 2007).

Solar energy drives the global ecosystem and is the most constant and predictable of renewable sources. Currently, there are two distinct technologies for capturing and using it: photovoltaic (PV) systems that convert solar radiation into electrical current and solar thermal systems that use it to heat water. Today's PV module converts from 5-15% of the solar energy directly to DC electricity. This DC electricity can be stored in batteries and converted to AC electricity in a converter to be used in conventional appliances. With a typical maximum solar insolation of 800 W/m2 a PV module produces maximum about 100 W/m2 of collector (AER, 2008). The efficiency of a solar PV module depends on the environmental impact such as the surrounding air temperature and the dust contamination of the surface of the PV cells. The reduction of the efficiency of a solar PV cell due to high air temperature is estimated to 8% for Malaysia conditions and the reduction in efficiency due to dust contamination is assumed to be 2 % (AER, 2008).

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Figure 3 Solar PV panel (AER, 2008).

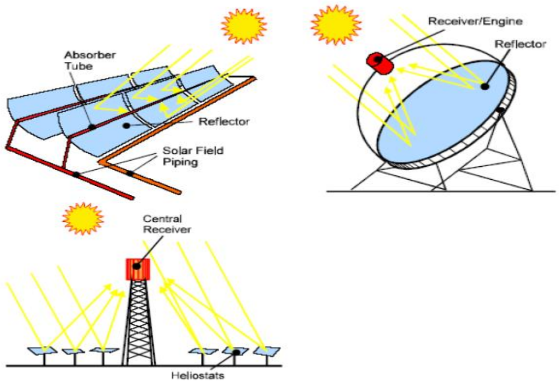

Figure 4 Solar thermal concepts (AER, 2008)

The life time of solar PV panels is 25 years. Other minor component in a solar PV system such as converter, batteries etc. have shorter life time approximately between 5 to 15 years. This development will bring the cost below 0.5USD/W which will make PV directly competitive on the grid making PV the first choice for roof cover material worldwide. Costing for solar PV system installation is about 5000 to 1000USD/kW. While for current energy cost is about 0.25 to 1.60USD/kwh. At present the levelized cost of solar thermal power varies from 120 to about 210 USD/MWh for a location like Malaysia. The low cost is for combined plants where most of the power is by gas and the high cost for those with solar only. Costing for solar thermal system installation is about installation cost 2500 to 6000 USD/kW. While for current energy cost is about 0.12 to 0.34USD/kWh (AER, 2008).

B. Wind energy

The terms wind energy describes the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. Since relatively few observations are available at 80 m, the Least Square extrapolation technique is utilized and revised here to obtain estimates of wind speeds at 80 m given observed wind speeds at 10 m (widely available) and a network of sounding stations. Tower data from the Kennedy Space Center (Florida) were used to validate the results. Fig. 5 below shows that potential of wind energy for Malaysia is level 1 which is the velocity of wind is less than 5.9 m/s (GWEC, 2007). The mean wind speed over the sea surface around the sea surrounding Malaysia is generally below 5 m/s. Table 1, it is observed that the highest wind speed is in east peninsular Malaysia for grids 1, 2, 3 and 4, grid 8 in Sarawak and in Sabah at grid 13 as shown in Fig. 6. Wind speed at these locations reach above 5m/s during the northeast monsoon season and for the rest of the year wind speed is low. The direction of the wind is from the northeast and east quadrant during the northeast monsoon season and south and southwest quadrant during the southwest monsoon season (Chiang et al., 2007).

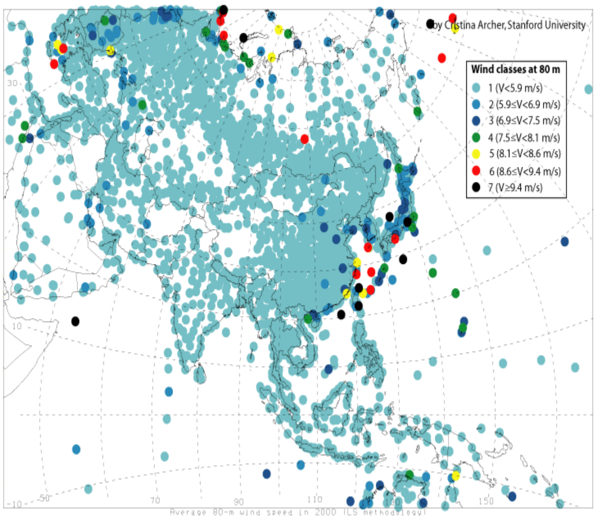

Figure 5 Wind energy potential for Asia (GWEC, 2007).

Table 1 Month mean wind speed (Chiang et al 2007)

Month	East Peninsular Malaysia				West Peninsular Malaysia			Sarawak				Sabah				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Jan	5.8	6.8	6.7	5.7	2.4	0.7	2.2	5.7	3.8	2.5	3.9	4.0	6.8	4.0	3.1	2.7
Feb	4.8	5.3	5.4	4.6	1.6	0.7	2.4	4.7	3.8	2.2	3.4	3.7	6.2	4.2	5.7	1.9
Mar	3.9	4.0	3.8	3.3	1.4	1.0	1.4	3.8	2.5	1.9	2.6	2.8	5.2	4.0	3.6	2.3
Apr	2.7	2.0	1.7	1.1	1.2	0.9	1.4	1.2	1.2	0.9	0.9	1.3	2.9	2.2	0.5	1.3
May	2.2	2.5	2.1	1.6	1.0	1.0	1.6	1.4	1.2	0.8	0.7	1.2	1.6	1.5	0.0	1.4
Jun	3.1	3.4	3.1	2.6	1.4	1.5	1.9	2.2	1.0	0.6	1.2	1.6	2.7	2.5	2.6	1.7
Jul	2.4	4.9	4.3	3.7	1.3	2.1	2.2	3.2	1.5	1.2	1.7	1.7	3.5	2.8	3.5	1.6
Aug	3.9	4.8	4.5	3.7	1.6	1.4	1.9	2.9	1.2	1.5	2.0	2.4	4.4	3.5	2.1	2.8
Sep	3.3	3.5	3.3	3.0	0.9	0.8	1.3	2.9	1.6	1.1	1.2	8.7	2.9	2.7	0.0	1.9
Oct	0.0	1.1	1.7	2.7	1.6	1.2	1.5	2.7	1.5	1.0	1.9	1.7	2.8	2.7	3.1	1.2
Nov	5.1	3.6	2.7	2.3	2.1	1.7	2.2	1.6	1.4	1.3	1.2	1.9	2.4	2.1	3.1	1.8
Dec	5.1	7.6	5.9	5.0	2.4	1.5	2.9	4.6	2.5	1.4	1.7	2.1	4.3	2.8	4.3	3.1
Mean	3.5	4.1	3.8	3.3	1.6	1.2	1.9	3.1	1.9	1.4	1.9	2.8	3.8	2.9	2.6	2.0

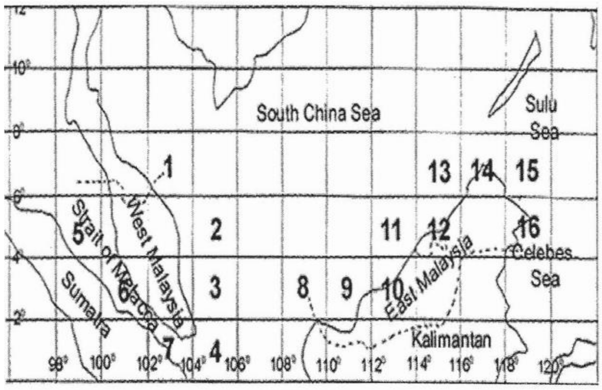

Figure 6 Map of Malaysia with study location(Chiang et al., 2007).

Energy conversion principle of wind turbine is effect of the kinetic energy of the air flow. The power content in the wind is proportional to the cube of the wind speed and the air density. The energy in the wind is converted into rotational energy by the wind turbine rotor. The conversion can be made either by aerodynamic forces acting on the rotor blades or by the air pressure acting on the rotor blades. The rotational energy can be converted into electrical energy via a generator be utilized for mechanical work. The technology for grid connected wind turbines is well proven and wind turbines have been commercially available for more than twenty years. The capacity of the first commercially available wind turbines in the 1980'es was in the range 15 to55 kW. The capacity has gradually increased and today the wind turbine capacity is in the range between 1 and 5 MW. The modern grid connected wind turbine is a three bladed, pitch regulated turbine with the nacelle mounted on the top of a tubular tower. The hub height of a modern wind turbine is in the order of 60 to 90 m and the rotor diameter is between 60 and 90 m depending on the capacity of the wind turbine. Fig. 7 and Fig. 8 show the modern grid connected wind turbine. The total energy conversion system for a grid connected wind turbine is installed in the nacelle. The main components are the rotor connected to the gearbox via a main shaft and the generator connected to the gearbox via a high speed shaft. The power generated by the generator is transmitted to the grid eventually through a step up transformer. Nearly all wind turbines use either induction or synchronous generators (AER, 2008).

Figure 7 Modern grid connected wind turbine (AER, 2008).

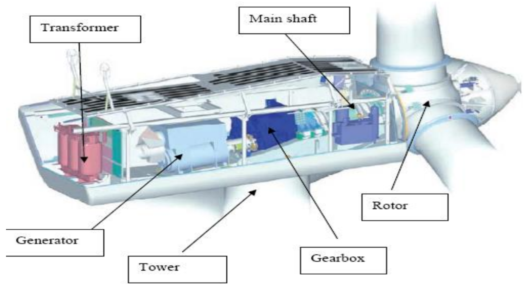

Figure 8 Nacelle of a grid connected wind turbine (AER, 2008)

The price for grid connected wind power plants on land is in the order of 1.9millUSD/MW installed capacity. This includes the wind turbine costs as well as other project costs but excluding costs for land. For off shore wind turbines the price is approximately 40 % higher. The annual operation and maintenance costs are typically 2% of the construction costs of the wind turbine. The cost per kW installed capacity for standalone systems is in general relatively higher compared to grid connected turbines which is 1 to 2 cents USD/kWh (AER, 2008).

C. Biomass energy

In ecology, ‘biomass’ is the mass of organic matter in the ‘standing crop’ of an ecosystem, such as woodland or a cornfield. The term has been taken over (and distorted) by energy technologists and come to mean the mass of

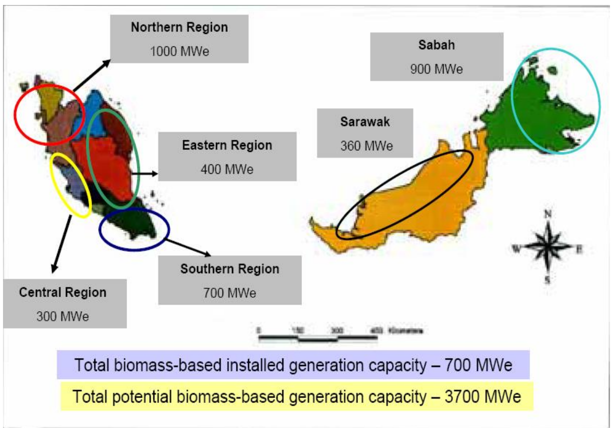

Figure 9 Potential of biomass energy in Malaysia (Anuar, 2008)

combustible material of organic origin in any volume of material. Conversion technologies may release the energy directly, in the form of heat or electricity, or may convert it to another form, such as liquid biofuel or combustible biogas. These can be classified into woody biomass, agricultural sources and wastes. Biomass can be used in several fields (heat, power, liquid biofuels and bio based products).

Malaysia has a great biomass and wood waste resources available for immediate exploitation. Much of this is readily available waste from the agricultural sector (Anuar, 2008). Fig. 9 below shows the potential of biomass energy in Malaysia. The broad objective of the Biogen project is the reduction in the growth rate of greenhouse gas emissions from fossil fuel fired activities and from the decomposition of unused biomass waste from palm oil mills (Velautham, et al 2007). Fig. 10 below shows the biomass energy resources from palm oil mills.

Figure 10 Biomass energy resources from palm oil mills (Velautham et al., 2007).

Technologies that convert solid biomass resources into energy for heat, power, and CHP (combined heat and power) fall into two general categories, combustion and gasification. Another way is using an anaerobic digestion to produce biogas (IEA, 2007). Fig. 11 shows the biomass conversion path.

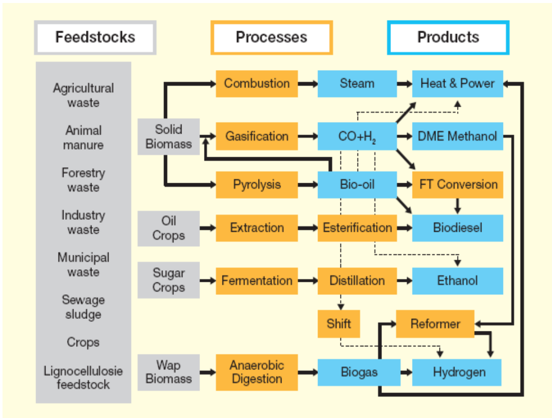

Figure 11 Biomass conversion path (IEA, 2007).

Because of the variety of feed stocks and processes, costs of bio-power vary widely. Co-firing in coal power plants requires limited incremental investment ($50 to $250/kW) and the electricity cost may be competitive (US$ 20/MWh) if local feedstock is available at low cost (no transportation). For biomass typical cost of $3 to $3.5/GJ, the electricity cost may exceed $30 to $50/MWh. Due to their small size, dedicated biomass power plants are more expensive ($1500 to $3000/kW) than coal plants.

Electricity costs in cogeneration mode range from $40 to $90/MWh. Electricity cost from new gasification plants is around $100 to $130/MWh, but with significant reduction potential in the future. Biogas plants are expensive and are normally only built for solving an environmental problem. The investment costs is about 315 to 940 USD/m3 biogas produced per day and the yearly O&M cost is about 62 USD/m3 biogas produced per day (1995 cost level). Technical lifespan is about 20 years. The annual operation and maintenance costs are typically 2% of the construction costs of the wind turbine. The cost per kW installed capacity for standalone systems is in general relatively higher compared to grid connected turbines which is 1 to 2 cents USD/kWh (IEA Energy, 2007). In April, Malaysia's cabinet approved the introduction of the Renewable Energy Act and the Act for a Feed-in Tariff Implementing Agency which will then be passed to parliament. Table II below shows the Malaysia's 2011 proposed biomass and biogas tariffs. The table shows significantly that the price is much cheaper than the conventional electricity supply (Gipe, 2011).

Table 2 Proposed biomass and biogas tariffs (Gipe, 2011).

	Years	MYR/kWh	€/kWh	CAD/kWh	USD/kWh	Degression
Biomass						
<10 MW	16	0.31	0.062	0.078	0.076	-0.5%
>10 MW<20 MW	16	0.29	0.058	0.073	0.071	-0.5%
>2 MW<30 MW	16	0.27	0.054	0.068	0.066	-0.5%
Bonus for gasification	16	0.02	0.004	0.005	0.005	-0.5%
Bonus for steam generation >14% effic.	16	0.01	0.002	0.003	0.002	-0.5%
Bonus for local manufacture	16	0.01	0.002	0.003	0.002	-0.5%
Bonus for municipal solid waste	16	0.10	0.020	0.025	0.025	-1.8%
Biogas						
<4 MW	16	0.32	0.064	0.081	0.079	-0.5%
>4 MW<10 MW	16	0.30	0.060	0.076	0.074	-0.5%
>10 MW<30 MW	16	0.28	0.056	0.071	0.069	-0.5%
Bonus for gas engine >40% effic.	16	0.02	0.004	0.005	0.005	-0.5%
Bonus for local manufacture	16	0.01	0.002	0.003	0.002	-0.5%
Bonus for landfill or seweage gas	16	0.08	0.016	0.020	0.020	-0.5%

D. Tidal wave energy

Tidal energy is due to gravitational forces of sun and moon while Wave energy is caused by the wind blowing over the surface of the ocean. There are concepts over 200 years old.

Fig. 12 below shows how the key areas for wave and tidal energy potential are distributed around the world. Western Europe, the west coasts of North and South America, New Zealand and Australia are the regions of the world where waves with the highest energies are found (O'Rourke et al., 2005).

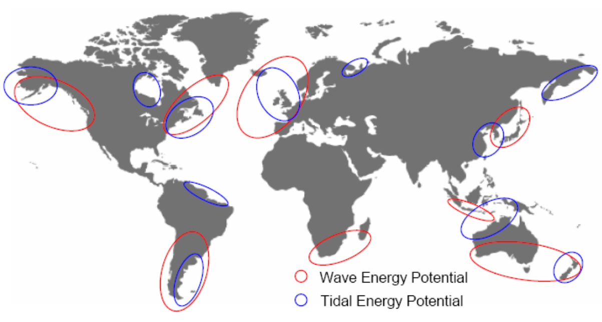

Figure 12 World and tidal wave energy potential (O'Rourke et al., 2005).

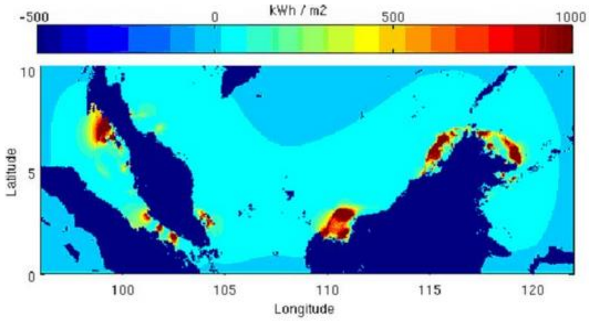

Figure 13 Energy density of tidal current (Seng et al., 2011).

Analytical assessment has been carried out to estimate the amount of electricity to be generated by MCTs (marine current turbines) and also to evaluate the economical viability and environmental benefits of installing MCTs in Malaysia. Fig. 13 below shows the potential of tidal energy in Malaysia. It was identified that Pulau Jambongan, Kota Belud, and Sibu are the locations with great potential for tidal energy extraction. The total amount of electricity that can be generated by MCTs on those locations is about 14.5GWh/year (Seng et al., 2011).

From the data obtained, wave power for each location was calculated. Table III shows the average wave power calculated from swell. In the months of November to February, wave power of around 2.0kW/m (wind wave) and 6.0 to 12.0kW/m (swell) is observed in the east peninsular Malaysia. For regions in Sarawak and Sabah, the available wave power is lower than in the east peninsular Malaysia. But in the months of July to October, the available wave power in Sabah and Sarawak is higher when compared to other regions in Malaysia, which have a potential of 3.0 to 5.0kW/m (swell). In west peninsular Malaysia, the wave power available is in the region of 0.5kW/m (wind wave) and 2.0kW/m (swell) throughout the year (Velautham et al., 2007).

Table 3 Average wave power calculated from swell (Velautham et al., 2007).

Month	East Peninsular Malaysia				West Peninsular Malaysia			Sarawak				Sabah				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Jan	11.8	7.9	8.6	5.7	2.2	1.9	0.7	7.6	7.5	3.2	5.8	5.4	5.7	5.4	11.9	3.1
Feb	10.8	5.8	6.7	3.5	1.9	1.0	0.8	4.5	5.1	5.5	3.8	4.6	4.9	3.5	5.0	2.5
Mar	5.4	3.8	3.9	2.9	1.4	1.3	1.8	3.5	3.0	3.9	3.5	2.7	3.8	4.2	4.2	3.6
Apr	2.9	2.8	1.9	1.2	1.7	1.0	1.4	1.3	1.6	0.8	1.5	2.5	2.3	1.8	1.5	1.0
May	1.1	1.9	1.9	1.1	2.1	1.3	1.2	1.6	0.8	1.1	2.0	1.1	1.9	3.5	2.4	1.1
Jun	1.6	2.1	2.1	2.3	2.4	1.8	0.9	1.4	2.8	2.4	2.2	3.6	3.1	4.4	2.4	0.6
Jul	1.8	3.9	3.3	2.3	2.7	2.2	1.6	3.0	5.3	3.3	4.0	4.7	5.1	5.4	3.3	2.5
Aug	2.0	2.9	3.8	2.8	2.6	2.3	1.9	2.5	2.5	2.9	3.0	4.7	4.6	4.1	2.0	4.3
Sep	1.8	2.3	2.1	2.5	1.5	2.2	0.8	1.5	2.2	1.2	2.3	3.5	3.3	3.6	1.2	1.2
Oct	1.9	2.5	2.8	1.9	2.1	1.7	2.7	4.0	4.1	2.3	2.9	3.6	4.5	3.8	2.5	1.5
Nov	6.0	5.0	5.0	2.3	2.5	2.3	0.8	6.3	5.2	5.9	4.2	4.8	5.0	5.3	2.6	2.0
Dec	6.6	11.2	9.5	6.9	2.6	2.0	2.6	9.4	13.3	5.1	8.2	8.6	8.1	5.8	5.3	1.8
Mean	4.5	4.3	4.3	3.0	2.1	1.8	1.4	3.9	4.5	3.1	3.6	4.2	4.4	4.2	3.7	2.1

The mean wave power for locations situated in the west peninsular Malaysia is in the region of 0.5 to 2.0kW/m. In the east peninsular Malaysia, the mean available wave power is in the region of 1.0 to 12.0kW/m depending upon the season, with the higher wave power occur during the northeast monsoon season. In Sabah and

Sarawak, the available mean wave power, is in the region of 1.0 to 8.0kW/m (MMD, 2010). TAPCHAN Systems is one of the several technologies of wave energy. These shoreline based systems use a gradually tapering channel to amplify wave heights to a level that allows a raised reservoir or lagoon a few metres above normal sea level to be filled. Electricity is generated as the water passes from the reservoir back to the sea via a low head turbine. Fig. 14 below shows the illustration of the system (Lotie , 2005).

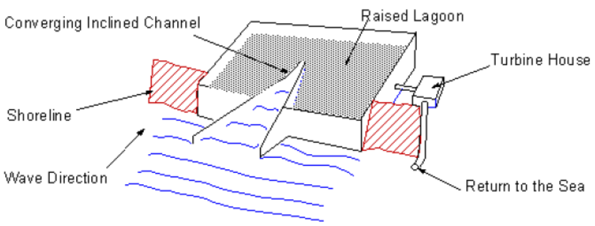

Figure 14 TAPCHAN system (Lotie , 2005).

Tidal barrages are installed in tidal estuaries or inlets and work by holding back the flow of water at high/low tides. Once a sufficient head of water has been formed, the water can be released through turbines to generate electricity (DN, 2003). Fig. 15 below shows the illustration of the system.

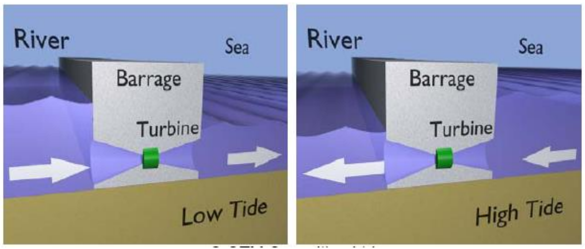

Figure 15 Tidal barrage (DN, 2003).

In addition to the significant initial capital costs, the period during with power can be produced is less than for a conventional power plant. It is because only operate during tidal cycles, the 8.6GW turbine capacity of the Severn Barrage could only offer the same output, averaged out over year, as conventional plant with around 2GW of generating capacity. Besides that, it is requires a large investment in expensive capacity which is only used intermittently and can therefore only replace a limited amount of conventional plant output. Preliminary estimates of unit electricity cost from tidal energy vary from 0.045 to 0.135$US/kWh, depending on the device and the assumption made in the evaluation. An assessment described in the CEC report estimated that a cost of less than 0.09$US/kWh would be achievable with first generation machine in a good current regime (current velocity of 3m/s) with load factor greater 30%. The capital cost per kW of establishing a wave-energy run power station is likely to be at least twice that of a conventional station running on fossil fuels. The load factor is likely to be much lower than a conventional station due to the variability of the wave climate. Naturally fuel or wave energy cost zero, leaving the operation and maintenance cost as the determining factor. Schemes will therefore have to be reliable in their energy conversion and robust enough to service the wave climate for many years. This means schemes designed for long lifetimes and with small numbers of moving parts (to minimize failures). In addition, the total capital investment required for wave energy schemes is dependent on overall average efficiencies and on location. Many of the devices have average efficiencies of around 30% (DGWA, 2001).

4. Conclusion and Recommendation

Renewable energy plays an important role in the supply of energy. When renewable energy sources are used, the demand for fossil fuels is reduced. Therefore, this study has been performed in order to enhance the development of renewable energy in Malaysia. All of the objectives of this study have been achieved by conducted in several contributing factors namely act/policy, geographical distribution, technology involved and economic analysis. The analysis has been done by gathering the related information and data from previous studies as well as and visits to sites and related authorities. The result of these study shows that biomass energy generation has the most encouraging potential to be developed in Malaysia. There is significant scope for developing biomass energy resources throughout Malaysia and biomass energy has the potential to provide sufficient electricity to meet all of Malaysia's domestic electricity requirements. There are a lot of biomass resources are available in all regions of Malaysia which is areas of larger total of resources are at the rural areas. According to the increase of coal price, the usage of coal can be exchanged by biomass resources and only minor modifications are needed at the coal-fired plant. As to support the green technology programmed, the government has plan many incentives to the development by implemented the project by biomass based energy. The improvement of developing the biomass energy can encourage the energy sectors of economy in this country.

According to this study, there are still have a limit that are could be improved for further study. Therefore, there are several recommendations that can be performed to enhance renewable energy development. Firstly, analyze widely about the potential of other renewable energy such as hydro, geothermal and etc. so that there will be a lot of data and information would be gathered for the future used. Finally, latest policies and funding mechanisms will be required to sustain and promote renewable energy investment.

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