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Social and Ecological Impacts of Marine Energy Development in Malaysia

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Abstract: The excessive usage of fossil fuels in Malaysia is increasing yearly to meet the increasing domestic demands. However, this will impact the environment as fossil fuels will emit hazardous gases into the atmosphere. The development of marine energy in Malaysia is still in early periods compared with China, the U.K, and America. Notably, the impact of marine energy extraction on shallow water regions is not yet fully understood, such as the changes in the topography, the effect on marine life, and the cost of development and maintenance for tidal stream energy. This paper is focused on the social and ecological impact of potential marine energy development in Malaysia. Significantly, this study relies on published data to analyse and identify potential sites for harnessing tidal stream energy. Numerical calculation shows that the coastal region receives higher available energy compared to the deep sea. Three sites are found to be the best location for tidal energy exploration in Malaysia, namely Pangkor Island, Port Klang, and the Malacca coastline. From these three sites, the available energy per year for Pangkor Island is 193.668 MWh, while for Port Klang and Malacca coastline are at 241.66 MWh, and 433 MWh respectively. Apart from the economical aspect, the social aspect of tidal energy exploration is also examined. The purpose of the Renewable Energy Act 2011 and Electricity Supply Act 1990 is to ensure proper legislation for the implementation of marine renewable energy in Malaysia, specifically regarding zones of the ocean, licensing, and installation requirements.

Keywords: *Marine renewable energy, Feed-in Tariff (FiT), Renewable energy policy, Clean Development Mechanism (CDM), Potential marine sites in Malaysia*

INTRODUCTION

Renewable energy is regarded as a primary driver of a country's socio-economic development to meet its energy needs. Besides, renewable energy comes from various sources like wind, marine, solar, biomass and more. Tidal and wave energy are two examples of the main sources that come from marine renewable energy. Generally, tidal energy occurs as the gravitational attraction between the Earth, the Sun and the Moon that will cause periodic changes in the water levels [1]. Since tidal energy is predictable and it is renewable energy source, it will be suitable to be implemented in Malaysia.

According to Paul A. J. Bonar [2] tidal energy in Malaysia only focused on the investigation of the tidal stream energy sources in the Straits of Malacca. Tidal stream energy is kinetic energy that is stored in the tidal flows [3]. There is some consideration that needs to be focused on while investigating tidal stream energy such as power potential, sea depth, flow speed and social and ecological impact [4]. However, through SEDA (Sustainability Development Authority Malaysia), Malaysia is still struggling to put an effort to promote

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significant renewable energy production to support domestic demand [5].

Hence, the objective of this paper can be summarised as follows:

- To update and propose potential location in Malaysia for the development and implementation of tidal energy scheme based on latest literature
- To identify the most significant social and ecological issues associated with tidal current energy generation
- To provide suggestion on how social and ecological impact associated with tidal energy development in Malaysia can be minimized

BACKGROUND STUDY

Marine Renewable Energy

Marine renewable energy can be categorised as tidal, wave, Ocean Thermal Energy Conversion (OTEC) and salinity gradient [5]. Tidal turbine is considered among these innovations to be the most cost-effective way of harnessing marine power. Compared to sun, wind, ocean, biomass and geothermal renewable resources, marine energy resources generated from water, waves, tides or marine currents can be used and converted into large-scale, sustainable electricity [6]. Tidal barrage, wave energy and tidal turbines are some examples of the marine energy technologies that existed. These technologies are used in different devices to harness energy and have different working mechanisms.

A tidal barrage is equivalent to a tidal dam that has more a detailed history than wave energy. It is one of the simplest ways in which to provide energy by engines, gates, and boat lock speeding water flow in both directions. The principle is the same as the development of hydroelectric power in a large reservoir [7][8]. Next, tidal turbines can be classified into two different types, which are vertical and horizontal axis tidal turbines. This is capable of capturing energy in all different directions for a vertical tidal turbine but a horizontal tidal turbine can collect more energy than a vertical tidal [7]. The principle of the tidal turbine is quite similar to the principle of the wind turbines. Nonetheless, instead of air, water is used as the harnessing tool. The effectiveness of tidal energy is influenced by the arrays of the tidal turbine [9], [10].

Tidal Stream Energy Conversion Theory

An appropriate turbine rotor derives from tidal flows kinetic energy. A wind turbine-like concept is used by the tidal stream energy converter. Both tidal steam turbines and wind turbines harness the moving fluid's kinetic energy. Therefore, power from the tidal stream is provided as follows:

$$\boldsymbol{P_o = \frac{1}{2}\rho A v^3} \quad (1)$$

where $\boldsymbol{\rho}(\frac{kg}{m^3})$ is the density of the fluid, $\boldsymbol{A(m^2)}$ is the cross-sectional area of the turbine rotor, and $\boldsymbol{v}(\frac{m}{s})$ is the speed of the fluid.

Equation 2 demonstrates the relation between the available fluid density, flow speed and availability of power consumption. The usable density of the moving fluid is directly proportional. Water is 832 times denser than air [11]. Therefore, the tidal turbine capacity is 832 times that of the wind turbine. This suggests a greater amount of energy or movement than the wind in tidal currents.

$$\boldsymbol{C_{pMax} = P/P_o} \text{ or } \boldsymbol{C_{pMax} = \frac{P}{\frac{1}{2}\rho A v^3}} \quad (2)$$

where P is the power generated by a turbine.

Tidal Stream Development

In 2050, 337 GW is expected to be used up so marine renewable energy is potentially available for all marine countries. Direct employment will be produced at approximately 1.2 million and a reduction in carbon emissions of 1 billion tons is expected. There are separate phases in the growth of marine renewable energy in America, Europe, and Asia countries. In the UK, the Research and Development Plan (R&D), which is aimed at 2 GW installed in the country by 2020, leads the wave and tidal energy market towards more integrated growth. In the UK and in Ireland alone 840TWh are expected annually, which is approximately 50 percent of the total energy potential for the European wave. Both the dam and the lagoon will use 121TWh per year for the output of tidal energy, which is equivalent to around 25% of the European tidal energy reserve. Economically recoverable with current technologies have been described as 50 TWh of wave energy resources, 18 TWh of tidal energy resources, and 30 TWh of tidal energy resources [7].

Next, America is one of the earliest countries that be able to discover wave energy and tidal energy as their development to generate electricity. The areas had marine resource extraction capacities such as Alaska, Washington, Oregon, California, Hawaii, Maine and 16 Massachusetts (OREC, 2012). The Electrical Power Researches Institute is estimated to be able to consume wave energy of 1,550 TWh, 130 TWh and 30 TWh per year in Alaska, Hawaii and Puerto Rico [12]. Moreover, China is one of the leading solar and wind energy firms in the world. Nevertheless, the nation began to enter the green marine energy market. The country is surrounded by the Pacific Ocean and the South China Sea and has plenty of marine power tools. A 190 million kW tidal power supply over 14,000 km coastal reserve. In addition, the provinces of Zhejiang and Fujiang are potential marine energy projects that can build 424 main power plants along the coast. Furthermore, for 20 years the Jiangxia tidal power station, the largest in China and the world's third largest, has operated. The total capacity of the plant is now 5020 MWh per year [13].

Next, Korea could be Asia's most potential leading country in renewable marine energy. During the trial phase ending in 2010, the largest tidal energy project "Seaturtle Project" near Jin-do generate 110 kW. The official construction started from 2011 to 2017 and is expected to harvest 150 MW. In addition, incoming tidal power plants are expected to generate maximum outputs of 520 MW, 840 MW and 1,320 MW respectively in 17 Garorim (2014), Gangwha (2017) and Incheon (2017) [13]. Meanwhile, the Malaysian Department of Survey and Mapping (DSMM) is Malaysia's main government agency to collect, process, store, and disseminate sea level information. There are 12 tidal stations along the Peninsular Malaysia coast and 9 tidal stations along the Sabah and Sarawak coast. Two large water bodies, the South China Sea and the Malacca Strait, embrace the land areas and the surrounding water regions are thought to have huge potential for harnessing marine renewable energy [4].

Environmental Effect of Marine Energy

Ecological Impact

Due to restricted access and high investment costs in marine environments, far less is known about marine ecosystems than terrestrial ecosystems, and while it may be fair to conclude that extraction of a small fraction of natural energy fluxes would have minimal ecological implications, it is not easy to quantify sufficient extraction limits [14]. Besides, marine energy devices can influence ambient flow patterns in several different ways. Offshore wind turbines have fixed or floating support structures that can interfere with local wave climates. Next, tidal turbines partially block current flows, speed up the flow around the system and generate highly mixed flows within the wake. Wave energy extraction can alter near-shore currents, promote early wave breakage and cause coastal drift and beach erosion [15]. Figure 1 shows the changes in the environmental behaviour where the tidal turbines will give a huge impact on the reduction to produce power generation [16].

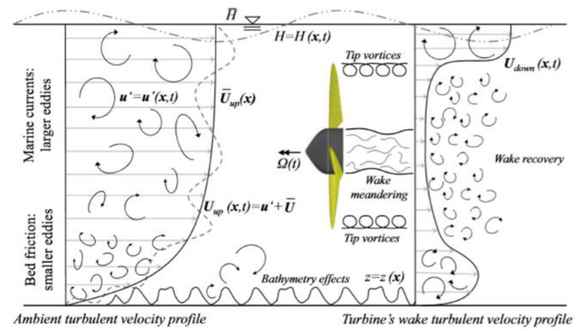

Figure 1 Illustration of turbulence flows created from the tidal turbines [17].

Social Impact

Social acceptance was generally assumed in the early years of the development of renewable energy, as public surveys revealed a high level of support for renewable energy [8], [18]. Support for renewable energy also stems from environmental concerns and ethical responsibilities for replacing the use of fossil fuels and reducing greenhouse gas emissions [19]. Next, support may be based on materialistic assumptions that renewable energy can create new job opportunities for local workers, provide low-cost or free electricity, and encourage energy independence [4]. Nevertheless, many political oppositions to renewable energy initiatives are often based on environmental and materialistic grounds. Developments in offshore renewable energy are often opposed by concerns about the cumulative impact of major developments on natural landscapes and marine life. Community stakeholders may also oppose projects that are concerned with adverse effects on community fisheries, navigational health, marine recreation, tourism, property values and even community harmony [19].

DATA COLLECTION

Numerical Calculation

The emphasis is then moved to measuring the energy density available at potential sites in Malaysia. The information is collected based on the published data such as sea depth, velocity of the tides and the swept area. In this numerical calculation, 0.4 is used for the power coefficient in Equation 3 to obtain the available energy and extractable energy.

$$P = \frac{1}{2}\rho A V^3 C_P \qquad (3)$$

where P=Power available (kWh), ρ=Water density (kg/m^3), A=Swept area of the tidal turbine (m^2), V=Tidal velocity (m/s) and C_P=Power coefficient.

Since the analysis is focused on the horizontal axis tidal turbine so the equation of the swept area is followed as Equation 4. The diameter, D of the turbine will fix which is 5m.

$$\boldsymbol{A = \frac{\pi D^2}{4}} \quad (4)$$

The energy density is calculated yearly for this research through Equation 5 as suggested in his technical paper by Yun Seng Lim [5].

$$\boldsymbol{E_{av} = \sum_{h=1}^{8760} [\frac{1}{2}\rho A V^3 C_P]} \quad (5)$$

where E_{av} = yearly average energy (kWh), ρ = water density (kg/m3), A = swept area of the tidal turbine (m^2), V = tidal velocity (m/s) and C_P = power coefficient. The value of 8760 represents the available hours per year.

Selection of potential sites

There are some parameters and considerations that need to be followed by the previous studies to select the potential site of the tidal stream energy such as the flow speed of the tidal stream and sea depth. 1 m/s is the mean tidal flow speed where it will be able to provide sufficient power consumption [13]. Moreover, sea depth for the potential site needs to consider the diameter of the turbine, and the top and the bottom clearance from the seabed. The suitable sea depth to be installing the turbine is around 15 m to 60 m. The average speed of tidal flow ranges between 0.2 and 3.5 m/s (Table 1). Low-speed tidal flow carries low kinetic energy [4]. In addition, potential sites where the development of tidal energy to be implemented must at least meet the minimum current flow speed.

Table 1 Characteristics of the tidal stream energy extraction

Characteristics	Criteria
Sea depth, H	Between 15 m and more than 60 m
Flow speed, U	≥ 1m/s

VALIDATION OF TIDAL FLOW SPEED

In this study, the Straits of Malacca, Pangkor Island and Port Klang are chosen for further research to identify suitable sites for installing tidal current devices. The scope of the study was on the shallow water however the deep sea and coastline region (shallow water) are chosen for this research to make better comparison and assumptions which is more suitable and give more benefits for the tidal turbine development in Malaysia.

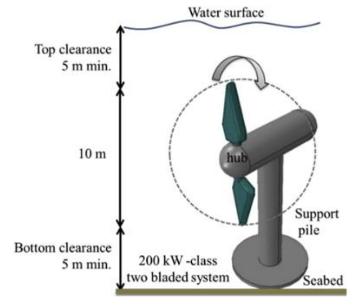

Figure 2 Illustration of the clearance for top clearance of the sea surface and the bottom clearance of the bottom of the seabed.

Table 2 shows the total value of extractable energy for the coastline is higher compared with the sea deep region. This is because the velocity of the flowing current has significant influence on the power consumption. Besides that, depth and velocity play the main role in the installation of the tidal stream current farm. For the power coefficient, a value of 0.4 is suggested while the Bentz limit is not appropriate to be used any longer since it is only suitable to be used for the wind turbines. Moreover, the diameter of the turbine is 5 meters for clearance upper and the bottom of the seabed to avoid any collision happening between the turbine and the marine life or human activities such as fishing, swimming and more (Figure 2).

Table 2 Summary of the data between deep-sea and coastline region.

Location	Deep sea		Coastline		
	Pangkor Island	Malacca	Pangkor Island	Port Klang	Malacca coastline
Depth, m	41.21	39.54	54	25	20
Velocity, m/s	0.7	0.3	1.3	1.4	1.7
Extractable energy, kW	1.502	0.108	8.843	11.045	19.770
Yearly extractable energy, MWh	13.161	0.952	77.46	96.754	173.2
Yearly available energy, MWh	32.902	2.380	193.668	241.887	433
Total height of the turbine, m	40.51	38.84	34.3	24.3	19.3

Assessment of Power Potential

There are three possible locations for the diversion of tidal streams which are Pangkor Island, Malacca coastline and Port Klang. Comparative research on the efficiency of two types of tidal turbines was carried out at these locations. Table 3 displays the performance comparison at these three possible sites between the horizontal axis tidal turbine and the vertical axis tidal turbine. A vertical tidal turbine with a height of 2.5 m (1 m), a diameter of 1.5 kW at 1.5 m/s (12 m/s) and a horizontal tidal turbine with a diameter of 10 m (35 m/s) (250 m/s) is a horizontal turbine. This performance study considered the availability, electrical output, and capability factors for the tidal current turbine.

Table 3 Characteristic of the tidal stream energy for deep-sea region

Location	Vertical tidal turbine		Horizontal tidal turbine		
	$E(t)$ (kWh)	E_e (kWh)	C_f	$E(t)$ (MWh)	E_e (MWh)
Malacca coastline	13140	3922.00	29.84%	2190	49.30
Port Klang	13140	3746.85s	28.51%	2190	42.65
Pangkor Island	13140	3586.55	27.29%	2190	52.90

Table 3 shows a single vertical tidal turbine with a mean value of 28 %. The vertical tidal turbine is 1.5 m/s and at this selected location the Straits of Malacca is supplied with this flow speed. A single horizontal axis tidal turbine, on the other hand, can produce around 2.25% of the electricity available. The key explanation is that turbines with a horizontal tidal axis have a higher output than turbines with a vertical axis. Moreover, the horizontal axis tidal turbine is not efficient because it only produces 2.9% of the energy available compared with the vertical axis tidal turbine. The importance of tidal farm production is evident when it comes to high electricity demand in Peninsular Malaysia. In June 2012, the highest electricity demand in Malaysia was 16 GW [5]. Tidal power will therefore play a greater part in Malaysia’s demands for electricity.

Social and Ecological Impact

Since social and ecological impact is one of the main focus of this research, the topography of the sites will be one of the major indicators for the validation of the result. The criteria for the selected areas for tidal turbines are based on Table 4.

Table 4 The criteria and the geography of the selected potential sites for tidal turbine

Topography of Sites	Land area	Population	Total of species of animals
Pangkor Island	18 km^2	25, 000 people	• 65 Reptiles species • 17 Amphibians species • 82 Herpetofauna species
Port Klang	329, 847 km^2	631, 000 people	• Different types of mammals • Different types of birds
Malacca coastline	65 km^2	821, 110 people	• 600 coral species • 1200 fish species • Sea turtle • Sea snake

Table 4 demonstrates the parameters and geography in general of the selected areas that can establish the physical-biological relationship. For instance, water flows, tidal range, livestock and animal movement create a virtual world [20][21]. This relationship gives insights into the behaviours of marine animals on turbine blades in particular. The total animal species in the selected areas are registered to show their movement and the range of possible encounter outcomes. In addition, it may help to quantify the category of animals at risk. There are some factors of the interactions of marine animals with turbine blades:

- The geography of the selected areas
- Position in the water column with sites where tidal energy likely to be harvested
- The specific behaviour and life stages of animals may increase the chance the contact with a turbines
- The availability of the shelter for the animals
- Daily movement or seasonal migration
- Creation of artificial corals
- Increased prey concentrated near the turbine.

DISCUSSION

Validation of Selected Sites

Port Klang is Malaysia's main gateway and is the busiest port located on the western coast of the Malaysian peninsular due to the nation's capital, Kuala Lumpur, at the north end of the Malacca Straits. The islands that surround it are able to form a natural barrier and being well protected. The port is well connected by a network of roads and rail links to other parts of the country and is approximately 70 km from the International Airport of Kuala Lumpur (KLIA). Last, Port Klang varies from 1.020 to 1.025 in water depth [20]. Because of Port Klang's main shipping area, the site does not suitable for harnessing the tidal tide turbine because it will disturb the ships' daily route (refer to Figure 3).

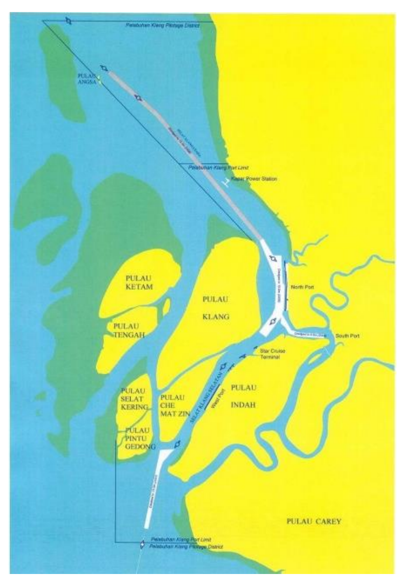

Figure 3 The route of the ships and cargos at Port Klang [20].

In addition to that, the boats' weight and speed will affect water flow in Port Klang greatly. The turbine operation is disrupted by the erratic and unpredictable flow speed of the water. The weight of cargoes and ships must also be taken into account, as the clearance of the top and bottom of the turbine can be calculated. The clearing of the turbine is 5 m for this study, so it is not appropriate for installation in the Port Klang area. The results obtained show that Pangkor Island and Malacca coastline are the potential locations for harnessing tidal stream turbines. The water depth is 35 m, and the flow rates are 1.3 m/s for Pangkor Island, while the water depth for Malacca is 20 m and 1.7 m/s for flow rates. The locations are selected according to their requirements and data.

Social Impact

Public perception and societal acceptance of renewable energy will also help provide an overview of the impact on society. The Web of Sciences, for example, was used to search for "Malaysia's renewable energy survey" to look for surveys relevant to renewable energy in Malaysia [22], [23]. In addition, more than 11 journal articles containing direct and indirect connections with the directions studied can be found in the database. The surveys examined in particular public acceptance of various renewable energy technologies, including micro-hydropower and solar power. Because it was a people individual's perception, they would always agree and disagree. Most of the public disagrees with renewable energy development because they are concerned about the effect on their urban ecosystem and marine life on construction. If that happened, their daily routine will be interrupted to earn the money. Both issues include local fisheries, navigational safety, marine recreation, tourism, property value and also the relationship between the community and nature.

Due to this situation, Malaysia launched an energy-consumption-related project named Clean Development Mechanism (CDM). According to the Asian Development Bank's annual reports (ADB), renewables contribute to 43 % of the overall energy expenditures, while efficiency accounts for the remaining 26 %. Soon, there is projected to be a significant demand for energy and finance developing in Asia countries [14]. Renewable energy also needs to be spent more sustainably. Energy sources growth allows the energy market to meet massive energy demand. It is also expected that new renewable energies will lead to more cuts in emissions and carbon credits. Table 5 (available in the Appendix due to space constraints) shows the CDM project divided into categories.

Table 5 Number of registered CDM projects in energy sectors in Malaysia

	Number of energy projects		
Years of registration	**Renewable energy**	**Energy efficiency**	**Emission Reductions (tCO_2e)**
2006	12		1,682,653
2007	6	3	444,683
2008	7		314,714
2009	27	1	1,743,966
2010	5		273,492
2011	12	2	789,689
2012	26	1	1,790,108
Total	**95**	**7**	**7,039,305**

Table 5 shows that most CDM projects are related to wind, hydro and biomass energy, accounting for 28 percent, 26 percent and 10 percent respectively. Among the CDM projects, there are 108 projects or 2.42% in Malaysia. Green Tech Malaysia anticipates that the annual capacity of Malaysia will surpass CER 18 million in 2010. In the period 2006-2012, this amounted to about 100 million tCO_2e. Green Tech Malaysia, therefore, assumes that each tCO_2e has a price range of approximately US$ 3 to 10. This corresponds to a flow to Malaysia by carbon credit of 0.3 to $1 billion in capital [24]. Project developers in Malaysia have started to apply for CDM projects since 2002. The number of CDM projects is improving year on year. In 2007 it contributed for 9.2 million tCO_2e [24]. Table 6 shows the number of registered CDM energy projects, i.e., renewable energy and energy efficiency.

Table 6 Comparison of FiT rates of marine renewable energy in other countries

Country	**The Ratio of Marine Renewable Energy FiT to**				
	Electricity Tariff	**Solar FiT**	**Biogas FiT**	**Biomass FiT**	**Hydro FiT**
France	1.1	2.0	1.5	3.3	2.5
German	0.6	0.9	3.8	2.8	1.2
Ireland	1.1	-	-	1.5	-
Italy	1.6	1.4	-	-	-
Korea	0.2	0.1	-	-	1.2
Malaysia	2.6	1	4.7	4	5.6
Portugal	1.2	0.8	-	-	-
Scotland	0.6	-	-	-	-
Spain	0.4	0.3	0.5	0.5	0.9
UK	0.7	0.5	-	-	1.7

Apart from carbon credit, FiT is believed to support future investors by incorporating it into the revenue of marine renewables developments. FiT has become a widely employed mechanism for renewable energies worldwide and is proved to be the most successful. In Malaysia, however, the latest FIT program does not include marine renewables [24]. The configuration of FiT will show the overall costs of the project. It is essential to propose reasonable marine renewable energy FiTs to enhance the interest of project developers and to assist finance the project. The generator cost may be the largest part of the cost of the project. The projects are likely to be designed, approved, planned, built, controlled, operated, maintained, insured, and financed above the mature projects of the subsequent sector. Each of these must be included in the rules and regulations and explained on behalf of them.

The government of Malaysia aims to increase renewable energy consumption from less than 1% today to 5.5% in 2015 and 11% in 2020. FiT is therefore a secure mechanism that guarantees renewable energy production long-term returns for investors because it offers fair investment returns to project developers. Tidal stream energy in Malaysia is still in the early stages of R&D and is regarded as the latest technology [24]. A variety of research performed by local universities has shown positive results. Politicians also need to look at the potential of marine renewable energy usage in the community. Malaysia's model may become inspired by the marine renewable energy harness experiences in countries like the UK, France, Italy, Germany and Korea. Soon, FiT will be implemented for marine energy to promote the installation and production of marine energy harnessing equipment.

Table 7 shows that the electricity tariff produced in Malaysia is 2.6 which is considered to be high compared to other developing countries such as France, Germany, Ireland and more. That is because Malaysia's electricity tariff is the lowest among the other countries where the range is between €0.05 / kWh and €0.11 / kWh. In Malaysia, solar energy FiT is similar to the planned tidal energy FiT, but the biogas, biomass, and hydro FiT are less than they are.

The FiT proposed for tidal energy in Malaysia is contrasted as shown in Table 7 with those of other countries. According to its energy efficiency and manageable project costs, Tidal Stream (shallow) is the most feasible technology for marine renewable energy technologies. Its technology has also been chosen for comparison. All FiTs from the different technologies were converted to €/kWh before comparison. EUR 1 is equal to RM4.38 during the research.

Table 7 Power generation, MWH of commission RE installation from 2015 to 2018

Year	Biomass	Biogas	Small hydro	Solar PV
2015	58111.05	210462.30	55406.38	264185.56
2016	87629.13	188137.00	49026.53	320051.42
2017	215826.50	266846.80	74831.27	432820.44
2018	242021.20	229570.50	65377.23	468209.55

Ecological Impact

Conflict potential exists where the evolution of tidal energy can have an impact on protected species and conservation areas. This scenario will also destroy marine animals for their protected area and habitat. In addition, underwater noise is a source of concern because the sound is used by a wide range of species to communicate, navigate, hunt for food, prevent predators and identify potential mates. Unfortunately, impact assessments are limited by a lack of information on device performance data and species behavioural responses.

Underwater noise may result in physical harm, temporary or permanent hearing loss, altered behaviour or patterns of movement, habitat loss, masking of important biological sounds, and increased vulnerability to predation and other hazards. In addition, noise-induced stress may result in hypertension, hormonal imbalance and reduced disease resistance among marine mammals, although these effects may be almost impossible to measure. For example, during the construction of both the Horns Rev and the Nysted offshore wind farms in Denmark, porpoises were driven out of the construction area, returning only after pile-driving had ceased. Similarly, the significant decline in harbour seal haulage at the Scroby Sands Wind Farm was precisely consistent with pile-driving activities, although this may also be related to increased vessel activity in the area [25].

The sound produced during the construction or operation of marine renewables is unlikely to cause damage or injury to marine species at relatively close range or to cause significant long-range behavioural effects. However, underwater noise and vibration affect different species in different ways and with larger arrays and extended installation periods, noise exposure and habitat exclusion may become a major ecological concern. Since sound noise involves an electrical magnetic field emitted by a tidal stream turbine, which may interfere with the orientation and navigation of animals as their ability to detect predators or prey, or cause adverse effects on growth, reproduction, or survival. Fortunately, the electromagnetic field has not had any significant effects on the movement or reproduction of migratory fish. To conclude, the risks of EMF emissions from developments in tidal turbine streams are assumed to be relatively small, but further work is needed to confirm this conclusion.

Preparedness (Impact and Prevention)

Environmental and ecological effects cannot be avoided with any technological growth. The same applies to this report. Early action should be taken so that environmental security against danger and risk can be minimized and preserved. One of the preventions is the development of acoustic instruments. The key facility for the acoustic instruments is to track marine animal activity. This also helps to reduce the collisions between marine life and tidal turbine blades. Next, the most exposure of the marine life to the tidal turbines will help to provide essential information on their availability physical farm. In addition, the impact of water flow around the turbine indicates the movement of marine life and the range of possible findings.

Acoustic can be classified into three different roles which is prevention of collision with marine animals, animal detection around turbine blades and noise produced by marine devices. An example of the acoustic device that has been installed is at Stagfordlough Northern, Ireland. A tidal power device consists of 16 m open blades that is linked to a pile in the seabed in 26.2 m of water. Moreover, the current flow speed can reach up to 4.8 m/s for the device, the blades can be raised and lowered for maintenance [25]. The objective is to reduce the collision of marine animals with the turbines while the blades are rotating and operating. The restriction of movement in marine life will destroy and endanger their habitats. Operational noise effects on marine mammals were considered as part of the electromagnetic field. Sea-Gen noise measurements in service are carried using high-precision drifting boat instruments [20]. Models of underwater sound propagation are used to estimate the difference between the noise level and the turbine distance.

Energy Policy of Malaysia

The energy policy of Malaysia is determined by the Malaysian Government, which addresses issues of energy generation, distribution, and consumption. The Ministry of Energy, Green Technology and Water has identified main energy objectives that would be instrumental in guiding the development of its energy sector. Supply, utilisation and environmental are the principles.

The RE targets to reduce social and environmental effects through the Renewable Energy Act 2011 are being pursued in Malaysia. The Act allows for the incorporation of other eligible sources under the FIT scheme, including tidal and wave energies. Moreover, environmental and energy security are both key aspects that need to be considered to develop a policy on marine renewable energy. This is because cost, energy storage, materials and maritime governance will be addressed through development. Nonetheless, one of the projects under the Small Renewable Energy Project (SREP) 2011 Renewable Energy Act was a major failure and the Energy Commission Act 2001 law was then implemented by the nation's energy market. In addition, SREP was also confronted by the National Renewable Energy Strategy and Action Plan. While the previous RE programs in Malaysia several times fail, the Renewable Energy Act 2011 is subsequently passed in FiT on renewables.

Table 8 (in Appendix A due to space constraint) shows the power generation of the RE commission plant from 2015 to 2018. Unfortunately, there is no energy generated from geothermal energy until 2018, nor is it included in the Renewable Act 2011. This is because the Renewable Energy Act 2011 limited only to inland energy sources. Malaysia's government should therefore promote marine renewable energy throughout the current renewable energy legislation and policy.

Law and Interface of Marine Renewable Energy

The ocean is a huge region that requires various approaches to the shore. The government was encouraged, as initiated under international law of the sea, to establish marine renewable energy in Malaysia. It would lead to the dedication of ocean guidance before using and improving it. In 1982, the United Nations Convention on Sea Law (UNCLOS) III was established in Malaysia to govern all matters that will be covering Malaysia's sea and territorial waters. The first law that regulate the matter of natural resources discovery and development is the Continental Shelf Act (CSL) in 1996, while the Exclusive Economic Zone Act 1984 (EEZ) is applied for the 200 nautical miles of territorial sea from the baselines. The presence of EEZ would help control the water territory without any problems in the growth of marine RE.

However, the Baselines of the Maritime Zones act 2006 is also important to the creation of maritime RE regulation in Malaysia, as the legislation concentrates on the establishment of baselines and limits between maritime boundaries and coastal areas for maritime zones. The Electrical Power Act 1990 also takes the lead in controlling the energy supply markets, the tariff for energy and the licensing and control of electricity systems. The Sustainable Energy Development Authority (SEDA) is responsible for the promotion of RE through the implementation of the FiT. The SEDA Act defines the functions involved in supporting and enforcing RE laws and policies.

Legal and Regulatory

Law and regulation control during the development process must be taken into consideration to minimize risks during the installation, operation and decommissioning phases against marine RE energy. Marine RE energy commonly covers the world and marine fields. In addition, the marine RE technology included a broad range of all forms such as public opinion, such as fisheries, tourism and shipping industries for sailing. The RE Act 2011 and Electrical Supply Act 1990 failed because the advanced technology was limited compared with Japan, China, and Europe. For example, under the Act of Promoting Utilization of Sea Areas in the Development of Power Generation Facilities, Japan's government allocated offshore wind power by using renewable energy sources. Instead, European laws and policies are developed, known as their advanced technology.

One clear example of a maritime RE law that can be enforced in Malaysia is the Canadian Marine Renewable Energy Act. The goal is to help the production of marine RE in Nova Scotia in Canada. The Act focused on the awareness of marine RE to produce electricity in Malaysia. The production of tides, tidal and ocean energy is further increased. Local regulations and regional laws need to be tightened up and governed to protect the interests of communities and current maritime users

CONCLUSION

The data collected for the research has concluded that it is feasible to introduce marine renewable energy in Malaysia, but with a certain amount of limitations. The limitations apply mainly to the effective identification of marine energy projects in both CDM and FiT systems to minimise the social and ecological impacts. Based on the selection of the potential location in the development of tidal stream energy in Malaysia a few factors influenced the impacts on social and ecological. These are tidal flow speed, the depth of shallow water, the topography of the locations, the land area, the population of the location, and the total species of animals.

Pangkor Island and the Straits of Malacca are chosen as the potential locations to harness tidal stream energy. Besides that, both locations can fulfil the characteristics of the tidal stream energy extraction and gave positive impacts to produce sufficient electricity. Moreover, the selection location for Port Klang is eliminated due to the surrounding area not being suitable for the tidal stream energy to be implemented. This is because the movement of cargo and ships will disturb the operation of the tidal turbines. The clearance for the top and bottom seabed also needs to be considered because it will help to avoid the collision between the blades of the turbines and the ships.

Next, acoustic system devices can help to reduce the numbers of population of marine life from endangered. The system will help to detect the movement of the marine animals from being near the turbine blades and the signal will be transferred to the operator as a signal to stop the rotation of the blades. However, the electromagnetic field will produce noise sounds which can disturb their habitat life and daily routines. Because of that, further study is needed to reduce the rate of pollution to avoid marine life from risk and danger.

Besides that, CDM can be a significant driving force in Malaysia's marine renewable energy growth. Most CDM projects are classified as renewable energy, which accounts for 69 percent of all projects. In 2012 the energy-related CDM projects in Malaysia reported a reduction in emissions of 1,790,108 tCO2e. One of the CDM ventures, the Shihwa Tidal Power Plant, was launched in 2011 and in the monitoring period from July 2011 to September 2013 has managed to reduce carbon emissions by as much as 591,870.9 tCO2e. The strong success of Malaysia's renewable energy projects and the CDM tidal energy project have presented a promising future for Malaysia's marine renewables.

The proposed tidal stream FiT (shallow) is close to the solar power FiT introduced, which makes it a technology worth studying. In contrast, the planned tidal stream (deep) and wave energy FiTs are higher than the implemented FiT of other sources of renewable energy and the traditional price of electricity. In addition, the Malaysian Government plays a key role in driving marine renewable energy production forward. The government should be providing financial support for significant R&D of the above-mentioned technology. The Acts that are involved in the development of marine renewable energy in Malaysia will help for a better understanding in terms of rules and regulation while operating tidal stream energy.

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APPENDIX A

Table 8 CDM project grouped in types.

Type	Number	(%)	CERs/year (000)	(%)	2012 CERs (000)	(%)	CERs Issued (000)	(%)
Afforestation & Reforestation	69	0.8	3, 285	0.3	30, 956	0.8	4,072	0
Agriculture	2	0.02	59	0	41	0		
Biomass energy	906	10	61,000	5	157, 093	6	24, 717	3
Cement	50	0.6	7, 578	1	26, 568	1	2, 154	0.2
CO_2 usage	4	0	116	0	287	0.01	10	0.001
Coal bed / mine methane	112	1.3	72, 128	6	167, 428	6	33, 614	3
EE household	108	1.2	4, 107	0.3	5, 282	0.2	135	0
EE Industry	163	1.8	7, 568	1	17, 165	1	2, 052	0.2
EE own generation	481	5	63, 560	5	183, 561	7	44, 105	5
EE service	37	0.4	1, 720	0.14	1,022	0.04	6	0
Energy distribution	29	0.3	10, 422	1	9,910	0	316	0
Fossil fuel switch	150	1.7	69, 509	6	167, 428	6	33, 614	3
Fugitive	66	0.7	49,353	4	84, 158	3	9,834	1
Geothermal	35	0.4	12, 210	1	13, 242	1	4, 206	0.4
HFC_s	23	0.3	81, 727	7	476, 504	18	414,363	43
Hydro	2, 280	26	316, 855	26	416, 765	16	94, 482	10
Landfill gas	434	5	65, 831	5	190,088	7	24, 688	3
Methane avoidance	776	9	34, 270	3	96, 666	4	11,298	1
Mixed renewable	6	0.07	412	0	140	0.01		
N_2O	107	1.2	57, 793	5	251, 769	10	212, 767	22
PFC_s and SF6	18	0.2	5, 540	0	11, 785	0.5	1,758	0.2
Power plant	110	1.2	59, 168	5	51, 187	2	1,656	0.2
Solar	333	3.8	11, 464	0.9	6, 366	0.2	145	0.01
Tidal	1	0.01	315	0	1,104	0.04		
Transport	48	0.5	5, 823	0.5	7,030	0.3	439	0
Wind	2, 523	28	232, 036	19	312, 679	12	71, 729	7
Total	**8, 871**	**100**	**1,233,845**	**100**	**2,612,586**	**100**	**973,934**	**100**