CHAPTER 1: INTRODUCTION

1.1 BACKGROUND OF STUDY

According to the International Energy Agency (IEA), the global total primary energy supply has increased from 6,109 Mtoe[1] to 13,113 Mtoe from 1973 to 2011. In 2011, oil (31.5%) made up the largest percentage of the fuel consumed, followed by coal/peat (28.8%), natural gas (21.3%), biofuels and waste (10.0%), nuclear (5.1%), hydro (2.3%) and other energy sources[2] (1.0%). The total primary energy supply is largely came from OECD[3] (40.5%), China (20.9%), Asia excluding China (12.1%), Non-OECD Europe and Eurasia (9.0%), Middle East (4.9%), non-OECD Americas (4.5%) and Africa (5.3%). The global electricity generation by fuel has increased from 6,115 TWh to 22,126 TWh from 1973 to 2011. In 2011, the fuel shares of electricity generation are largely came from coal/peat (41.3%), natural gas (21.9%), hydro (15.8%), nuclear (11.7%), oil (4.8%) and other energy sources (4.5%). In term of regional shares of electricity generation, OECD (48.9%) has the highest shares, followed by China (21.5%), Asia excluding China (9.9%), Non-OECD Europe and Eurasia (7.8%), Non-OECD Americas (5.0%), Middle East (3.8%) and Africa (3.1%) (IEA, 2013).

The global total final fuel consumption is increased from 4,674 Mtoe to 8,918 Mtoe from 1973 to 2011(IEA, 2013). Almost all (93%) of the energy consumption

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[1] Tonne of oil equivalent (toe) is a unit of energy, which is the amount of energy released by burning one tonne of crude oil, approximately 42 billion joules (the SI unit of energy) or 42 GJ.

[2] Other includes geothermal, solar, wind, biofueld and waste, and heat.

[3] OECD consists of 34 countries which signed the Convention on the Organisation for Economic Cooperation and Development. The countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.

growth is in non-OECD countries. Non-OECD energy consumption in 2030 is 61% higher than 2011, with an average annual growth of 2.5%. Nearly 90% of the net increase in global energy consumption came from China and India (BP, 2013). The expected utilisation is mainly come from developing countries, with a 70% of growth in demand (Mansor, 2008). The increasing energy consumption is attributed to the growing population and emerging economy. This growth trend intensifies the world challenge regarding the limitations in energy supply, which can subsequently lead to resources crisis.

A majority of the energy resources being used nowadays is non-renewable. Fossil fuel, for example, is non-renewable and contributes to environmental pollution. The burning of fossil fuel produces carbon dioxide (CO_2), a type of Greenhouse Gas (GHG) that could intensify human-induced global warming. Fossil fuel combustion accounts for 90% of global CO_2 emissions in 2012. A total of 30.3 billion tonnes CO_2 was emitted from coal, oil and natural gas in 2010 (EIA, 2012). In 2012, the actual global emission was 34.5 billion tonnes, recording a 1.4% growth compared to 2011. The CO_2 emission is largely attributed to the energy-related human activities. Following a shift towards a greener society – with less fossil-fuel intensive activities, increased usage of renewable energy and energy saving – the global CO_2 emission has reduced by a meagre 1.1%, compared to an average annual increase of 2.9% since 2000 (Olivier et al., 2013).

As a developing country, the energy demand in Malaysia is also expected to increase substantially (Gan & Li, 2008). In 2009, the energy production and electricity consumption in Malaysia were 89.69 Mtoe and 101.00 TWh respectively (IEA, 2011). Both the energy and electricity demands are expected to reach 98.7 Mtoe (+10%) and

274 TWh (+171%), respectively by the year 2030 (APEC, 2013). By 2020, around 10.8 GW of new energy-generation capacity will be required by Malaysia as 7.7 GW of existing capacity will be terminated (Peter, 2011). As the conventional energy sources are largely non-renewable, reducing the utilisation of conventional energy sources is of utmost importance to mitigate climate change. Malaysia has committed to voluntarily reduce up to 40% of carbon emission intensity per Gross Domestic Product (GDP) by the year of 2020 (0.373 tCO_2e/*RM* thousand) compared to 2005 (0.621 tCO_2e/*RM* thousand) (Theseira, 2013). To achieve this target, it is imperative to implement more renewable energy projects to gradually replace non-renewable energy sources.

A series of environmental policies which are related to renewable energy including Five-Fuel Diversification Policy (1999), Small Renewable Energy Program (SREP) (2001), Greenhouse Gas Mitigation Policy (2002), Renewable Energy Act (2011) and Sustainable Energy Development Authority (SEDA) Act (2011) have been enacted. They could bring great impacts to the conventional energy system. By implementing the above-mentioned energy policies, the energy system is expected to be improved in terms of shares of renewable energy sources and environment.

Clean Development Mechanism (CDM) is one of the mechanisms under the Kyoto Protocol which allows emission-reduction projects in developing countries to gain carbon credits. The carbon credits can be traded and sold, and become a tool for industrialised countries to meet their emission reduction targets under the Kyoto Protocol (CDM, 2014a). The mechanism encourages sustainable development and emission reductions simultaneously. Sustainable development is a development scheme that fulfils the present needs without compromising the needs of future generation and brings the aspects of environment, economy and social into one.

The Feed-in Tariff (FiT) system was introduced under the Renewable Energy Act and SEDA Act in 2011 to allow the purchase of electricity produced from renewable resources by the national utilities. Malaysia is expected to achieve 4,000 MW of renewable energy by 2030 compared to 219 MW in 2011 (KeTTHA, 2011). Utilisation of renewable energy is foreseen to realise a low carbon energy system and combat energy shortage. This system is widely used around the world and has been recognised as the most effective method to encourage growth of shares of renewable energy.

Renewable energy market has become increasingly important as a result of future needs of energy consumption and low carbon environment. The vital challenge of the power sector in Malaysia is the issue of sustainability, which is to ensure the security and reliability of energy supply and the diversification of the various energy resources. Security and reliability of supply are crucial in ensuring a smooth implementation of development projects to spur economic growth in Malaysia. Meanwhile, diversification of energy resources is crucial to ensure that the country depends not only on a single source of energy (Leo-Moggie, 1996). Therefore, several types of renewable energies including biomass, biogas, hydroelectric and solar photovoltaic have been introduced into the energy system of Malaysia. The above-mentioned renewable energies are also recognised in the current FiT system and qualified to be sold to the national utilities at reasonable prices.

1.2 THESIS ORGANISATION

This study contains five chapters, beginning with an introduction of the study in the first chapter. A background of study, objective and the scope of study will be described here. The second chapter contains the literature review which includes the explanation of various terms used in this study, updated information regarding the development of marine renewable energy and the review of previous studies done by other researchers. Chapter 3 describes the methodologies which are used in this study, including interview, calculation by using Net Present Value method and survey. The fourth chapter focuses on the results and discussion of the study. Finally, Chapter 5 discusses the conclusions of the study and recommendation for future work.

1.3 PROBLEM STATEMENTS

Solar power and hydroelectric receive the highest attention in the renewable energy market due to the maturity of the technology and longer history in Malaysia. However, marine renewable energy has its own attraction owing to two main reasons. First, there is a need for Malaysia to diversify its energy sources in line with the Five Fuel Diversification Policy 1999. Second, the abundant coastline with favourable climate suitable for marine renewable energy generation and thus, making it a potential and novel technology worth exploiting in Malaysia. Prudent utilisation of various natural resources in Malaysia is crucial to diversify the energy sources in Malaysia. The country is surrounded by two large bodies of water, the South China Sea and the Straits of Malacca. These water regions are suitable for tidal energy and wave energy harnessing according to researchers (Chong & Lam, 2013; Maulud et al., 2009).

To-date, the development of marine renewable energy is still in its infancy. Prior to the commercialisation, the economic and social aspects are two crucial studies to be examined. The development of marine renewable energy requires plenty of economical aids. For instance, CDM and FiT are believed to be vital driving forces to the development of marine renewable energy. Besides, the opinion and acceptance level by the public towards marine renewable energy technology is vital for pushing forward its development. Literature review and data collection will be conducted in the first stage, followed by data analysis. This research is expected to fill the gaps of understanding in the aspects of economic and social components, which are a matter of concern for most of the policymakers, project investors and public.

1.4 OBJECTIVES

Three objectives have been proposed in this study:

i. To examine the feasibility on implementation of renewable energy projects of CDM in Malaysia;
ii. To propose reasonable FiT rates that may cover the costs of marine renewable energy; and
iii. To investigate the level of public acceptance of marine renewable energy development in Malaysia.

The first two objectives are set to study the feasibility of marine renewable energy project by considering the economic aspect. Renewable energy is known to be costly compared to conventional power stations. CDM and FiT are two important components for reducing the cost of marine renewable energy project. Apart from the economical aspect, social aspect is equally important in the feasibility study. A survey will be conducted within Malaysia to know the level of public acceptance of marine renewable energy.

The framework of study has been illustrated in Figure 1.1. The outcomes of the aforementioned objectives could become a preliminary feasibility study on marine renewable energy in Malaysia.

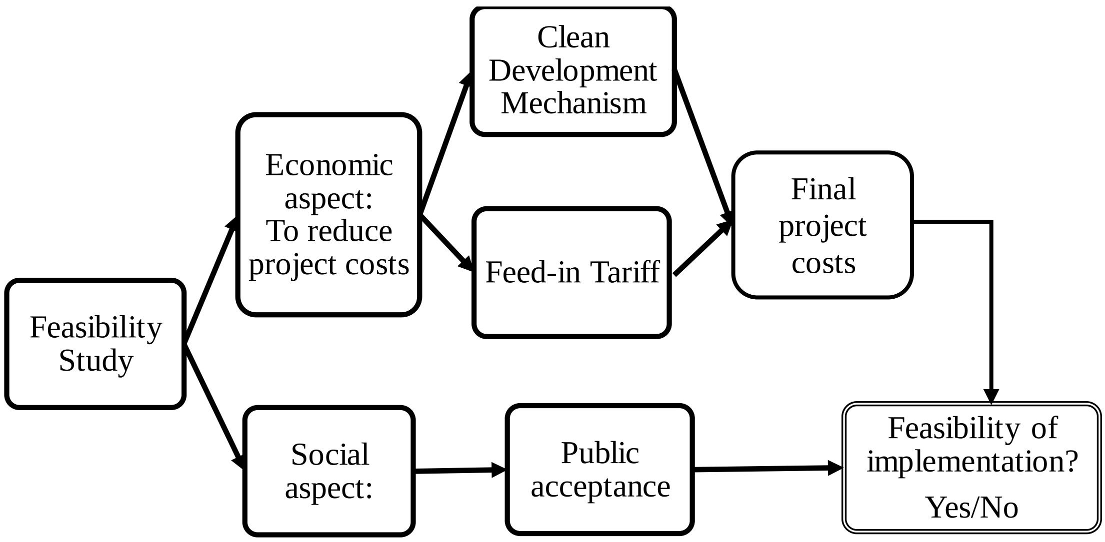


Figure 1.1: Framework of study

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter consists of literature review regarding both international and national efforts which may foster the development of marine renewable energy particularly in Malaysia. It is important to obtain a thorough understanding of the up-to-date marine renewable energy development, Malaysia's energy system, Clean Development mechanism, Feed-in Tariff and public acceptance of marine renewable energy in order to conduct the feasibility study.

2.2 MARINE RENEWABLE ENERGY

As shown in Figure 2.1, marine renewable energy can be categorised as tidal barrage, tidal current energy, wave energy, Ocean Thermal Energy Conversion (OTEC) power, and salinity gradient power (Powertech Labs, 2009). Among these technologies, tidal turbine is considered as the most cost effective way to harness marine energy. Similar to renewable resources from the sun, wind, wave, biomass and geothermal, marine energy resources derived from wind, waves, tidal or marine currents can be used and converted into large-scale sustainable electrical power (Sakmani et al., 2013).

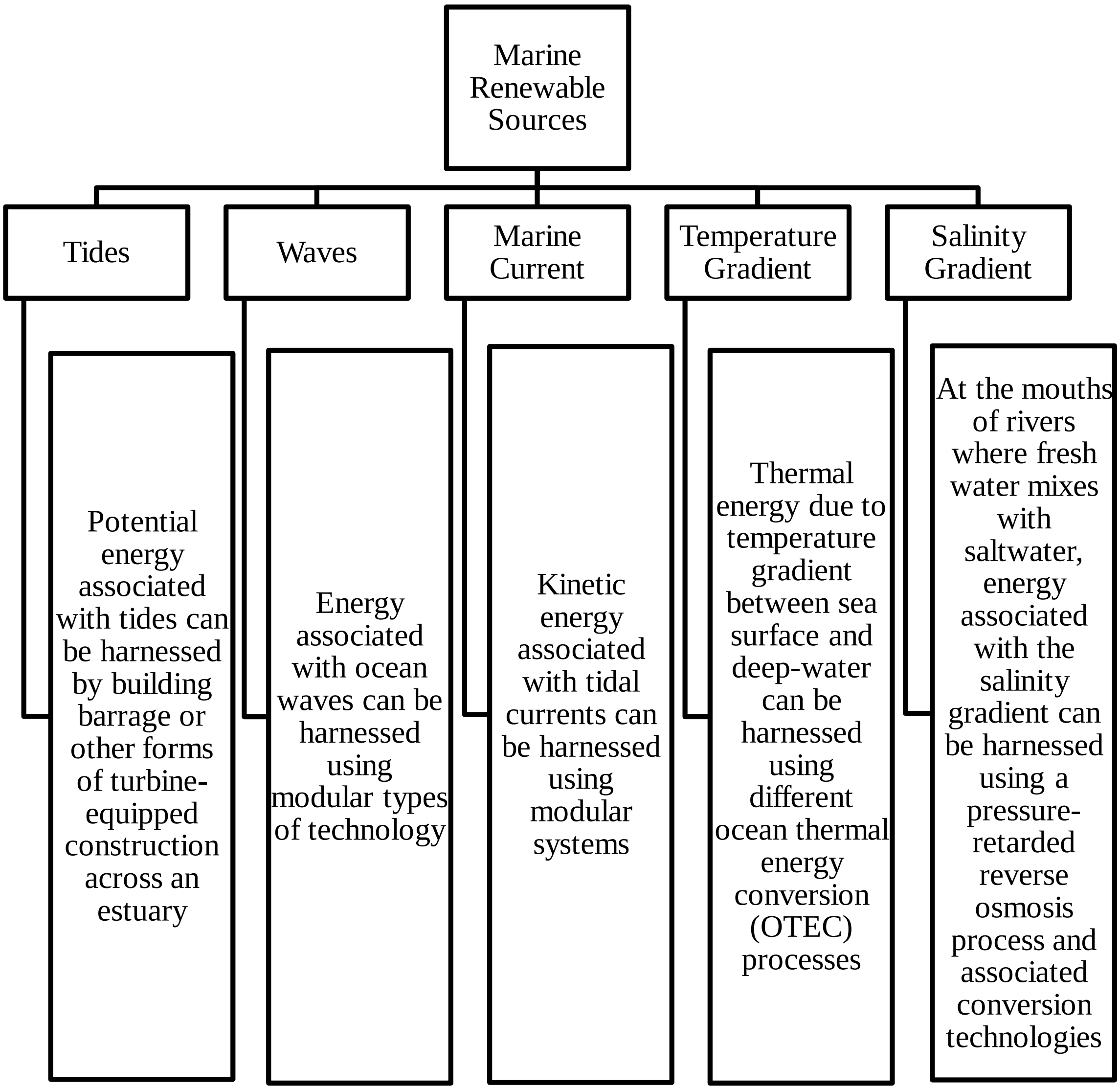


Figure 2.1: Types of marine renewable energy (Source: Chong & Lam, 2013)

The aforementioned technologies use different devices to capture energy and possess different working mechanisms. Brief explanations of each marine energy technologies are shown as below:

- Tidal barrage: It has longer history compared to wave energy, tidal current energy, OTEC and salinity gradient. It is one of the simplest ways to produce electricity by accelerating the flow of water in both directions using turbines, sluice gates, embankments and ship locks (Etemadi et al., 2011). The principle is similar to that of hydroelectric generation, where water is kept in a large, dam-like structure built across the mouth of a bay, or estuary in an area with a large tidal range. Water level changes caused by tides will develop a height difference across the barrage. Water will flow through the barrage via the turbines and generate energy during the ebb tide (receding), flood tide (water fill the reservoir through sluice gates), or during both tides (Chong & Lam, 2013).

- Wave energy: There are several ways to harness power from waves. Oscillating Water Column (OWC) is said as an economic method that is suitable to Malaysia (Chong & Lam, 2013). The most well known design is the Wells Turbine which has symmetrically shaped airfoils mounted at 90° to the airflow. Additional power may be required in order to connect the OWC to the grid. Hence, plenty of assessments are required to be conducted in order to know the feasibility of OWC in Malaysia.

- Tidal turbine: It can be categorised as either vertical-axis or horizontal-axis turbine (Dai & Lam, 2009). The vertical-axis turbine is capable to capture the energy from all directions while the horizontal-axis turbine is capable to capture more tidal energy (Chong & Lam, 2013). The principle is similar to that of wind turbines. Nevertheless, water has been used as the medium of harnessing instead of air. The effectiveness of tidal energy generation is greatly influenced by the tidal turbine’s arrays (Ahmadian & Falconer, 2012).

- OTEC: It utilises the temperature difference between warm surface of the ocean and the colder layers underneath to generate energy. Therefore, this technology is best suited to areas near the equator, where the intense solar radiation warms the surface significantly (Chong & Lam, 2013).

- Salinity gradient power: This technology is a rather new concept that makes use of the process of osmosis when saltwater and freshwater mix. The pressure induced by the movement of water across a membrane can turn the turbines (Chong & Lam, 2013).

2.3 GLOBAL MARINE RENEWABLE ENERGY DEVELOPMENT

All maritime countries are theoretically feasible to harness marine renewable energy as 337 GW is estimated to be exploitable by 2050. Approximately 1.2 million direct jobs will be created and 1 billion tonnes of carbon emission is expected to be avoided (Huckerby et al., 2012). The five main continents including America, Europe, Africa, Asia and Australia have different stages of marine renewable energy development.

Europe has the most countries that vigorously involving in marine renewable energy commercialisation whereas Africa is the most inactive player in the industry. United Kingdom (UK), Ireland, Germany and Portugal aim to deploy 1.95 GW through marine resources by 2020. USA and Canada also put much effort in the development of marine renewable energy (RenewableUK, 2011). In Asia, Korea, Japan, China and

Taiwan also join the path to exploit energy from ocean (O-Brien & Reid, 2009). Among the countries which are utilising marine renewable energy, UK is the leading country which is substantially harnessing wave and tidal power (Appleyard, 2012).

2.3.1 EUROPE

In UK, the Research and Development (R&D) Strategy pushes wave and tidal energy community towards a more inclusive development as it targets 2 GW of installed capacity by 2020 within the country. The UK and Irish waters alone are estimated to harness 840TWh/year, which is equivalent to approximately 50% of the total European wave energy resource. For tidal range energy resource, both barrage and lagoon are expected to harness 121 TWh/year, equivalent to approximately 25% of the European tidal energy resource. It is said that 50TWh/year of wave energy resource, 18TWh/year of tidal stream energy resource and 30TWh/year of tidal range energy resource has been assessed as being economically recoverable with today's technologies. As the current UK annual electricity demand is around 350TWh/year, wave and tidal energy in UK is possible to support the entire energy system (RenewableUK, 2013). In order to achieve this aim, funding has been issued to the wave and tidal demonstration facilities. The European Marine Energy Centre, the Wave Hub in the South West of England, as well as the New and Renewable Energy Centre are allocated with a sum of €10 million, €24 million and €12 million respectively (Kent, 2009). Between 2010 and 2012, there are almost 40 wave and tidal sites have been licensed throughout the UK while the vast majority are in Scottish waters. Full scale devices which are installed or currently operating in UK waters have been illustrated in Table 2.1

Table 2.1: Full scale devices installed or currently operating in UK Waters

Type	Operator	Device	Location
Tidal	Andritz Hydro Hammerfest	HS1000	Fall of Warness, EMEC
	Marine Current Turbines	SeaGen	Strangford Lough, Northern Ireland
	Neptune Renewable Energy	Proteus	North Humberside
	OpenHydro	Open Centre turbine	Fall of Warness, EMEC
	Scotrenewables Tidal Power	SR250	Fall of Warness, EMEC
	Alstom	DeepGen 1MW	Fall of Warness, EMEC
Wave	Aquamarine Power	Oyster 800	Billia Croo, EMEC
	E.ON	Pelamis P2	Billia Croo, EMEC
	Fred.Olsen	Bolt "Lifesaver"	FaBTest, Cornwall
	ScottishPower Renewables	Pelamis P2	Billia Croo, EMEC
	Seatricity	Oceanus	Billia Croo, EMEC
	Wello	Penguin	Billia Croo, EMEC

Source: RenewableUK, 2011

Northern Ireland has installed the first tidal current turbine connected to the national grid in Strangford Lough (See Figure 2.2). The Marine Current Turbine (MCT) is the pioneer in popularising commercial-scale tidal turbine - SeaGen which recorded 2,500 MWh of electricity generation to the UK grid (RenewableUK, 2011). Meanwhile, Northern Ireland is also actively involves in harnessing tidal energy. A prototype has been installed by MCT with a single 300 kW turbine off Lynmouth in the Bristol Channel in 2003 (Denny, 2009). Subsequently, MCT deployed a 1.2 MW SeaGen in

Northern Ireland's Strangford Lough in April 2008 that is capable to supply electricity to about 1,500 homes. Currently, the MCT is working on a 100 MW tidal energy farm off the Antrium (Kidd & Taylor, 2012). An environment assessment concluded that the offshore wind and MRE in Northern Ireland could generate 900 MW and 1,200 MW of electricity by 2020 without significant negative impacts to the environment and other sea users.

Figure 2.2: SeaGen 1.2MW tidal energy convertor was installed in Strangford Lough in Northern Ireland in 2008 (Source: Sea Generation Ltd., 2012)

Germany's Electricity Feed-in Law was enacted in 1991. Under this law, the utilities were obliged to buy the "green" electricity at 90% of the retail rate of electricity, which was exceeding the price of conventional electricity. Next, the Renewable Energy Sources Act was introduced in 2000 to guarantee stable FiTs up to 20 years. As a result of the vigorous impetus of FiT, the RE market in Germany grows substantially. Now, Germany has the world's largest market for solar photovoltaic and wind energy. Its national supply of renewable electricity is doubled from 2000 to 2007, and achieves the target of 12.5% renewable electricity consumption in 2010, which is 3 years ahead of schedule (Bohme, 2012). The success of FiT in Germany had induced numerous other countries including France, Italy and Spain to follow its footstep (Voosen, 2009). Even though solar power and wind energy are given the most attention, marine renewable energy is also increasingly developed in the country. In Germany, the sufficient flow velocities make it a suitable place to harness tidal power where the island of Sylt has approximately 3 m/s of flow velocity (Zander, 2010). Besides, the North Sea coast is a potential place for wave harnessing. The first wave power generation plant had been installed to obtain 250kW of electricity to about 120 households (Lepisto, 2006).

In Italy, 5.2% of the energy is sourced from renewable resources in 2005. The FiT system expected to increase the RE consumption to 17% in 2020 (Renewable Energy Focus, 2012). Currently, there is a 500 kilowatt (kW) tidal power prototype being tested in the Strait of Messina. If the trial is successful, a fleet of 50 tidal turbines with an installed power of 20 MW each will be installed. The Strait of Messina has current speeds of 2.5 m/s or 4 to 5 knots, which change direction every six hours. The wave and current energy potential along the Straits are estimated to hit 19,900 TWh/year of energy, which is around 10% of the world's electricity needs in 2006 (Burgermeister, 2008).

2.3.2 AMERICA

To-date, the United States (US) commenced many wave and tidal energy projects within the country. The locations that are identified to have potent in harvesting marine power including Alaska, Washington, Oregon, California, Hawaii, Maine and

Massachusetts (OREC, 2012). According to a report by Electric Power Research Institute, Alaska, Hawaii and Puerto Rico are able to harness wave energy of 1,550 TWh, 130 TWh and 30 TWh respectively annually. Besides, the West Coast which comprises Washington, Oregon and California has tendency to harness wave energy of 590 TWh annually. Next, the East Coast which formed by Maine, Massachusetts, New York, North Carolina, South Carolina, Florida and so on are possible to harness 240 TWh every year. Furthermore, the Gulf of Mexico is able to obtain 80 TWh of wave energy every year. Hence, the total wave energy that can be harnessed in US is 2,640 TWh/year, which is 26 % greater than the estimation in 2004 (EPRI, 2011).

It is believed that the Pacific Northwest coastline in the North America is capable to generate 40-70 kW per meter of tidal energy (Dwinnell, 2009). The Annapolis Tidal Generating Station, which is located in Annapolis Royal and completed in 1984, is one of the famous tidal barrages in the world. It is the only modern tidal plant in the North America and possesses generating capacity of 20 MW. This station can produce more than 30 million kW per year and supply to 4,000 homes (Fan, 2006).

2.3.3 ASIA

Korea might be the most potential Asia country that lead in marine renewable energy. The largest tidal energy project “Seaturtle Project” near Jin-do has generated 110 kW during the trial phase which ends at 2010. The official construction began and expected to harvest 150 MW from 2011 to 2017. Besides, the incoming tidal power plants in

Garorim (2014), Gangwha (2017) and Incheon (2017) are foreseen to generate total outputs of 520 MW, 840 MW and 1,320 MW respectively. The subsidies supplied by both government and private sectors in developing marine renewable energy hit Korean won (KRW) 13,297 million (RM417 million) from 1989 to 2008. The FiT for tidal energy with dam and without dam in Korea ranged from KRW62.81-75.59/kWh (RM0.20-0.24/kWh) and KRW76.63 – 90.50/kWh (RM0.24 – 0.28/kWh) respectively, for a duration of 15 years (OSEC, 2010).

China is one of the global leaders in wind and solar energy. Nevertheless, the country started to join the marine renewable energy market. The country has abundant resources of marine power as it is surrounded by the South China Sea and the Indiana Ocean. More than 14,000 km of coastline reserve a tidal power of 190 million kW. Besides the 38.5 million kW of tidal power that is under development, the country has an annual output of 87 billion kWh of electricity. The provinces of Zhejiang and Fujian are potential sites for marine power harnessing where 424 tidal power stations can be built along the coastline (Zhao, 2011). Besides, a wave energy system will be installed along the coastline of Dong Ping in Guangzhou province to generate 10GW of electricity (Young, 2010). Besides, the Jiangxia tidal power station, which is the largest in China and the third largest in the world, had been operating for 20 years. Now, the power station has annual net generating capacity of 5020 MWh (Zhao, 2011).

The catastrophe of Fukushima nuclear power plant in 2011 awoke Japan regarding the urge to find an alternative in replacing this destructive energy sources. As a result, the ocean becomes a good choice since the Tokyo Government has estimated that around 300 million to 400 million kW of electricity could be harnessed from wave power. The Saga University and the Hiroshima University has already joined the path of wave energy harnessing and it is possible that the wave power may surpass the solar and wind power. Besides, the Kurushima Straits in the Seto Inland Sea is suitable to harness tidal energy due to sound topography condition. Furthermore, the technology of OTEC is also applicable in Japan due to the distinct temperature difference of surface water and deep seawater (Sentaku Magazine, 2012).

2.3.4 AUSTRALIA/OCEANIA

The Australian Government had enacted some policies that are prospective to impel the development of marine energy technologies. Marine renewable energy is one of the potential yet underdeveloped renewable energies in Australia. The marine renewable energy technologies in Australia are developing as four tidal or wave energy plants with a combined capacity of less than 1 MW have been established.

The country possesses abundant wave energy resources along its western and southern coastline, especially in Tasmania. A study to assess wave energy resource in Australia has shown that the resource in deep water is approximately 525,000 Megawatt (MW) and in shallow water is approximately 171,000 MW. About 3,467.98 Tera-joules (TJ) of wave energy can be harnessed on the entire Australian continental shelf, where the Western Australia is contributing the most energy. Besides, the northern margin, especially the north-west coast of Western Australia is highly suitable to harness tidal energy. The Northwest Shelf, Darwin, Torres Strait and the Southern Great Barrier Reef are containing sufficient tidal energy resources to produce electricity. The entire Australia continental shelf has the total tidal kinetic energy of 2,441.92 TJ which again largely contributed by Western Australia that produce 1,496.33 TJ. The region nearby Pacific Ocean is possible for OTEC harnessing. However, OTEC is relatively new among the marine energy technologies used in Australia. Most of the OTECs are in pilot scale or demonstration scale plants (ABARES, 2012).

New Zealand is located in a strategic location where it has abundant marine renewable energy resources to be harnessed in the nearby Tasman Sea. The country targeted to achieve 90% of renewable electricity by 2050 (Power Projects Limited, 2008). The government Energy Efficiency and Conservation Authority has allocated The Kaipara Harbour and the Cook Strait are the most promising sites for utilising underwater turbines, as 11,000 MW and 13,000 MW of tidal electricity can be harnessed respectively.

2.4 COSTS

Levelised Cost of Energy (LCOE) is the price at which electricity must be generated from a specific energy source to break even over the lifetime of the project (NREL, 2013). In order to calculate LCOE, several factors have to be considered. The factors affecting LCOE of marine renewable energy are listed in Figure 2.3. The difference of LCOE of marine renewable energy and that of other types of renewable energy is that, seabed rent has been taken into account (SI Ocean, 2013).

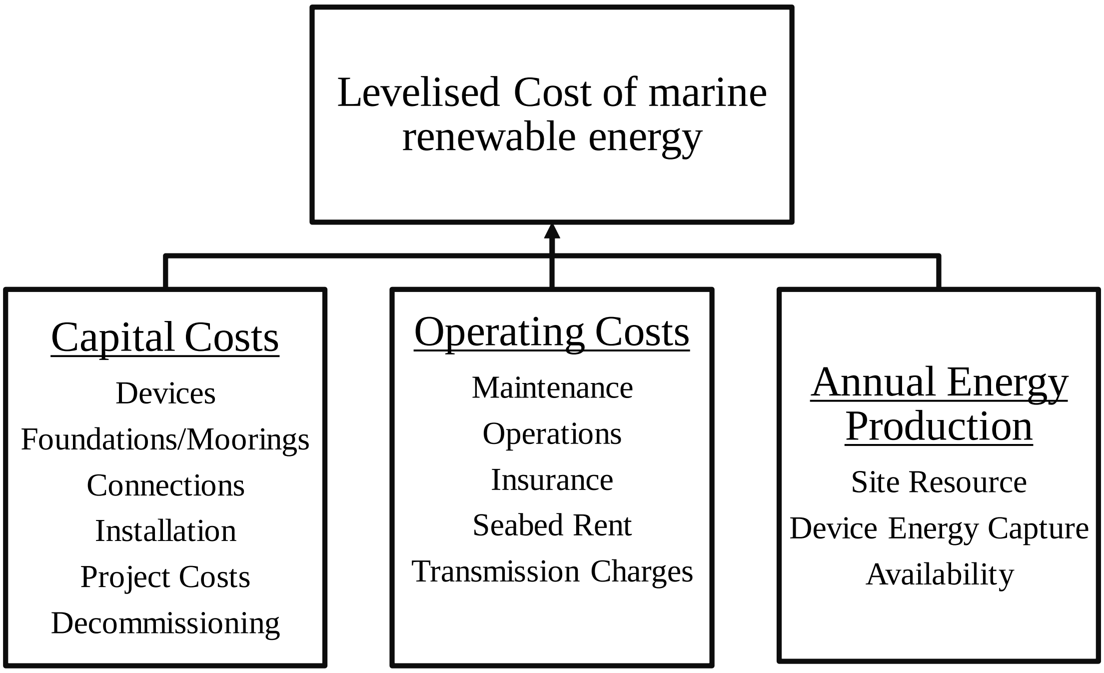


Figure 2.3: Factors affecting LCOE of marine renewable energy (Source: Carbon Trust, 2006a)

2.4.1 CAPITAL COSTS

The capital cost of marine renewable energy device is constituted by several components, which generally can be attributed to station-keeping, structural, energy conversion components and sub-assemblies, and project costs (Carbon Trust, 2006a). Station-keeping parts include the moorings or foundations (e.g. a monopile) while structural components are the entire parts that hold the device together (e.g. the steel shell of a floating wave energy device). For wave energy devices, there is some overlap between structural and energy conversion components as the structure's geometry and size has a significant bearing on the device's ability to absorb power. Energy conversion components include parts of the power train or power take-off system, such as hydraulic pistons, hydraulic motors, gearboxes, frequency converters and electrical generators.

Project costs include hardware such as subsea cables, transportation, installation and commissioning. For large installations or marine energy farms, station-keeping might be considered under the category of project costs. The comparison of capital cost breakdown for a particular wave energy device and tidal stream energy device is shown in Figure 2.4 (a), (b), (c) and Figure 2.5 respectively.

(a)

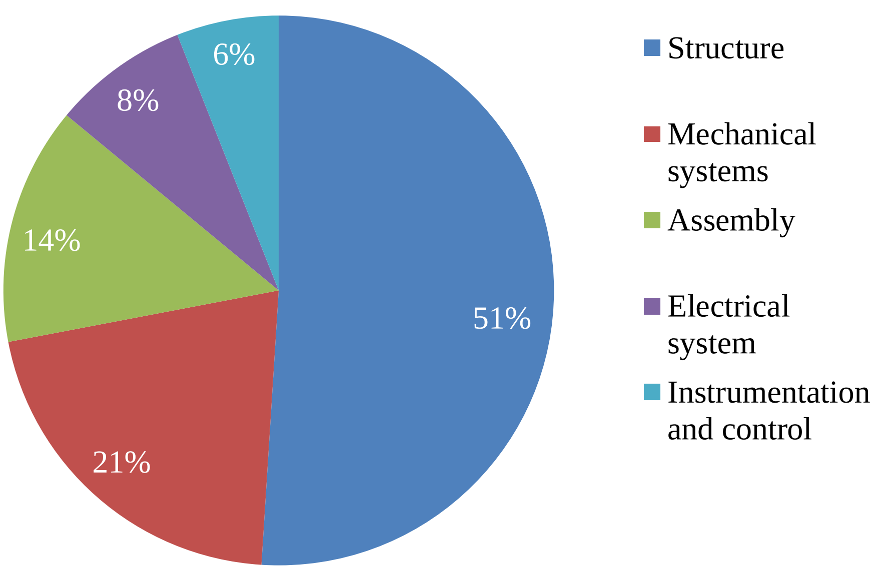
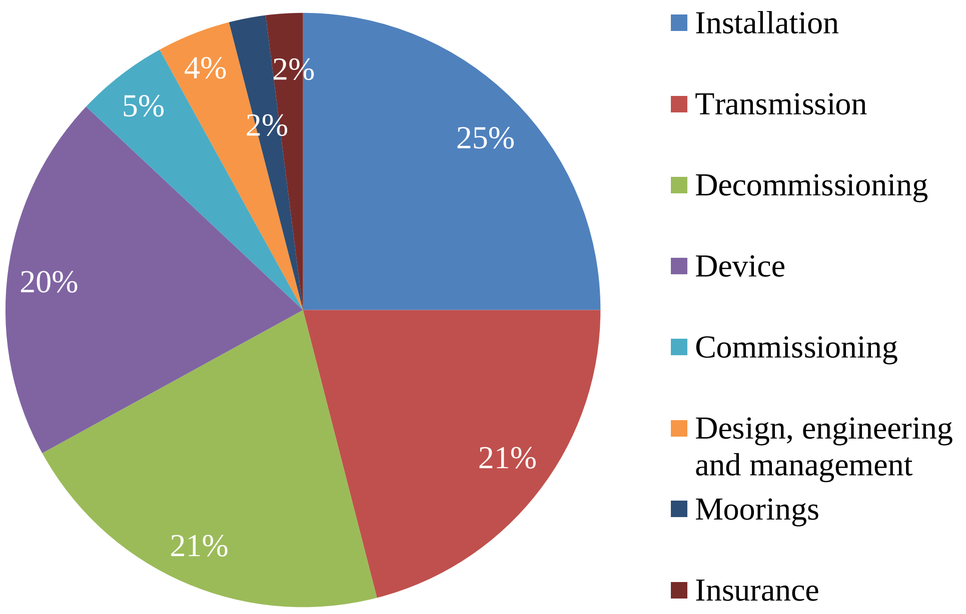


Figure 2.4: Capital cost breakdown for wave energy device

(a) Capital cost breakdown; (b) Capital cost breakdown for installation of a single device; and (c) Capital cost breakdown for installation of wave farm of a certain size involving one particular energy device

(Source: Carbon Trust, 2006)

(b)



(c)

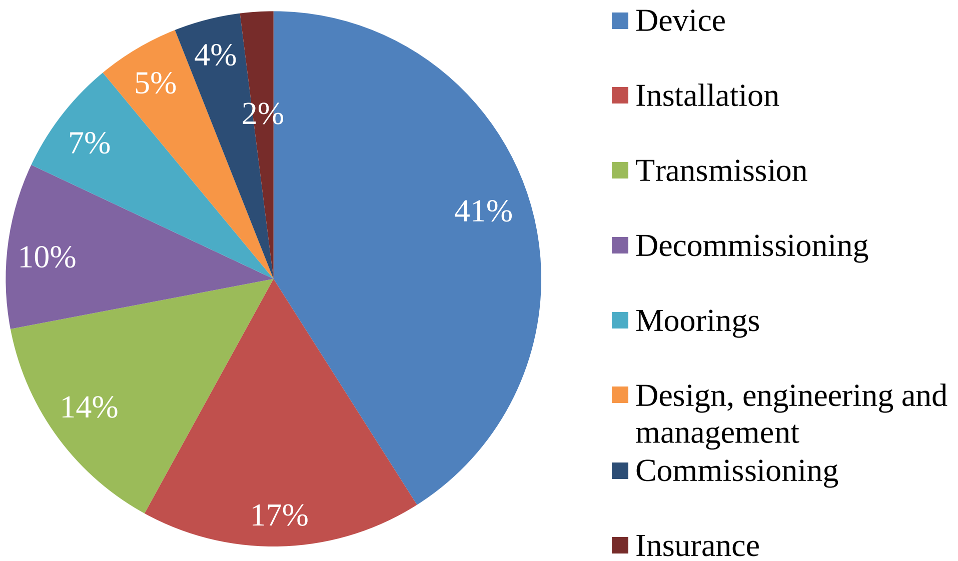


Figure 2.4, continued

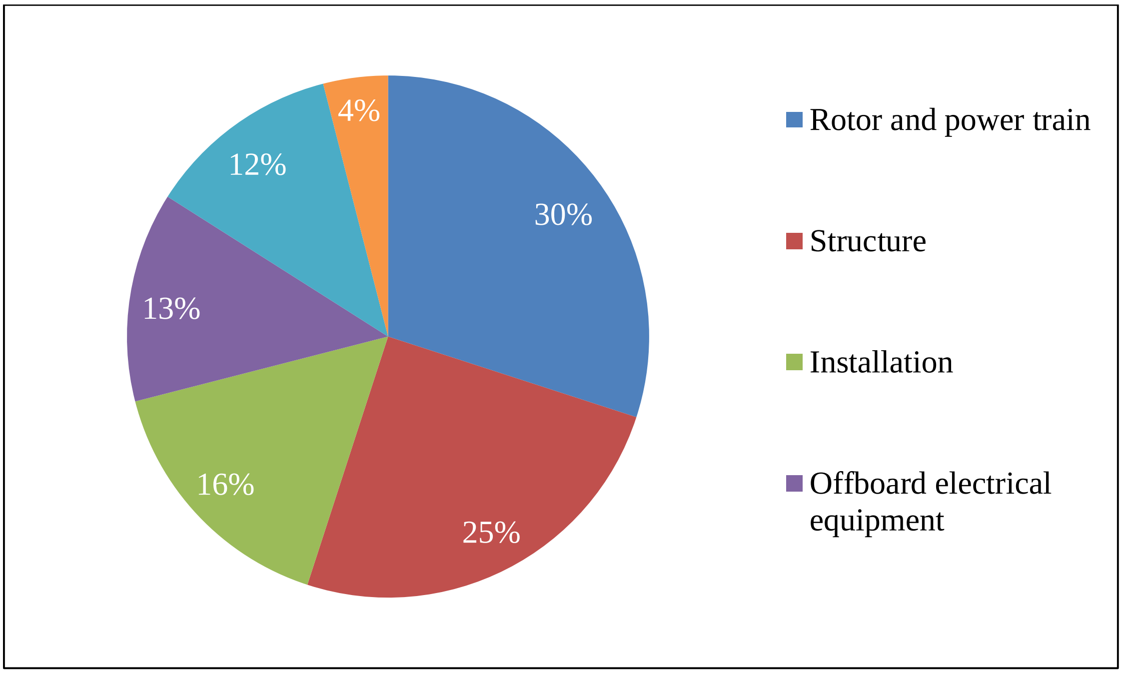
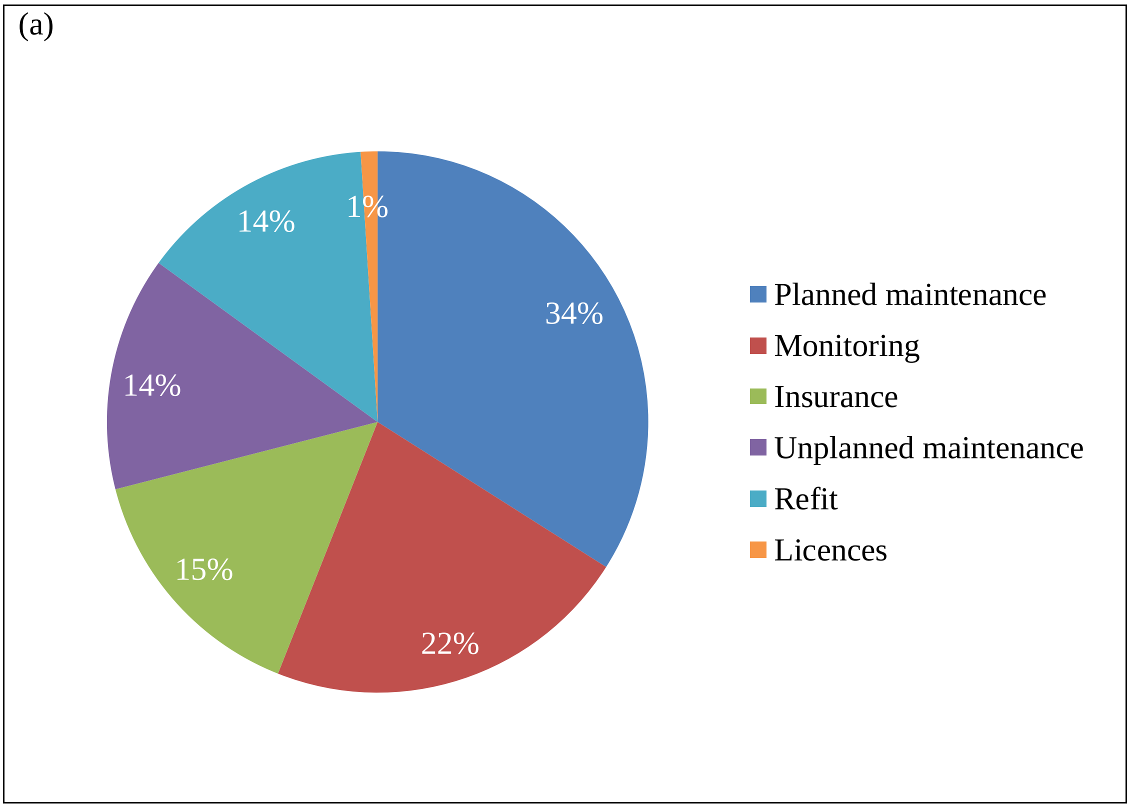


Figure 2.5: Capital cost breakdown for tidal stream energy device installation of a particular energy device in a farm of a certain size (Source: Carbon Trust, 2006a)

2.4.2 OPERATING COSTS



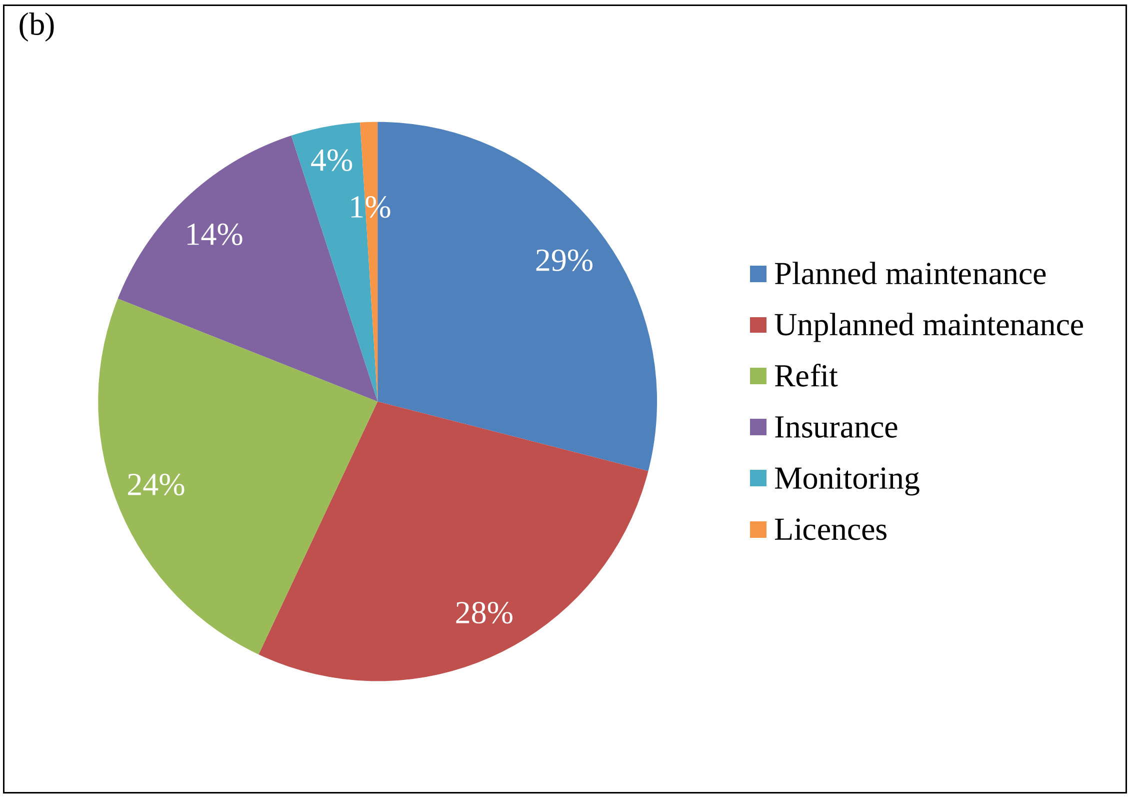


Figure 2.6: Operating cost breakdown for wave energy device

(a) Operating cost breakdown for installation of a single device; and (b) Operating cost breakdown for installation of a certain size involving one particular energy device

(Source: Carbon Trust, 2006a)

The operating costs of marine renewable energy include planned and unplanned maintenance, licenses to be stationed and generate electricity at the location (often referred to as consents and permits), insurance, and ongoing monitoring activities. The breakdown for operating costs of wave energy device has been shown in Figure 2.6 (a) and (b). The costs allocation is calculated based on Discounted Cash Flow (DCF). Therefore, the figures show the annual average costs of wave energy. It is unlikely to happen in reality as the operation and maintenance costs would vary from year to year.

It is noticeable that about $1/7^{th}$ of the total operating costs are assigned to unplanned maintenance activities, which reflects a degree of uncertainty in the device's design for reliability. When a project consisting of several devices is implemented, licences and insurance have same weightings as in single device. Other components, particularly unplanned maintenance, become key components which may influence the projects' capital costs of different sizes and operation costs. Unplanned maintenance is hard to be identified, solely dependent on time for investigation and determination of problem (MACMMS, 2014).

2.4.3 ENERGY CAPTURE PERFORMANCE

The energy capture performance of a marine renewable energy device may influence the cost of energy. The key factors which influence the device's performance are i) availability of resource (wave or tidal conditions); ii) efficiency of the device (mechanical components that absorb energy, e.g. the rotor of a tidal stream turbine); and iii) power take-off system (everything between the prime mover and the electrical terminals for connection to the grid) (Carbon Trust, 2006a). It is necessary to look closely at the specific device designs to know the performance characteristics in detail.

2.5 DEVELOPMENT IN MALAYSIA

Malaysia is a maritime country located in the Southeast Asia, consisting of two major land areas, Peninsular Malaysia (West Malaysia) and Malaysian Borneo (East Malaysia) (See Figure 2.7). The land areas are embraced by two large bodies of water, which are the South China Sea and the Strait of Malacca. The water regions are believed to possess abundant potential for marine renewable energy harnessing.

Figure 2.7: Map of Malaysia

The National Oceanography Directorate (NOD) of the Ministry of Science, Technology and Innovation (MOSTI) has drafted a consolidated marine renewable energy technology roadmap to review, identify and strengthen the programs for the energy market derived from wave, tide, current and OTEC as shown in Table 2.2 (Yaakob, 2012). This roadmap provides a complete plan for the development of marine renewable energy within Malaysia. It is especially useful for policymakers in collaboration with researchers to supervise and keep the development of marine renewable energy on track.

Table 2.2: Summary of marine renewable energy roadmap proposed by the National Oceanography Directorate

<table>
<tr><th>Components</th><th>Current</th><th>Short term (2011-2012)</th><th>Mid Term (2013-2015)</th><th>Long Term (2016-2020)</th><th>Beyond 2020</th></tr>
<tr><td rowspan="4">Potential projects, grants and collaborations network</td><td rowspan="4">• Wave/wind/current mapping (Marine atlas)
• Ocean temperature profiling
• Chemical, geological, physical and biological oceanography study covering regional seas</td><td rowspan="2">Implementation of testing facilities for demo of small scale (pilot project) ocean energy conversion devices</td><td>Make ocean energy part of the hybrid system especially for islands</td><td rowspan="2">Use the ocean energy to generate hydrogen for remote islands (for use in dual cells)</td><td rowspan="3">To install 6 units 10MW conversion devices</td></tr>
<tr><td>To install 500kW conversion device</td></tr>
<tr><td>Implementation of numerical modelling for the ocean energy system</td><td>Detail physical and numerical modelling of potential sites</td><td>To install 10MW conversion device</td></tr>
<tr><td>Development and testing of 20kW ocean energy generation</td><td>Potential demonstration facilities/marine laboratory</td><td colspan="2">Niche market for indigenous technology for the equatorial belt countries</td></tr>
</table>

In the initial stage, a marine atlas including wave, wind and current mapping, ocean temperature profiling, chemical, geological, physical and biological oceanography study covering the regional seas has to be prepared. In the short term, a numerical simulation for the marine renewable energy system, pilot projects and field tests have to be carried out in order to foresee the operational performance of large-scale marine renewable energy farms. Marine renewable energy is expected to become a crucial energy source to sustain the electricity demand from the nation, especially in some remote islands. This is the reason why integration of renewable energy into the existing energy system in remote island communities is of interest to researchers (Das & Balakrishnan, 2012; Mohamed, 2012; Rae & Bradley, 2012).

2.5.1 PHYSICAL MARINE CONDITIONS

Several recent studies from local institutions have produced estimates of the exploitable marine renewable energy resource in the water regions of Malaysia. In the West Coast of Peninsular Malaysia, the Straits of Malacca is suggested to be suitable for tidal energy extraction (Chong & Lam, 2013). In particular, *Pangkor* Island has been proposed based on its water flow velocity, seabed roughness, water depth, conditions of ocean water and environmental considerations (Sakmani, et al., 2013). In the East Coast of Peninsular Malaysia, *Tanjung Berhala* is the most potential site for tidal energy extraction with an estimation of 90 to 203kW resource (Maulud et al., 2009). In the East Malaysia, *Jambongan* Island, *Kota Belud* and *Sibu* are suggested to be the most potential sites for tidal energy extraction. An estimation of 14.5 GWh can be harnessed annually by using marine current turbines (Lim & Koh, 2010). The Sabah Trough, which has the water depth of 2,900 m and temperature difference of 26 °C from bottom to water surface, is suggested to be a potential site in harnessing OTEC (Chong & Lam, 2013). The researchers are also keen on other forms of marine renewable energy including wave energy and salinity gradient (Abdul Maulud et al., 2008; Ahmad et al., 2011; Chiang et al., 2003; Muzathik et al., 2010).

Physical marine conditions may affect the overall development cost of a marine energy project. Hence, an overview of the marine conditions is vital to be known. According to Sakmani, et al. (2013), the concerns should be focussed on parameters such as seabed topology, tidal stream velocity, water level of tides, seabed topography and wind pattern which may act as a disturbance. The Straits of Malacca is a shallow and narrow water area with an average depth of 25 m. In the northern area, the straits is wider and deeper with an average depth of 66 m while towards south, it becomes narrower and shallower to about 20 m in depth. The current speed on the surface along the Straits of Malacca is around 10-70 cm/s while the current speed at the layer of 30-50m is 0-30 cm/s. Tides are mainly semidiurnal with a tidal range of 1.6 $\pm$3.7 m in the Strait depending on the location. Semidiurnal tide is a type of tide which shows the Moon's declinational effect in production for a period of 12 hours 24 minutes. When the semidiurnal tide is dominant, the highest tidal current occurs at spring tides and the lowest at the neap tides. This indicates the availability of minimum and maximum tidal energy. The wind pattern in the Straits of Malacca is greatly influenced by the monsoon season which has speed of around

10 m/s. Wind has no great influence on the velocity but it should be considered as a disturbance to the surface current which may influence the location for the height of the turbine to be installed.

2.6 RENEWABLE ENERGY-RELATED POLICIES IN MALAYSIA

The Malaysian Government has implemented the Four Fuel Diversification Policy in 1981 in order to relieve oil shortage and fulfil future energy demand. Increase in natural gas consumption gradually reduces the dependency of oil in energy market (PTM, 2007). As stipulated in the Eighth Malaysia Plan, the policy was revised in 1999 to be known as Five Fuel Diversification Policy. Renewable energy has been included as the fifth fuel besides crude oil and petroleum products, natural gas, hydro as well as coal and coke (PTM, 2011).

Subsequently, the SREP was launched in May 2001 to assist the utilisation of renewable energy under supervision of the Special Committee on Renewable Energy (SCORE). The SREP is similar to the FiT system but it only targeted on the small scale renewable energy projects. Small power plants were established and renewable resources including biomass, biogas, municipal waste, solar, mini-hydro and wind energy were used to generate electricity. The electricity suppliers can sell all the generated electricity to the national utility through national grids (Chua & Oh, 2010). After that, the enactments of both Renewable Energy Act and SEDA Act in 2011 transformed the FiT system into a more detailed and complex mechanism (Haris, 2010).

2.6.1 ELECTRICITY CONSUMPTION IN MALAYSIA

Table 2.3: The primary energy supply, final energy demand, energy input in power stations, installed generation capacity, electricity generation and final electricity consumption in Malaysia from year 2002 to 2012[4]

Year	Primary Energy Supply (ktoe)	Final Energy Demand (ktoe)	Energy Input in Power Stations (ktoe)	Installed Generation Capacity (MW)	Electricity Generation (ktoe)	Final Electricity Consumption (ktoe)
2002	53198	33290	18148	9705	6384	5922
2003	57582	34586	16682	18829	6748	6313
2004	62403	37322	17747	18711	7075	6643
2005	66379	38284	19698	18964	7214	6943
2006	68078	38563	20843	20035	7740	7271
2007	72573	41605	22070	21420	8385	7685
2008	75529	41969	24164	21666	8423	7987
2009	74583	40845	24616	24028	9091	8287
2010	78298	41476	27696	24161	9791	8993
2011	79289	43456	27924	25692	10746	9235
2012	83937	46710	29250	25582	11562	10011

Source: Energy Commission, 2014

According to Table 2.3, energy indicators including primary energy supply, final energy demand, energy input in power stations, installed generation capacity, electricity generation, and final electricity consumption are in rising trends from 2002 to 2012. The rising trends are attributed to both population and economic growth. For electricity generation, the sources are primarily constituted from hydro, thermal station and Co-Gen. Final electricity is largely consumed by industrial sector

[4] The compilation of data is done by the Energy Commission, Malaysia through Tenaga Nasional Berhad, Sabah Electricity Sdn. Bhd., Sarawak Electricity Corporation Berhad, IPP Semenanjung, IPP Sabah and IPP Sarawak

(4,509 ktoe), commercial sector (3,325 ktoe), and residential area (2,126 ktoe). From 2011 to 2012, the electricity generation and final electricity consumption increases 7.6% and 8.4% respectively to reach 11,562 ktoe and 10,011 ktoe respectively. The growth of final electricity consumption which leads the growth of electricity generation brings to the need of higher installed generation capacity in future.

As shown in Figure 2.8, 94.1% of the electricity is generated from gas, coal, and oil in 2011. This shows that fossil fuel is a dominator in the field of energy generation in Malaysia. From 1995 to 2011, the generation of electricity in Malaysia increase from 41,813 GWh to 118,165 GWh which is 182.6%. Among all of the sources, the percentage of coal in generating electricity increases from 9.7% in 1995 to 41.9% in 2011. The reason for the increase is attributed to the opening of new coal fire power stations and government licensing of independent power producer as the efforts to reduce the high reliance on natural gas in the generation mix. The development of alternative energy sources such as hydroelectric and coal industries are planned to ensure the demand of energy for year 2015. Contrarily, the share of natural gas as energy input in the power stations decreased from 66.5% in 1995 to 51.1% in 2011.

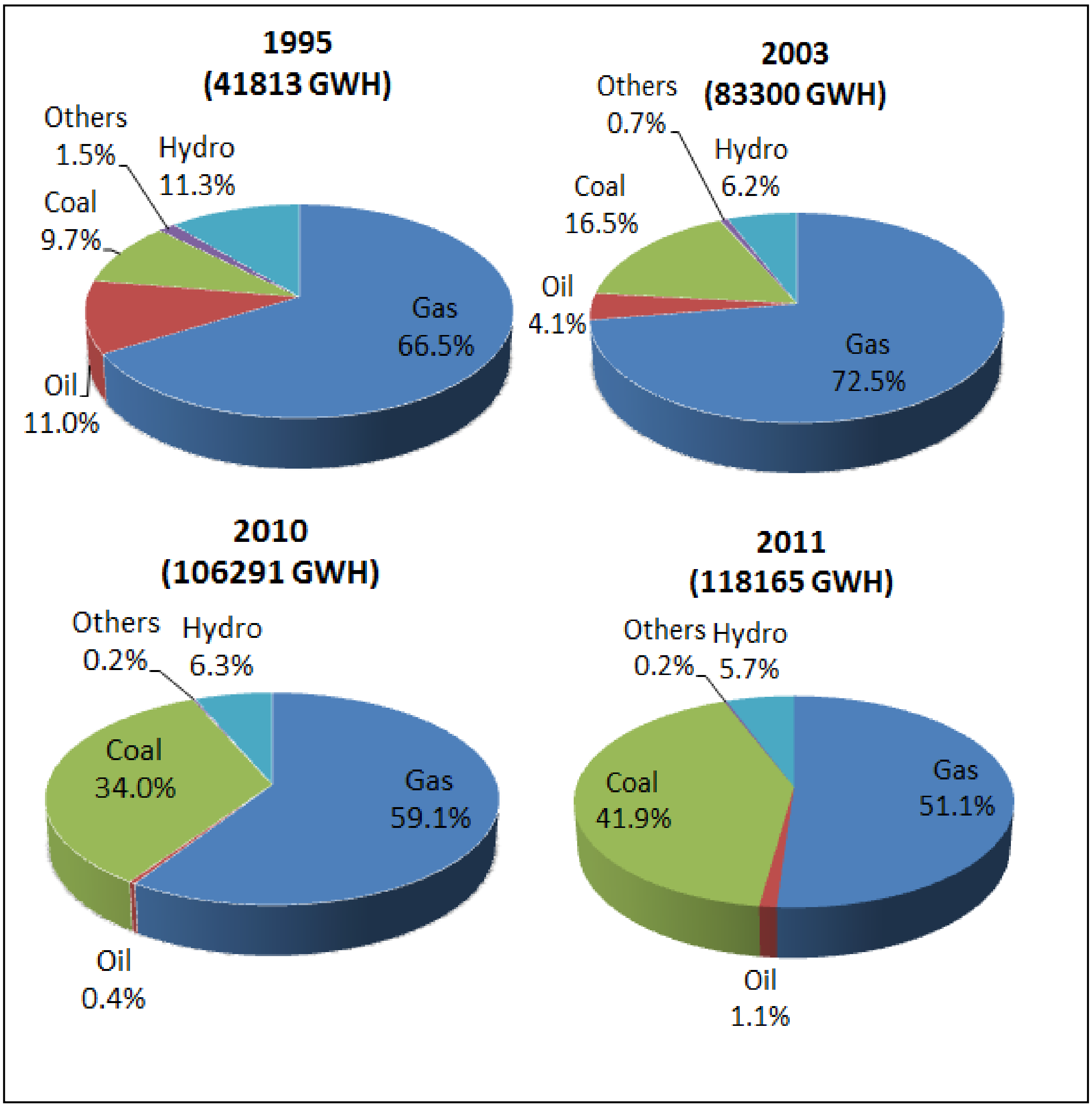


Figure 2.8: Malaysia Generation Mix of Electricity for 1995, 2003, 2010 and 2011

Source: Energy Commission, 2014

2.6.2 COST OF ELECTRICITY IN MALAYSIA

Cost of electricity of a household can be calculated by identifying the electricity tariff rate, the power rating of the appliance, and the duration of appliance operated. The unit of electricity tariff is given in *Ringgit Malaysia* per kilowatt hour (*RM*/kWh) whereas the unit of power rating of the appliance is given in Watt (W). The duration of operation for the appliance are measured in hour (h).

The household energy consumption is calculated as follows:

Energy Usage (kWh) = Power Rating (W) x Operating Hour (h) Equation 2.1

The household electricity cost is calculated with the following equation:

Electricity Cost (*RM*) Equation 2.2

= Energy Usage (kWh) x Electricity Tariff Rate (*RM* per kWh)

According to Equation 2.1 and Equation 2.2, energy usage and electricity cost equation is directly proportional to the operating hours of the appliance. Therefore, by reducing the operating hours of the appliance, the electricity usage, and electricity cost can be reduced. Table 2.4 shows the difference in the domestic tariff offered by the three main electricity suppliers in Malaysia, which are *Tenaga Nasional Berhad (TNB), Sabah Electricity Sdn Bhd (SESB)* and *Sarawak Energy Berhad (SEB).*

Table 2.4: Domestic tariff of main electricity suppliers in Malaysia[5]

Company Unit (kwh)	TNB	SESB	SESCO
For the first 100 kWh (1 - 100 kWh) per month	21.8	17.5	34.0
For the next 100 kWh (101 - 200 kWh) per month	21.8	18.5	29.0
For the next 100 kWh (201 - 300 kWh) per month	33.4	33.0	29.0
For the next 100 kWh (301 - 400 kWh) per month	40.0	33.0	29.0
For the first 100kWh (401 - 500 kWh) per month	40.2	33.0	33.0
For the next 100 kWh (501 - 600 kWh) per month	41.6	34.5	33.0
For the next 100 kWh (601 - 700 kWh) per month	42.6	34.5	33.0
For the next 100 kWh (701 - 800 kWh) per month	43.7	34.5	33.0
For the next 100 kWh (801 - 900 kWh) per month	45.3	34.5	33.0
For the next kWh (901 kWh onwards) per month	45.4	34.5	33.0
Minimum monthly charge	RM3.00	RM 5.00	RM 5.00

Source: (TNB, 2014)

2.7 CLEAN DEVELOPMENT MECHANISM

Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC) which was adopted on 11 December 1997 in Kyoto, Japan, and entered into force on 16 February 2005. This protocol aims at fighting the

[5] All units are in cent/kWh unless otherwise specified. SESB domestic consumers whose monthly consumption are 350 kWh and below will be given an adjustment so that there will be no increase impact on their monthly bills. A RM20 subsidy on monthly electric bills is provided by the Malaysian Government to all eligible TNB residential customers.

global phenomenon that is climate change, by reducing the GHG concentrations in the atmosphere and preventing dangerous anthropogenic interference with the climate system (UNFCCC, 2007).

Table 2.5: List of Annex 1 countries to the UNFCCC

• Australia	• Estonia	• Italy	• Netherlands	• Slovenia
• Austria	• Finland	• Japan	• New Zealand	• Spain
• Belarus	• France	• Latvia	• Norway	• Sweden
• Belgium	• Germany	• Liechtenstein	• Poland	• Switzerland
• Bulgaria	• Greece	• Lithuania	• Portugal	• Turkey
• Canada	• Hungary	• Luxembourg	• Romania	• Ukraine
• Croatia	• Iceland	• Malta	• Russian Federation	• United Kingdom
• Czech Republic	• Ireland	• Monaco	• Slovakia	• United States of America
• Denmark				

Through the Kyoto Protocol, 41 countries have agreed and obliged to the commitments of reducing GHG emissions. These countries are referred to as Annex I countries as shown in Table 2.5 and constituted by the industrialised/developed countries. Contrarily, the developing countries, which do not have any legally binding targets under the Kyoto Protocol, are referred to as non-Annex I countries.

The Kyoto Protocol has three market mechanisms including Joint Implementation (JI), International Emissions Trading (IET) and CDM. CDM is the only mechanism that involves both the Annex I and non-Annex I countries to cooperatively reduce the climate change and to achieve sustainable development through technology transfer. The introduction of CDM brings mutual benefits to both the Annex I and non-Annex I countries. This is as stated in the Article 12 of Kyoto Protocol that written:

"...The purpose of the clean development mechanism shall be to assist Parties not included in Annex 1 in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex 1 in achieving compliance with their quantified emission limitation and reduction commitments under Article 3..." (UNFCCC, 2007).

In CDM, the GHG reductions will be quantified in standard units, as known as "Certified Emission Reductions (CERs) or carbon credits. Figure 2.9 illustrates schematically how the CDM works. In order to comply with the emission limitation targets, Annex I countries may purchase CERs from either the primary market (original party who makes the reduction) or the secondary market (party who resold). Trading of CERs resulting from a specific project to Annex I countries can be done once the CERs are certified. As a return for the CERs, a sum of money would be transferred to the non-Annex I countries.

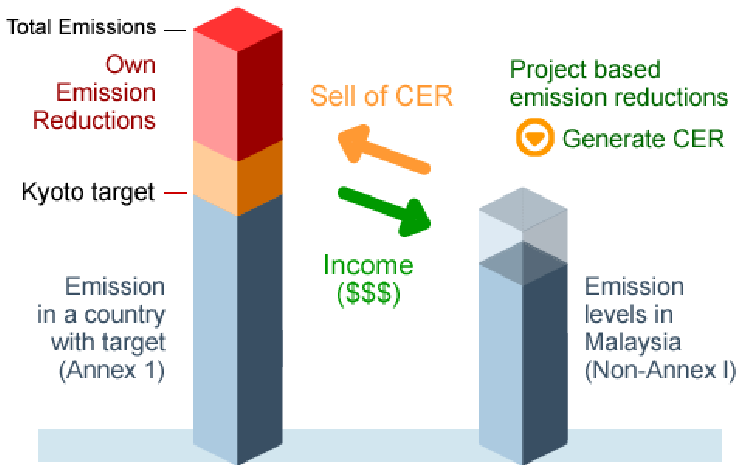


Figure 2.9: This picture shows how the CDM works

(Source: GreenTech Malaysia, 2010a)

2.7.1 INSTITUTIONAL ADMINISTRATION IN MALAYSIA

Through the enactment of GHG Mitigation Policy (2002), Malaysia established a comprehensive administration framework as shown in Figure 2.10 to assist the potential CDM projects. The Ministry of Natural Resources and Environment (NRE) has been granted responsibility by the cabinet as the Designated National Authority (DNA). DNA is the authorised body which aids in approving local CDM projects prior to the registration of projects with the United UNFCCC. In particular, the DNA is empowered to endorse, consult and monitor the registered CDM projects by communicating with the CDM Secretariat, the National Committee on CDM (NCCDM) and the project owners.

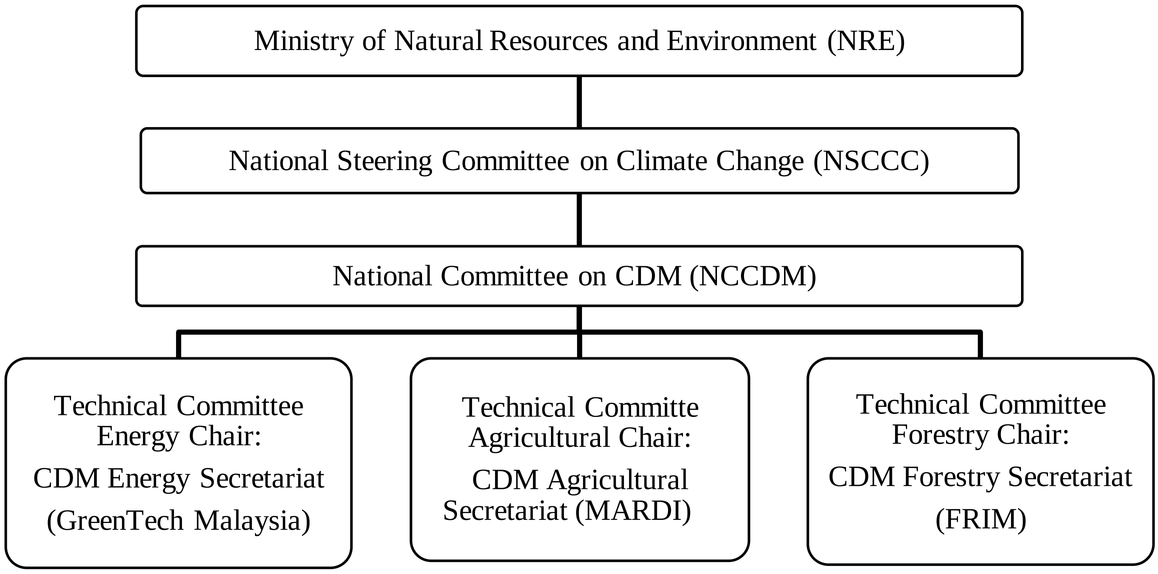


Figure 2.10: The CDM Institutional Administration in Malaysia

(Source: NRE, 2005)

The National Steering Committee on Climate Change (NSCCC) has been established since 1994 coincides with the ratification of Malaysia as a party in the UNFCCC. The NSCCC will be responsible to formulate and coordinate national policy, strategy, action plan and implementation plan related to climate change. Furthermore, they act as the national focal point for external financial and technical assistance for climate change programme and discuss Malaysia's point of views on issues regarding climate change in international platform (GreenTech Malaysia, 2010c). This committee will also directly in charge three technical committees, which are on energy, agricultural and forestry. The technical committees are chaired by the GreenTech Malaysia, Malaysian Agricultural Research and Development Institute (MARDI) and Forest Research Institute Malaysia (FRIM) respectively.

Similar to the NSCCC, the NCCDM is also formed by a group of committees. The NCCDM will review and evaluate the proposals of CDM projects as requested by the DNA, as the CDM projects are against the policy related issues of the approved national CDM criteria, the NCCDM will provide some recommendation on the approval of the projects to the DNA. The screening results of projects are from the advice of the Technical Committee on CDM (TCCDM). Besides that, the NCCDM helps the DNA in developing CDM national policies, strategies, national CDM criteria and guidelines for implementation of CDM projects. As a requirement in the CDM, the members of NCCDM should meet more than three times every year, or more often if necessary (GreenTech Malaysia, 2010b).

There are three core technical committees in the institutional administration. Technical committees of agricultural and forestry will not be discussed as the concern of this study is related to energy only. GreenTech Malaysia, formerly known as Malaysia Energy Centre (known as *Pusat Tenaga Malaysia (PTM)* in Malaysian language), possesses five main criteria for the CDM projects. Firstly, the project must lead to sustainable development to the society, in terms of social, economic and environmental. Secondly, unilateral projects are not allowed since involvement of an Annex I country must be met. Thirdly, Malaysia must obtain benefits through improved or transferred technology. Fourthly, criterion stated by the CDM Executive Board (EB) must be fulfilled, such as real, measurable and long-term benefits related to mitigation of climate change. Fifthly, the project must have the ability to be implemented, for instance, having secured financing (Pedersen, 2008; PTM, n.d).

2.7.2 PROJECT CYCLE

A standard protocol of CDM project cycle has been designed in the national level. There are generally 10 steps to go through as shown in Figure 2.11. Firstly, the project developer in private or public sector will come out with a new CDM project idea after some planning and establishment. As a follow, a Project Idea Note (PIN) will be prepared by the project developer to be submitted to the NCCDM. The PIN is a brief description that provides indicative information of the project activity. It is noteworthy that a project is unnecessarily started with a PIN. A PIN usually consists of the following items:

1. Type and size of the project;
2. Location;
3. Anticipated total amount of GHGs reduction compared to baseline scenario;
4. Suggested crediting life time;
5. Suggested CER price in $/tonne CO_2eq reduced;
6. Financial structuring and socio-economic or environmental benefits.

After receiving the PIN from the project developer, the Technical Committee assisted by the Secretariat will evaluate the project based on the national criteria. If the project is acceptable, the NCCDM will approve the project and authorise the project partners to participate in a CDM project by issuing a conditional letter of approval. This document permits the development and adoption of Project Design Document (PDD) by the CDMEB.

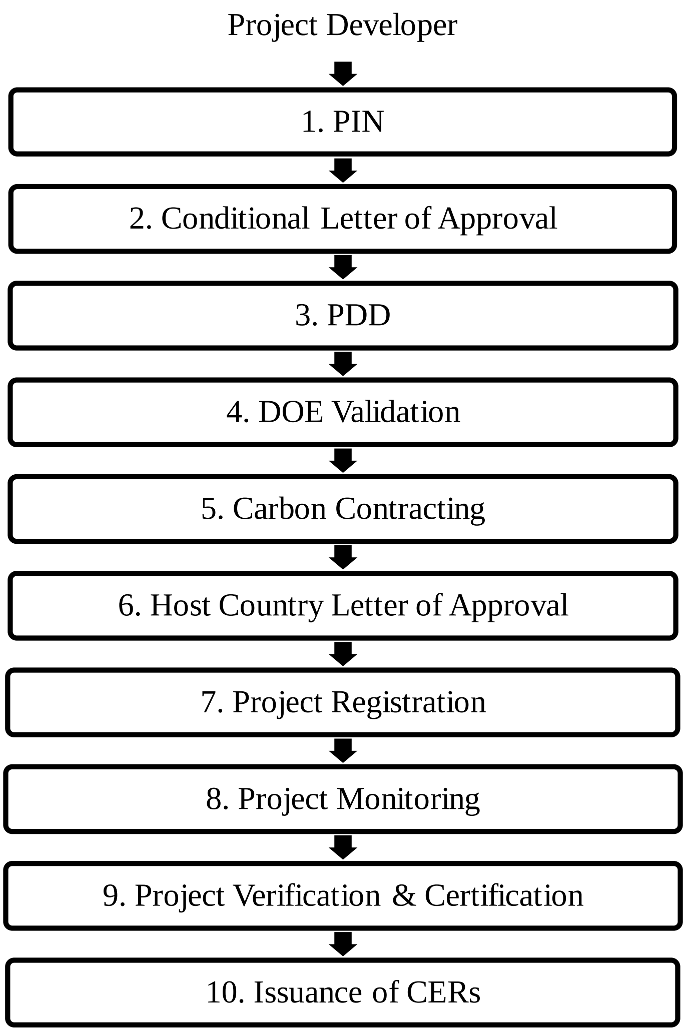


Figure 2.11: National Clean Development Mechanism Project Cycle

(Source: Malaysia Energy Centre, 2008)

A PDD is a standardised document which provides a more detailed description of the project activity. The contents of PDD basically include the general description of project activity, baseline methodology, duration of the project activity, monitoring methodology and plan, calculations of GHGs emissions by sources, environmental impacts and stakeholders' comments (Department of Environment and Natural Resources, 2003). For small scale projects, the PDD is not too demanding for documentation where the modalities and procedures for small-scale projects are largely simplified. To be qualified as small-scale projects, the CDM projects must not exceed some specified requirements as stated in paragraph 6 (c) of decision 17/CP. 7 (Baker & Mckenzie, 2012; World Bank, 2003):

- Renewable energy projects must not more than 15 MW in capacity;
- Energy efficiency improvement projects which reduce up to an equivalent of 60 GW hours on energy consumption per year either on the supply or the demand side;
- Other projects that both reduce emissions and emit less than 60 kilo-tonne of CO_2 equivalent annually;
- Afforestation or reforestation measures or action that results in GHGs removals of less than 16 kilotonnes of CO_2 per year; and
- Developed or implemented by low income communities and individuals as determined by the host party.

Subsequently, the finalised PDD will be sent to the Designated Operational Entity (DOE) for validation. A DOE is an independent auditor accredited by the CDMEB to validate whether a project proposal achieve the eligibility requirements or verify if the implemented project has achieved expected GHGs emission reduction, and recommend the amount of CERs that should be issued. Usually, either validation or verification should be done to the same project if it is in large scale. Nevertheless, the CDMEB may authorise the DOE to perform both functions.

After validation by the DOE, it reaches the stage of carbon contracting. This process involves both the project developer and the CERs buyers. They need to negotiate and compromise, to subsequently sign the Emission Reduction Purchase Agreement (ERPA). This agreement comprises:

a) The terms and conditions of credit delivery and payment between the project developer and the buyer with a standard contractual relationship;

b) Designated for the legal aspects of credit ownership; and

c) The terms of payment and delivery and risk management inherent to the transaction.

Next, the PDD must be submitted to the DNA with an addition of administration fee. After that, the DNA will send a final letter of approval to the project developer. If necessary, the project developer will be questioned on some detailed information or clarification on the project by members of the NCCDM. The letter of approval is only valid in 6 months' time.

Some of the project developers might choose to skip the process of submitting PIN. This is allowable with the replacement of Additional Information Sheet (AIS) submission. This form requires information on the efforts of the project to achieve sustainable development and technology improvement. This information is vital to be the references for the decision makers – the NCCDM.

And then, the DOE will pass the validate PDD and the approval letter to the CDMEB for official registration to declare the project as a CDM project. Although registration implies that the validated project has been formally accepted by the EB as a CDM project, the board can request to review the project before giving consent to its registration.

Certainly, the declaration as a CDM project does not means an end to the procedure of CDM qualifying. When the operation of project has been commenced, it will be monitored to identify the actual amount of emission reductions. Through measuring and recording the performance-related indicators, it can review whether the anticipated emission reductions prior to the project operation have actually been achieved. The monitoring activities will be conducted based on an approved monitoring methodology. Within the project boundary, the data collected during monitoring should give sufficient information on the emissions regarding the performance of the project activities.

Same as stage 4, the DOE will take up the responsibilities to verify the validation of the CDM project whether the CERs have resulted according to the guidelines and condition. The project developer has the right to decide the frequency of verification activities, within the acceptance of the DOE. The transaction cost will rise up if the frequency of verification increases, however, the CERs can be issued and transacted more frequently. The verified CDM project will be certified with written assurance by the DOE.

Finally, the completion of certification report will be followed by the issuance of CERs. This process will be instructed by the Executive Board (EB). 6 to 12 months required for a CDM project to be accepted and registered, subject to the completeness of the project including documents and verification process. As a follow up, the project developer will update the DNA on their project development once every six month. In addition, the Secretariat including GreenTech Malaysia, MARDI and FRIM will monitor the CDM project through site visits, depending on criticality of the project, that is, project implementation and CER issuance.

2.8 FEED-IN TARIFF

Feed-in Tariff (FiT) is a kind of incentive module that catalyses the development of renewable electricity for both small- and large-scale projects (Mabee et al., 2012; Sovacool, 2009). The renewable energy project owners would earn monetary incentives through selling of generated electricity (Cory et al., 2009; T. D. Couture, 2009) to the power utility. The power utility authority will buy the renewable electricity on different tariff rates depending on the types of renewable technology and size of project (Mabee, et al., 2012). The FiT is an agreement of electricity purchase in between the power utility authority and the renewable energy producers with a fixed premium price by every kilowatt hour (kWh) of electricity connected to the national grid over a specific duration (Cory, et al., 2009; KeTTHA, 2011).

The FiT policies can be categorised as market-dependent or market-independent from the actual electricity market price (Klein et al., 2008). Market-independent FiT policies, as known as fixed-price policies, offer a fixed or minimum price for electricity from renewable energy sources delivered to the grid. Market-dependent FiT policies, as known as premium price policies, add a premium payment above the market price (Mendonca, 2007). The most commonly used FiT policy option is the market independent, which is also used in Malaysia.

Both market-dependent and market-independent FiT policies have advantages and disadvantages. For market-independent FiT policy, inflation has not been taken into its tariff calculation methodology. It offers sufficiently high revenues in the early years, while diminishing the marginal rate impact of the payments in the later years. Since inflation is neglected, it brings to the consequences that the FiT will tend to lead to a gradual decline in the real value of renewable energy developers' revenues (T. Couture & Gagnon, 2010). As a contrast, market-dependent FiT policy offers a constant premium or bonus over and above the average retail price. However, the investors have to bear the risk payment level is lower than the market price, which brings negative consequences to market growth, investor security and for social.

2.8.1 FEED-IN TARIFF SYSTEM IN MALAYSIA

In Malaysia, *Tenaga Nasional Berhad (TNB), Sabah electricity Sdn. Bhd. (SESB)* and Northern Utility Resources Sdn. Bhd. (NUR) are the obligated Distribution Licensees (DLs) to buy electricity from Feed-in Approval Holders (FIAHs) (*KeTTHA*, 2011, 2012). FiT system in Malaysia accepts 4 types of renewable energy sources including biomass, biogas, mini-hydro and solar power as shown in Table 2.6. This is because the above mentioned renewable energies are the most used compare to other type of renewable energies. Certainly, wind energy, geothermal and marine renewable energy are yet to be fully assessed on their feasibility to enter the FiT system. These technologies might become possible once the policymakers ensure the feasibility or availability of the resources (Jacobs, 2012).

Table 2.6: Feed-in tariff by SEDA, Malaysia, 2012

Description of Qualitifying Renewable Energy Installation	FiT Rates (RM/kWh)											
	Biogas			**Biomass**			**Small Hydro**			**Solar PV**		
	2012	**2013**	**2014**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
(a) Basic FiT rates having installed capacity of:												
(i) up to and including 4 kW	0.3200 (€0.07)	0.3184 (€0.07)	0.3168 (€0.07)	0.3100 (€0.07)	0.3085 (€0.07)	0.3069 (€0.07)	0.2400 (€0.06)	0.2400 (€0.06)	0.2400 (€0.06)	1.2300 (€0.28)	1.1316 (€0.26)	1.0411 (€0.24)
(ii) above 4 kW and up to and including 24 kW										1.2000 (€0.28)	1.1040 (€0.27)	1.0157 (€0.23)
(iii) above 24 kW and up to and including 72 kW										1.1800 (€0.27)	1.0856 (€0.27)	0.9988 (€0.23)
(iv) above 72 kW and up to and including 1 MW										1.1400 (€0.26)	1.0488 (€0.24)	0.9649 (€0.22)
(v) above 1 MW and up to and including 4 MW										0.9500 (€0.22)	0.8740 (€0.20)	0.8041 (€0.18)
(vi) above 4 MW and up to and including 10 MW	0.3000 (€0.07)	0.2985 (€0.07)	0.2970 (€0.07)									
(vii) above 10 MW and up to and including 20 MW	0.2800 (€0.06)	0.2786 (€0.06)	0.2772 (€0.06)	0.2900 (€0.07)	0.2886 (€0.07)	0.2871 (€0.07)	0.2300 (€0.05)	0.2300 (€0.05)	0.2300 (€0.05)	0.8500 (€0.20)	0.7820 (€0.18)	0.7194 (€0.17)
(viii) above 20 MW and up to and including 30 MW				0.2700 (€0.06)	0.2687 (€0.06)	0.2673 (€0.06)						

Table 2.6, continued

(b) Bonus FiT rates having the following criteria (one or more):									
(i) use of gas engine technology with electrical efficiency of above 40%	+0.0200	+0.0199	+0.0198						
(ii) use of locally manufactured or assembled gas engine technology	+0.0100	+0.0100	+0.0099						
(iii) use of landfill or sewerage gas as fuel source	+0.0800	+0.0786	+0.0771						
(iv) use of gasification technology				+0.0200	+0.0199	+0.0198			
(v) use of steam-based electricity generating systems with overall efficiency of above 14%				+0.0100	+0.0100	+0.0099			
(vi) use of locally manufactured or assembled gasification technology				+0.0100	+0.0100	+0.0099			
(vii) use of municipal solic waste as fuel source				+0.1000	+0.0982	+0.0964			
(viii) use as installation in buildings or building structures							+0.2600 (+€0.06)	+0.2392 (+€0.05)	+0.2201 (+€0.05)
(ix) use as building materials							+0.2500 (+€0.06)	+0.2300 (+€0.05)	+0.2116 (+€0.05)
(x) use of locally manufactured or assembled solar PV modules							+0.0300 (+€0.01)	+0.0276 (+€0.01)	+0.0254 (+€0.01)
(xi) use of locally manufactured or assembled solar inverters modules							+0.0100	+0.0092	+0.0085

(Source: KeTTHA, 2011)

2.8.2 FEED-IN TARIFF OF MARINE RENEWABLE ENERGY

The European countries are currently taking the lead in introducing marine energy into their FiT systems. Korea is the only country in Asia that fixed the rate of marine energy in their FiT system due to their aggressiveness in developing tidal barrage projects. The comparison of FiT rates for marine energy in several countries had been displayed in the Table 2.7. It clearly demonstrates that the highest rate was set in Italy, which is €0.34/kWh. This might be due to the huge potential of Italy in harnessing marine energy and this lead to the confidence of the government to encourage more marine power project developments. Certainly, the rate setting is also depends on the country's current economy and the government's main aims and interest. Therefore, the list of rates is merely reflecting the global status of marine energy nowadays as the FiT system plays a vital role in admitting the contribution of marine energy. Furthermore, it gives an overview to the countries that are yet to set a rate for marine energy in their FiT systems since lessons from other countries are crucial for the policymakers to make decision. This is a truth that the country would not include that particular type of renewable energy into their FiT system unless the portion of renewable energy utilisation within their countries is significant or the development of that specific type of renewable energy is mature and optimistic. However, this is not an ordinary feature of a specific kind of renewable energy source being accepted into the FiT system. It depends on many inputs such as the project developers, electricity end users and policymakers.

Table 2.7: Comparison of feed-in tariff for marine energy in different countries

Country	FiT	Type of marine energy	Duration (years)
France	€0.15/kWh	Wave and tidal energy	15-20
German	Starting bonus: €0.02/kWh, total guaranteed rate: €0.15/kWh	Offshore wind energy (start from 2016)	5 -12
Ireland	€0.22/kWh	Wave and tidal energy	15
Italy	€0.34/kWh	Wave and tidal energy	15
Korea	**₩ 62.81 – 90.50/kWh[6] (€0.04 – 0.06/kWh)	Tidal energy (with or without dam)	15
Portugal	€0.23/kWh	Wave energy	15
Scotland	€0.15/kWh €0.25/kWh	3 ROCs[7] for tidal energy 5 ROCs for wave energy	-
Spain	€0.0686/kWh for first 20 years, €0.061/kWh thereafter	Wave and tidal energy	No limit but decreasing
UK[8]	€0.10/kWh	2 ROCs for wave and tidal power	-

Sources: (Leary & Esteban, 2009; O-Brien & Reid, 2009; OSEC, 2010; Portman, 2010; Rousseau, 2006)

[6] Rates by October 2012 show that ₩ 1 is €0.00070.

[7] ROC is Renewable Obligation Certificates

[8] UK has no feed-in tariff system, but a system of certificates is provided.

2.9 PUBLIC ACCEPTANCE OF MARINE RENEWABLE ENERGY

Study on public acceptance of marine renewable energy is generally rare. While writing the thesis, *Web of Science* has been used as a search engine to find for relevant journal papers. “Marine energy public acceptance” has been inserted as the keyword to search for suitable journal papers. 9 journal papers which comprise direct and indirect relationship with the studied direction can be found in the database. To-date, almost all of the surveys regarding public acceptance of tidal and wave energies were conducted in Europe countries. Positive results were obtained in most of the studies implying high acceptance level of the respondents.

Web of Science was once again used to search for renewable energy-related surveys conducted in Malaysia through the keyword of “renewable energy survey Malaysia”. 11 journal papers which comprise direct and indirect relationship with the studied direction can be found in the database (including 1 paper published by the author). In particular, the surveys analysed public acceptance on specific renewable energy technology including micro-hydropower and solar power. Table 2.8 has summarised the most relevant and recent academic literature on public acceptance of marine renewable energies and renewable energy related studies conducted in Malaysia.

Table 2.8: Literature review on the public acceptance of marine renewable energies and renewable energy related studies in Malaysia.

Study	Country	Methodology	Aim of research	Main results
Alexander et al., 2013	Scotland	Mailing survey	To investigate fishers' attitudes towards offshore energy extraction and any influential factors in terms of fishing experience and practice, association membership, location, and knowledge of offshore renewable energy installations.	• Majority of fishers held either neutral or positive attitude towards wave and tidal energy extraction. • Mainland fishers acted negatively towards the developments due to increased exposure to renewable energy developments. • The fishers' attitudes did not significantly influenced by gear type, fishing association membership and length of time fishing.
Devine-Wright, 2011	Northern Ireland	Focus group and questionnaire survey	To analyse the importance of place attachment when explaining public responses to a tidal energy project.	• Place attachment and place related symbolic meanings emerged as a significant, positive predictor of project acceptance.
Heras-Saizarbitoria, 2013	Northern Spain	Semi-structured in-depth interviews	To analyse the public acceptance of the oscillating water column (OWC) shoreline plant of Mutriku.	• People had little information about the project.
Maulud & Saidi, 2012	Malaysia	Mailing survey and structured interview	To investigate the responses of renewable energy stakeholders towards renewable energy initiatives of Malaysia.	• The government was not keen to subsidise renewable energy generations and leave it to the private sector to be the prime movers. • The monopolistic government linked utility company themselves are not keen as the capacity of renewable energy generations tends to be small (less than 10MW) and margin is small. • Feedstock owners themselves are not keen as alternative usage gives better yield.
Murni et al., 2013	Malaysia	Questionnaire survey	To analyse the post-installation public acceptance of Micro-hydropower system in the *Ba'Kelalan*, Malaysia.	• Amenity benefits are more important than economic benefits. • The community management committees operate the systems by a "do nothing until there is a problem" approach.
Gomesh et al., 2013	Malaysia	Questionnaire survey	To investigate Malaysian's perspective on renewable energy mainly in the solar energy sector.	• Malaysian welcomes renewable energy mainly in the area of solar energy. • Malaysian is ecologically concern and ready for any policies that has a solving mechanism in energy crisis.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

This chapter describes and explains the research methodology used to conduct the study. A structured methodology describing the approach and model is designed to analyse the information in an orderly manner. For the first part, data was collected through literature review and interview. The sources of literature review were books, academic journal papers, conference proceedings, reports and updated information from relevant websites. The second part adopted the Net Present Value (NPV) method to anticipate the FiTs for different marine renewable energy technologies. In order to validate the results, the calculated tariff rates were compared with the implemented tariff rates in other countries. Following this, the project costs of tidal energy (shallow) were calculated by considering the inclusions of carbon credits and FiT. For the third and last part, a survey was conducted within *SS2, Petaling Jaya, Selangor* by using questionnaires as measuring tool. The collected data was analysed by using IBM SPSS Statistics Version 20.

3.2 DATA COLLECTION

The first part of the study is to examine the feasibility of CDM in the implementation of renewable energy projects in Malaysia and the only tidal energy project. It assists in the consideration of carbon credits to reduce the project costs of tidal energy. Subsequently, the results of both the first and second parts are used to indicate the breakeven point of a tidal energy project. The data collection was completed through literature review and interview. The sources of literature review were contributed by books, academic journal papers, conference proceedings, reports and to-date information from relevant websites. The websites of GreenTech Malaysia and UNFCCC were the main contributor to the secondary data.

3.2.1 INTERVIEW

An interview with GreenTech Malaysia had been carried out in order to obtain information regarding the CDM energy-related projects registered in Malaysia. GreenTech Malaysia or Malaysian Green Technology Corporation is formerly known as *PTM*, set up by the Ministry of Energy, Green Technology and Water Malaysia (known as *Kementerian Tenaga, Teknologi Hijau dan Air (KeTTHA)* in Malaysian language) on 12 May 1998. In August 2009, the Government implemented the National Green Technology Policy as a directory to the management of a sustainable environment. In order to pursue it further, *PTM* was restructured and became **GreenTech Malaysia** on 7 April 2010. The establishment of this non-profit organisation is to catalyse green technology deployment for socio-economic growth in Malaysia and to place the country as a hub for green technology by 2020, which subsequently transform Malaysia into a Green Community by 2030 (GreenTech Malaysia, 2014). The purpose of communicating with GreenTech Malaysia is to obtain the recent data of energy-related projects in Malaysia which are ratified by CDM. GreenTech Malaysia is the appointed Secretariat of the CDM and responsible for the evaluation of the entire CDM energy project applications in the country. Communication *via* emails was conducted with the CDM Energy Secretariat to acquire for the data.

3.3 CALCULATION METHOD

Reasonable FiTs that may cover the costs of marine renewable energy were proposed by using a method of calculation. NPV was used as the calculation method in anticipating the tariffs of various forms of marine renewable energy technologies. The proposed FiT of tidal energy (shallow) was used in the following example of reduction of the project cost. The proposed FiT reflects the avoided costs of conventionally produced electricity. Renewable energy technologies with higher project costs usually possess sufficiently high tariffs to ensure the return of investment (ROI) of project investors.

3.3.1 NET PRESENT VALUE APPROACH

Cost-based tariff calculation method is commonly used by the policymakers in setting FiT. Usually, a 5-10% internal rate of return is assumed in an investment annually. Higher internal rate of return is possible, depends on the type and scale of renewable energy project. Generally, tariff calculation takes the following cost components into account (Jacobs, 2012).

i. Investment costs for each plant (including material and capital costs);
ii. Grid-related and administrative costs (including grid connection cost, costs for the licensing procedure, etc.);
iii. Operation and maintenance costs;
iv. Fuel costs (in the case of biomass and biogas);
v. Decommissioning costs (where applicable).

A simplified NPV approach was used to calculate the FiTs of four types of marine renewable energy. The basic principle of NPV approach is to recognise that the value of money spent and income generated in the future is ‘discounted’. In other words, the value of RM1 today is more than RM1 in the future. Discount rates represent either the project return or risk (Carbon Trust, 2006b). NPV approach is a standard method to verify feasibility of an investment. A project is viable if the present value of all cash inflows is greater than the present value of all cash outflows. In this case, the NPV is a positive value.

In this study, NPV is assumed zero when all cash inflows and outflows reach a breakeven point. Zero NPV indicates the minimum earning point to the investors without causing loses. Incomes could be earned through many ways and FiT is one of them. In this context, FiT is assumed to be the only profit that could benefit the project investors. The expression for NPV is formulated as given in Equation 3.1.

$$\mathrm{NPV} = \frac{\sum_{0}^{n}\left(\frac{Production \times FiT}{year} - \frac{OPEX}{year}\right)}{(1+r)t} - \ CAPEX \qquad \text{Equation 3.1}$$

Where, *Production* is the annual average energy generated from the specific technology in kW; *FiT* is the proposed FiT that will be calculated; OPEX is the operation and maintenance expenses per year; *r* is the internal rate of return in percentage; *t* is the anticipated project lifetime in year and *CAPEX* is the capital expenses.

The rated power of the device is the amount of power that can be generated when running at its full capacity. In reality, the operation of device generates less power, which gives mean power output. Capacity factor is the average energy output of device as a percentage of its rated power as shown in Equation 3.2. For instance, a capacity factor of 30% means that the generator will produce the energy equivalent to 30% of energy produced if it could run at full load. In reality, the capacity factor is not a design driver, but a consequence of the balance of output and cost. It is unlikely to conclude which device has the better overall economics from the capacity factor alone.

$$\text{Capacity Factor (\%)} \qquad \text{Equation 3.2}$$

$$= \frac{Energy\ output\ (in\ kWh)}{Energy\ available\ (in\ kWh)}$$

$$= \frac{Annual\ energy\ output\ [kWh]}{Rated\ power\ of\ device\ [kW] \times time\ in\ the\ year\ [h]}$$

$$= \frac{Mean\ power\ output\ over\ a\ period\ of\ time\ [kWh]}{Rated\ power\ output\ over\ a\ period\ of\ time\ [kWh]}$$

The anticipated FiTs of marine renewable energy were calculated by adopting the data in Table 3.1. The data is obtained from a report prepared by *Ernst & Young* to the Scottish Government. Data from foreign country was used due to two main reasons. First, marine renewable energy is a conceptual development in Malaysia which is lack of economical information. Second, growth of marine renewable energy market in Scotland is rapid in recent years. In the UK waters, the majority of the tidal and wave devices are installed in Scotland. The data was reliable to be used as a result of rigorous audits. According to Table 3.1, wave energy has the highest capital expenditures

(*CAPEX*) and operating expenditures (*OPEX*) if compared to other technologies. Contrarily, tidal range has the lowest *CAPEX* and *OPEX* with high production.

Table 3.1: Information regarding various marine energies demonstration projects obtained from a report to the Scottish Government

Technology	**Commercial project costs for 10MW project**						
	CAPEX (€/MW)	**OPEX (€/MW/year)**	**Rated Power (MW)**	**Capacity Factor (%)**	**Production (MW)**	**Project Life (years)**	**IRR (%)**
Wave	4,060,000	240,000	50	35	153,300	21	12
Tidal Range	3,220,000	40,000	700	20	1,226,400	21	10
Tidal Stream Shallow	3,820,000	180,000	100	35	306,600	21	12
Tidal Stream Deep	3,940,000	140,000	60	37	194,472	21	14

(Source: Ernst & Young, 2010)

3.3.2 VALIDATION OF THE PROPOSED FEED-IN TARIFF

A comparison between the proposed FiTs and the implemented tariffs in the classifications of technology and country was conducted to validate the results. The proposed FiT will be compared with the conventional electricity tariff and implemented

FiTs in other countries, as well as different renewable energy technology including solar energy, biomass, biogas and hydropower. The tariffs are as shown in Table 3.2.

Table 3.2: Conventional electricity and feed-in tariffs in various countries

Country	Conventional Electricity Tariff (€/kWh)	Solar Energy (€/kWh)	Biogas (€/kWh)	Biomass (€/kWh)	Hydropower (€/kWh)
France	0.14	0.0736-0.2851	0.812-0.0974	0.045	0.0607
Germany	0.25	0.1178-0.1702	0.0392-0.0847	0.0588-0.1401	0.0337-0.1257
Ireland	0.21	-	-	0.085-0.150	-
Italy	0.21	0.199-0.237	-	-	-
Korea	0.04-0.39	0.49-0.51	-	-	0.05
Malaysia	0.05-0.11	0.19-0.28	0.06-0.07	0.07	0.05
Portugal	0.19	0.2905-0.5674	-	-	-
Scotland	0.40	-	-	-	-
Spain	0.17	0.2694	0.1306	0.1306	0.078
UK	0.15	0.0873-0.19	-	-	0.0603-0.4402

(Source: PV Tech, 2014)

3.4 THE SURVEY

The third part of the study aims to gauge the level of public acceptance of marine renewable energy implementation in Malaysia. The entire updated studies of public acceptance on marine renewable energy were conducted in Europe. The study of public acceptance is part of the feasibility study as the social response may influence the scale, location and period of project implementation. A questionnaire survey was conducted in *SS2, Petaling Jaya, Selangor*. The collected data was analysed by using IBM SPSS Statistics Version 20. The Statistical Package for the Social Sciences (SPSS) is a program widely used in statistical analysis.

3.4.1 THE STUDY AREA

A study boundary was defined to specify the geographical limit in order to represent the level of acceptance of marine renewable energy in Malaysia. *SS2,* which is located in *Petaling Jaya,* was chosen as the study area. *Petaling Jaya* is a city located in the state of *Selangor,* Malaysia. It has a land area of approximately 97.2 km^2 and population of 61,367 in 2010. It was developed as a satellite township for *Kuala Lumpur*, and both cities share common geographical and population characteristics. The geographical location of *Petaling Jaya* is marked in Figure 3.1 with an equilateral triangle. *Petaling Jaya* shares a border with *Kuala Lumpur*, the capital of Malaysia. *Petaling Jaya* solved the problem of overpopulation in *Kuala Lumpur* five decades ago. Subsequently, the city has experienced dramatic economic growth and an increase in population.

Figure 3.1: The city of *Petaling Jaya* located adjacent to the capital of Malaysia, *Kuala Lumpur.* The circle indicates *Kuala Lumpur* while the equilateral triangle marks the location of *Petaling Jaya*

Petaling Jaya consists of three main sections, as shown in Figure 3.2. The sections are named systematically with letters such as *PJS*, *PJU* and *SS* labelling different regions, followed by digits. *PJS*, *PJU* and *SS* are abbreviations *for Petaling Jaya Selatan* (Southern *Petaling Jaya*), *Petaling Jaya Utara* (Northern *Petaling Jaya*) and *Sungei Way-Subang* (this area links both *Sungei Way* and *Subang*) respectively. The current study targeted inhabitants of *SS2*, which is one of the sections of *Petaling Jaya*

(GPS coordinates: 3.118491, 101.620089). *SS2* was chosen as the study area due to the following reasons. Firstly, a study location positioned along the Straits of Malacca on the west coast of Peninsular Malaysia was needed because previous studies carried out by Chong & Lam (2013) and Sakmani et al. (2013) have suggested that the Straits of Malacca has potential in harnessing marine renewable energy. Therefore, the level of acceptance among the public living in an area located along the Straits of Malacca is worth examining in a further study. *Petaling Jaya*'s location along the straits makes it a suitable study area.

Secondly, *Petaling Jaya* is a satellite city of *Kuala Lumpur* and was chosen as a study area based also on its potential as an urban representative. The energy sources utilised in *Petaling Jaya* are similar to those of most urban areas, being basically constituted from conventional power resources. This is because *TNB*, the main national utility in Peninsular Malaysia, supplies electricity to all sectors including industrial and residential. The energy is generated from a mixture of natural gas, coal, petroleum and hydro. *Petaling Jaya* is a mixed development area, categorised as high density residential and moderate commercial areas. Its residents are the second largest electricity consumers in Malaysia after industries. In 2011, the final electricity consumption in residential and industrial areas was 1,970 ktoe and 4,060 ktoe respectively (*Suruhanjaya Tenaga*, 2013). *SS2*, which consists of academic institutions, commercial centres, industrial factories and transportation systems, is foreseen to experience rising energy demand. Expansion of the energy mixture and sources has been predicted to solve the growing electricity demand as a result of increasing GDP.

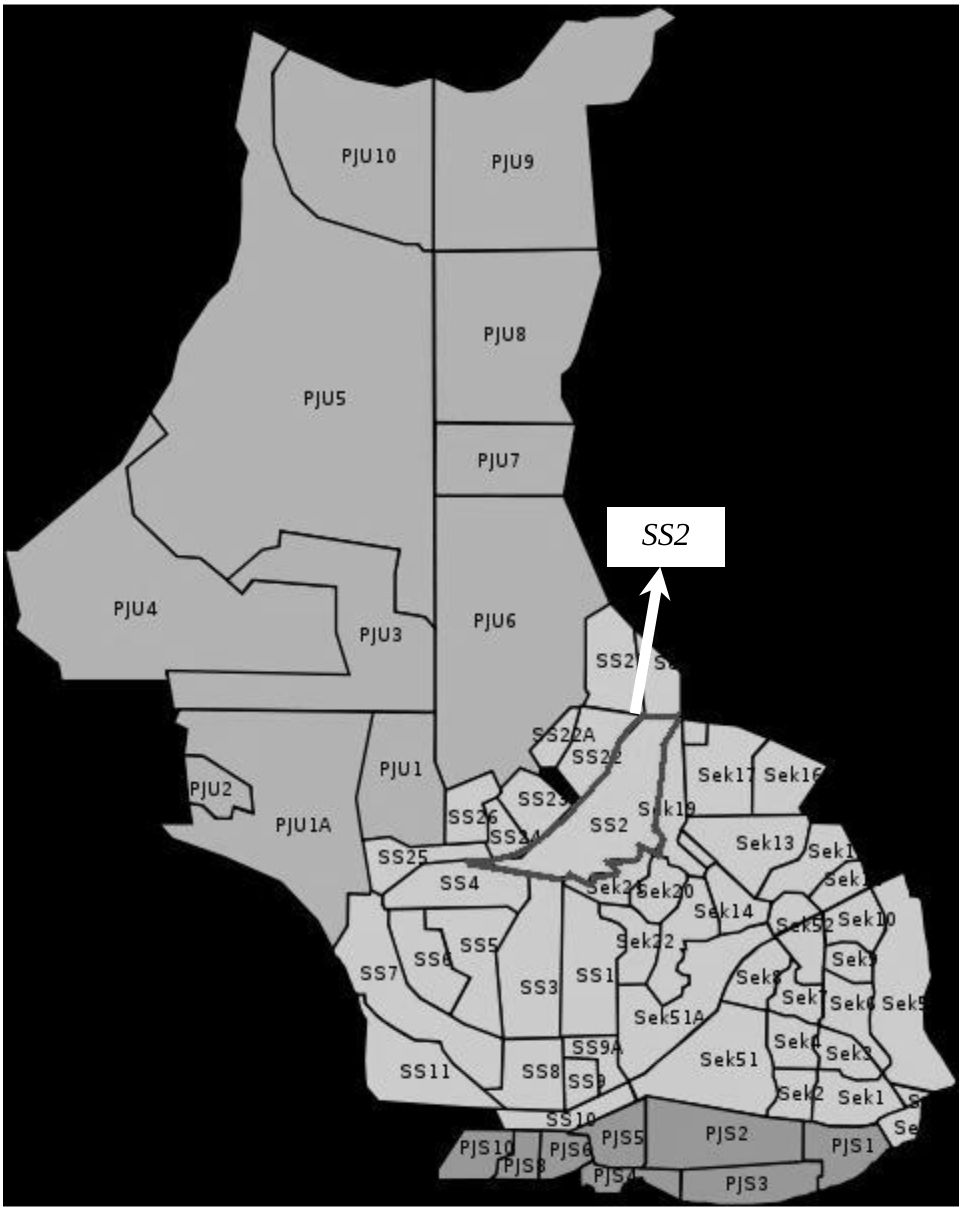


Figure 3.2: Map of *Petaling Jaya* showing the sections of *PJU, SS* and *PJS*

3.4.2 THE QUESTIONNAIRE

A total of 250 respondents were involved in the survey conducted during the period from 1 December 2012 to 15 March 2013. Random sampling was adopted in order to carry out this study. This ensures the representativeness of the samples and minimises the likelihood of bias. The entire population had an equal probability of being chosen for surveys. Questionnaires were distributed to the respondents without consideration of their level of understanding of marine renewable energy. The language used in the questionnaires was simple and understandable without many technical terms. This was because the respondents might be from different backgrounds, with different levels of exposure to this field, although respondents with a basic understanding of renewable energy were preferable.

The questionnaire was designed by taking a study on public acceptance of solar power in Malaysia as a reference. Most of the questions were modified in order to suit the current scope of study. The questionnaire comprised three parts, which begin with questions concerning socio-demographic parameters including age, gender, ethnic group, education level and monthly income. This part was designed to ensure respondents with different background or characteristics having equal rights to give their views and opinions. Next, an open-ended question and 13 close-ended questions were asked. The open-ended questions included illustrations of two marine renewable energy devices, as shown in Figure 3.3. The question was ‘What can you relate from the pictures?’ This question was expected to test the extent of understanding of the respondents towards marine energy technology.

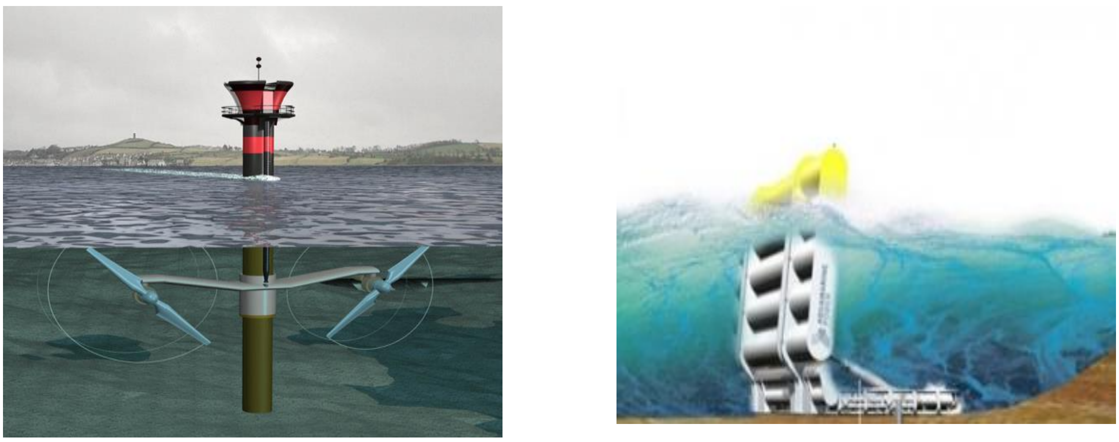


Figure 3.3: Pictures showing marine renewable energy devices were provided in the open-ended question

The close-ended questions were designed with both polar questions and Multiple-Choice Questions (MCQ). Polar questions are questions with only ‘yes’ or ‘no’ options while MCQ are questions with more than two options. While answering the MCQ, respondents were required to choose only one option so that complexity of the subsequent analysis is reduced. The polar questions are shown in Table 3.3 while the MCQ are shown in Table 3.4.

Table 3.3: Polar questions in the questionnaire

No.	Questions
1	Do you know what is renewable energy?
2	Have you heard of marine renewable energy?
3	Do you agree that marine renewable energy should be implemented in Malaysia?
4	Do you think Malaysian government should support the implementation of marine renewable energy?
5	Have you taken any steps to reduce your electricity consumption?
6	Do you think using renewable energy is a better alternative?
7	Are you currently considering the installation of any renewable energy system(s)?
8	Would your household be willing to pay an additional amount of electricity bills for the next 5 years for raising the level of consumption of green electricity?
9	Do you think the electricity generated by marine renewable energy is stable and reliable?

Table 3.4: MCQ in the questionnaire

No.	Questions		Answers
1	Which of the following types of renewable energy are you familiar with?	A.	Hydroelectric
		B.	Solar
		C.	Wind
		D.	Biomass
		E.	Marine
2	In your opinion, what are the challenges in implementing marine renewable energy in Malaysia?	A.	Political constraints
		B.	Social constraints
		C.	Economic constraints
		D.	Technical constraints
3	In your opinion, what is the main support that Malaysian government should provide in the implementation of marine renewable energy?	A.	Enhancing research & development (R&D)
		B.	Providing conducive environments for marine renewable energy business
		C.	Introducing appropriate legislative framework
		D.	Intensifying human capital development
		E.	Designing and implementing advocacy program
		F.	Others
4	In your opinion, what is the difficulty faced by the government in implementing marine renewable energy?	A.	Increase contribution of marine renewable energy in the mixture of national power generation
		B.	Facilitate the growth of marine renewable energy
		C.	Conserve environments for future generation
		D.	Enhance awareness on the role and importance of marine renewable energy
		E.	Others
5	How much are you willing to pay for using electricity generated by renewable energy? (in RM/kWh)	A.	0.10-0.50
		B.	0.51-1.00
		C.	1.01-1.50
		D.	1.51-2.00
		E.	Not sure

3.4.3 THE SAMPLES

Table 3.5: Sample size table

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	246
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	351
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	181	1200	291	6000	361
45	40	180	118	400	196	1300	297	7000	364
50	44	190	123	420	201	1400	302	8000	367
55	48	200	127	440	205	1500	306	9000	368
60	52	210	132	460	210	1600	310	10000	373
65	56	220	136	480	214	1700	313	15000	375
70	59	230	140	500	217	1800	317	20000	377
75	63	240	144	550	225	1900	320	30000	379
80	66	250	148	600	234	2000	322	40000	380
85	70	260	152	650	242	2200	327	50000	381
90	73	270	155	700	248	2400	331	75000	382
95	76	270	159	750	256	2600	335	100000	384

Note: N is number of the population while S is the sample size

Prior to the survey, identification of the sample size is important to ensure the validity of the study. According to the *Petaling Jaya* City Council (known as *Majlis Bandaraya Petaling Jaya (MBPJ)* in Malaysian language), 152 houses were recorded in this area and a typical household in *SS2* consists of 5 people. Multiplication of these two factors resulted in a population of 760. As shown in Table 3.5, the sample size was determined when the number of the population was identified. A sample size of 256 was required. The sample size table is formulated based on the formula shown in Equation 3.3 (Krejcie & Morgan, 1970).

$$S = \frac{X^2 NP(1-P)}{d^2(N-1)} + X^2 P\,(1-P) \qquad \text{Equation 3.3}$$

Where,

S = required sample size

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)

N = the population size

P = the population proportion (assumed to be 0.5 since this would provide the maximum sample size)

d = the degree of accuracy expressed as a proportion (0.5)

In fact, the real population exceeded the anticipated number of residents discussed above. It is because some households contained more than the average number of residents. According to the *MBPJ*, the actual total population in *SS2* was

15,406. The distribution of population based on ethnic group is tabulated in Table 3.6. The ratio of Malay, Chinese and India is rounded as 3:26:1.

Table 3.6: Distribution of *SS2* population based on ethnic groups

Ethics		**Population**
Native	(Malay)	1,311
	(Others)	71
Chinese		12,924
Indian		499
Others		52
Non-Malaysian		549
Total		**15,406**

Random errors are errors in measurement which lead to inconsistent measurable values when repeated measures of a constant attribute or quantity are made. Systematic errors are biases in measurement that lead to the situation where the mean of many separate measurements differs significantly from the actual value of the measured attribute (Taylor, 1982). In this context, random errors might occur due to imperfections in the questionnaires designed. Meanwhile, systematic errors might occur due to mistakes, misunderstanding, or the mood and sincerity of the respondents. Therefore, the questionnaire was validated by an invited expert in the renewable energy market prior to finalisation and the survey was conducted carefully in order to minimise both random and systematic errors. These errors were assumed to be negligible.

3.4.4 CHI-SQUARE TEST

Chi-square, $\chi 2$ test can be used to compare the observed count in each table cell to the count which would be expected under the assumption of no association between the row and column classifications. The chi-square test is used to determine relationship between nominal-nominal data or nominal-ordinal data. In other words, it is to test relationship in between two or more simple classification in categories without any order, populations, or criteria, such as boy/girl, happy/not happy and Muslim/Buddhist/Hindu. The test statistic is shown in Equation 3.4:

$$\chi 2 = \sum_{i=1}^{k} \left[\frac{(O_i - E_i)^2}{E_i} \right] \qquad \text{Equation 3.4}$$

Note: The degree of freedom are (r-1)(c-1), where r = number of rows and c = number of columns

Where,

O_i = the observed frequency in the i^{th} cell of the table

E_i = the expected frequency in the i^{th} cell of the table

The expected counts are nearly equal to the observed counts and the value of the chi-square test would be small ($p > 0.005$) if there is no association between the row and column classifications. It can be concluded that association in between the tested variables exists when the probability of obtaining differences between observed and expected counts is less than 0.005.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the results and discussion of the study. For the first part, an insight to the performance of energy-related CDM projects in Malaysia and the Sihwa Tidal Power Project showed a bright prospect for the development of marine renewable energy. Following this, FiTs for marine renewable energy were proposed based on the CAPEX and OPEX. An example of project cost reduction of tidal stream (shallow) was given as a follow. Then, the results which are obtained from the survey were analysed to complete the study of social aspect.

4.2 REDUCTION OF PROJECT COSTS THROUGH CARBON CREDITS

The number of energy-related CDM projects increased year by year since the ratification of Malaysia in the CDM in 2002. It coined the idea of considering carbon credits as a part of the revenues of marine renewable energy projects, which was believed to gain the attention from potential investors. The Sihwa Tidal Power Project has become the pioneer in the tidal energy sector to be registered in CDM. It is possible that future tidal energy projects would be registered in CDM once the projects have been proven to be capable of reducing carbon emissions. Therefore, the performance of energy-related CDM projects in Malaysia and the Sihwa Tidal Power Project in Korea were studied in order to evaluate the feasibility of project implementation within the country.

4.2.1 ENERGY-RELATED CLEAN DEVELOPMENT MECHANISM PROJECTS IN MALAYSIA

According to the annual reports of Asian Development Bank (ADB), 43% of the bank's total energy sector investments are for renewable, while the other 26% are for efficiency. Demand for energy and financing in developing Asia countries is expected to be great in the near future (Delina, 2011). This means that renewable energy is more viable to be invested. Diversification of energy sources is a need to energy market in order to fulfil enormous energy requirement. Hence, new renewable energy technologies are expected contributing to more emission reductions and carbon credits.

The CDM received a total of 4460 CDM projects in the pipelines by August 2012. Out of the total CDM projects, 69% is renewable energy projects. Both renewable energy and CDM are labelled as solution of environmental problems and climate change. Hence, they are in a good match contributing to sustainable development (Nautiyal & Varun, 2012; Wohlgemuth, 2012). Both of them lead to sustainable development and contribute positive impacts to the nations. Therefore, it is not surprising that majority of the registered CDM projects are attributed to renewable energy industries.

Table 4.1: CDM projects grouped in types (Source: Dawson & Spannagle, 2009)

Type	Number	(%)	CERs/year (000)	(%)	2012 CERs (000)	(%)	CERs Issued (000)	(%)
Wind	2,523	28	232,036	19	312,679	12	71,729	7
Hydro	2,280	26	316,853	26	416,765	16	94,482	10
Biomass energy	906	10	61,000	5	157,093	6	24,717	3
Methane avoidance	776	9	34,270	3	96,666	4	11,298	1
EE own generation	481	5	63,560	5	183,561	7	44,105	5
Landfill gas	434	5	65,831	5	190,088	7	24,688	3
Solar	333	3.8	11,464	0.9	6,366	0.2	145	0.01
EE Industry	163	1.8	7,568	1	17,165	1	2,052	0.2
Fossil fuel switch	150	1.7	69,509	6	167,428	6	33,614	3
Coal bed/mine methane	112	1.3	72,128	6	103,791	4	15,387	1.6
EE Supply side (power plants)	110	1.2	59,168	5	51,187	2	1,656	0.2
EE Households	108	1.2	4,107	0.3	5,282	0.2	135	0
N_2O	107	1.2	57,793	5	251,769	10	212,767	22
Afforestation & Reforestation	69	0.8	3,285	0.3	20,956	0.8	4,072	0
Fugitive	66	0.7	49,353	4	84,158	3	9,834	1
Cement	50	0.6	7,578	1	26,568	1	2,154	0.2
Transport	48	0.5	5,823	0.5	7,030	0.3	439	0
EE Service	37	0.4	1,720	0.14	1,022	0.04	6	0
Geothermal	35	0.4	12,210	1	13,242	1	4,206	0.4
Energy distrib.	29	0.3	10,422	1	9,910	0	316	0
HFCs	23	0.3	81,727	7	476,504	18	414,363	43
PFCs and SF6	18	0.2	5,540	0	11,785	0.5	1,758	0.2
Mixed renewable	6	0.07	412	0	140	0.01		
CO_2 usage	4	0.0	116	0	287	0.01	10	0.001
Agriculture	2	0.02	59	0	41	0		
Tidal	1	0.01	315	0	1,104	0.04		
Total	**8,871**	**100**	**1,233,845**	**100**	**2,612,586**	**100**	**973,934**	**100**
HFCs, PFCs, SF & N_2O reduction	148	1.7	145,060	12	740,058	28	628,889	65
Renewables	6,084	69	634,290	51	907,389	35	195,279	20
CH_4 reduction & Cement & Coal mine/bed	1,444	16	229,336	19	501,598	19	63,371	6.5
Supply-side EE	620	7	133,149	11	244,658	9	46,078	4.7
Fuel switch	150	1.7	69,509	5.6	167,428	6.4	33,614	3.5
Demand-side EE	308	3.5	13,394	1.1	23,469	0.9	2,193	0.2
Afforestation & Reforestation	69	0.8	3,285	0.3	20,956	0.8	4,072	0
Transport	48	0.5	5,823	0.5	7,030	0.3	439	0.05

According to Table 4.1, most of the CDM projects are related to wind, hydro and biomass energy, which recorded 2,523 projects (28%), 2,280 projects (26%) and

906 projects (10%), respectively. There are 108 projects (2.42%) in Malaysia among the CDM projects. The GreenTech Malaysia predicts that the yearly potential in Malaysia reaches 18 million CERs in 2010. This was equal to approximately 100 million tCO_2e from 2006 to 2012. Besides, the GreenTech Malaysia assumes that the price range is approximately USD 3 to 10 per tCO_2e. This is equivalent to a capital flow of USD 0.3 to 1 billion to Malaysia by earning the carbon credits (Pedersen, 2008).

Table 4.2: Number of registered CDM projects in energy sectors in Malaysia

Year of registration	**Number of energy projects**		**Emission Reductions (tCO_2e)**
	Renewable Energy	Energy Efficiency	
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**

Since 2002, project developers in Malaysia started to apply for CDM projects. The number of CDM projects increases from 3 in 2002 to 40 in 2007. It accounts 9.2 million tCO_2e in 2007 (Nadia, 2008; Yahaya, 2005). Until February 2008, there are 48 PIN and 61 PDD received by the *PTM*. The number of the registered CDM energy projects, i.e. renewable energy and energy efficiency, has been presented in Table 4.2. Particularly, renewable energy and energy efficiency projects account 95 and 7 projects respectively from 2006 to 2012. It brings more than 7 million tCO_2e emission reductions which largely contributed by 1,743,966 tCO_2e in 2009 and 1,790,108 tCO_2e in 2012.

4.2.2 TIDAL ENERGY PROJECT IN CLEAN DEVELOPMENT MECHANISM

Tidal energy is another potential renewable energy which is worthwhile to be discussed (Bahaj, 2013; Draper et al., 2013; Ng et al., 2013). It is a potential energy source to Malaysia as the country possesses high coast per area ratio, which is 14. The ratio is derived from the 4,675 km coastline and 328,550 km^2 land area (Central Intelligence Agency, 2012). The Straits of Malacca is a potential coastline to harvest tidal energy due to its constant minimum flow of 0.5 m/s and maximum flow of 4 m/s (American University of Washington DC, 2008). Tidal energy is more predictable than solar and wind energies because it generates energy through the interaction among the moon, the sun and the earth, which results in the formation of tides (Eccleston et al., 2011). The implementation of tidal energy needs more supports from the government due to its promising in energy source (Hassan et al., 2012).

There is one tidal energy project being registered in CDM since 18 June 2006. The Sihwa Tidal Power Plant Project is located in Jaggungarisum Island in Ansan-city, Gyeonggi Province, Korea (see Figure 4.1). The host parties are the Korea Water Resources Corporation (K-water) and Switzerland (involved indirectly). The power plant is foreseen to reduce GHG emission, to increase sustainable development, and to improve the water quality due to increased sea/inner water circulation. The power plant possesses installed capacity of 254 MW (25.4 MW per turbine, 10 units), which is expected to generate 552.7 GWh/year and transmit 507.629 GWh of electricity to the grid annually. The electricity will be transmitted to the Korea Electric Power Corporation South Sihwa substation which is located 10.5 km away from the plant.

Figure 4.1: The Sihwa Tidal Power Plant Project is located in the Republic of Korea, 37º2'N longitude and 126º4'W latitude (Source: CDM, 2014)

The Sihwa Tidal Power Plant Project is the largest tidal power plant in the world which needs a total project cost of approximately RM 814 million for the total installed capacity (approximately RM 3.25 million/MW). There is only one tidal energy project being registered in CDM. Majority of the marine energy projects are located in Europe, particularly in UK, which are listed in Annex I and ineligible to be registered in CDM.

4.2.3 CARBON REDUCTION FROM MARINE RENEWABLE ENERGY PROJECTS

Table 4.3: Annual estimated and actual emission reductions (Source: CDM, 2014)

Years	Annual estimation of emission reduction (in tonnes of CO_2e)	Actual monitoring period	Estimated emission reduction (in tonnes of CO_2e)	Actual emission reduction (in tonnes of CO_2e)
Year 1 (2011)	315,440	1 July 2011 – 31 March 2012	236,580	106,883.8
Year 2 (2012)	315,440	1 April 2012 – 31 October 2012	184,006	188,065
Year 3 (2013)	315,440	1 November 2012 – 31 March 2013	131,433	135,052
Year 4 (2014)	315,440	1 April 2013 – 30 September 2013	157,720	161,870.1
Year 5 (2015)	315,440			
Year 6 (2016)	315,440			
Year 7 (2017)	315,440			
Total estimated reductions (in tonnes of CO_2e)	**2,208,080**	**Total reductions (in tonnes of CO_2e)**	**709,739**	**591,870.9**
Total number of crediting years: 7				

According to the PDD, the Sihwa Tidal Power Plant Project is capable to reduce emissions of 315,440 tCO_2e, 589 tSO_x, 446 tNO_x and 31 tonnes of dust annually. The total amount of CO_2 emission reduction during the crediting period from 1 July 2011 to 30 June 2018 is 2,208,080 tonnes as presented in Table 4.3. As the installed capacity of turbines in the project is 254 MW, the estimated annual emission reduction is approximately 0.14 tCO_2e/MWh. The finding is near to the scenario in UK, which is expected to reduce carbon emission by approximately 0.15 tCO_2e/MWh. A total of 42 million tonnes/year of carbon dioxide emission could be reduced from the energy system of UK once the economically recoverable marine energy resource is fully exploited and displaced conventional fossil fuel generation (RenewableUK, 2013). Two scenarios are presented in Table 4.4 for deployment up to 2020, along with the resulting carbon dioxide displaced, given an assumed capacity factor of 35%.

Table 4.4: CO_2 displaced by wave and tidal sector in 2017 and 2020 under two deployment scenarios

Scenario	Year	Cumulative Capacity Deployed (MW)	CO_2 Displaced (tonnes/year)
Expected Deployment	2017	59	78,000
	2020	130	171,400
Viable Projects	2017	120	158,200
	2020	340	448,300

(Source: RenewableUK, 2013)

4.3 REDUCTION OF PROJECT COSTS THROUGH FEED-IN TARIFF

Besides carbon credits, it is believed that the introduction of FiT as a part of the revenues of marine renewable energy projects may gain the interest of potential investors. FiT is widely used in the world and proven to be the most effective mechanism to promote renewable energy. However, the current FiT system in Malaysia is yet to include marine renewable energy. Therefore, FiTs of marine renewable energy will be proposed in the following sections.

4.3.1 PROPOSED FEED-IN TARIFF FOR MARINE RENEWABLE ENERGY

The establishment of FiT must address the overall project costs. It is crucial to propose reasonable FiTs of marine renewable energy in order to increase the interest of project developers and to assist in the challenge of project finance. The costs of generator may be the most significant part of the project costs. The project development, permitting, preparation, installation, monitoring, operations, maintenance, insurance and financing are possibly higher than the subsequent mature sector projects. Hence, the FiT plays a vital role in supporting these pre-commercial extraordinary costs and moves a marine energy development project nearer to an equal with mature alternatives (The Ocean Renewable Energy Group, 2011). The Malaysian government planned to raise the energy consumption of renewable energy from less than one percent today to 5.5 percent in 2015 and 11 percent in 2020. So, FiT is a reliable system which ensures the long-run of renewable energy generations since it provides project developers a reasonable return on investment.

Marine renewable energy is considered as a new technology in Malaysia and it is still in its infancy of R&D. Positive results have been obtained in several researches which were carried out by the local universities. However, the potential of marine renewable energy utilisation in the country is yet to be analysed by the policymakers. Inspiring results from the experiences of marine renewable energy harnessing in countries such as UK, France, Italy, German and Korea could be the role model for Malaysia. It is possible that FiT for marine energy will be introduced in the near future in order to encourage the installation of marine energy harnessing devices and to subsidy the development.

The rate of marine renewable energy FiT will be suggested and discussed in this part based on several aspects. It should be higher than that in other conventional types of renewable energy in the existing FiT system including biogas, biomass, mini hydro and solar PV due to several justifications. Firstly, the cost of marine renewable energy is relatively high compared to the other types of renewable energy. The cost components are investment costs, grid-related and administrative costs, operational and maintenance costs and decommissioning costs. Fuel costs are not taken into account since the technologies of marine renewable energy do not consume any fuel throughout the energy generation and harnessing processes.

A study conducted by Li et al., 2011 used an integrated model to estimate the energy cost of a tidal current turbine farm near Vancouver, BC, Canada. TE-UBC is used as a cost effective numerical model due to its acceptable accuracy. The lifetime of the turbines is generally 5 to 20 years (Buckley, 2005). The designers of tidal current turbines in UK and Canada predicted a 30-year lifetime for the designs. Nevertheless, the real operational lifetime of tidal current turbines is uncertain until more reports on full-scale devices operation and pre-commercial testing are gained (Gulli, 2005). The results of the study showed that energy cost decreases significantly as the farm lifetime increases. However, the Operational and Maintenance (O&M) cost is influenced by the lifetime of the device owing to the need of attention for older equipment. Besides, the farm size attributes to energy cost too. Larger farm causes lower energy cost as a result of the difference in O&M cost for farms of different sizes, instead of difference in capital cost. According to the study, tidal energy farms vary from USD0.30-0.45/kWh (RM0.97-1.45/kWh) of energy cost, depending on the size of the farm and the extent of hydrodynamic interactions (Li et al., 2011). Furthermore, a calculation by the British government shows that the Severn Barrage project cost is approximately £317 (RM1,392.50) per MWh. Therefore, the marine energy is still considered as expensive at this stage. As a comparison, the offshore wind power only costs around £85 (RM373.40) per MWh, which is about 4 times less than the costs of marine energy (Zander, 2010).

The duration of renewable electricity that can be sold to the distribution licensees is based on the characteristics of the renewable resources and technologies. For instance, in the Malaysia's FiT system, both biogas and biomass have 16 years while both mini hydro and solar PV have 21 years of effective period for the developers to sell their electricity. 15-20 years is the most common and acceptable contract duration in in other countries. Therefore, an estimation of 20 years of contract duration could be set for the marine renewable energy, which is still within the contract timelength of other forms of renewable energy. This length of timeframe would be sufficient to support the entire life cycle of marine power station.

The energy cost of solar power is approximately USD0.11-0.18/kWh (RM0.34-0.55/kWh) (IRENA, 2012). On the other hand, the average cost of hydroelectricity with 10 MW of generation capacity is USD0.03-0.05/kWh (RM0.09-0.15/kWh) (World Watch Institute, 2012). Both of the technologies have the FiTs ranging from USD0.23-0.40/kWh (RM0.7194-RM1.23/kWh) and USD0.07-0.08/kWh (RM0.23-0.24/kWh), respectively. In other words, the technologies will be credited an extra USD0.15-

0.22/kWh (RM0.45-0.68/kWh) and USD0.03-0.05/kWh (RM0.09-0.14/kWh), respectively. The subsidies vary due to the difference in popularity and extensiveness of that specific technology being used. Hence, the marine renewable energy which has energy cost ranging from USD0.38-0.55/kWh (RM1.17-1.70/kWh) is believed to achieve a FiT rates ranging from USD0.49-0.65 (RM1.50-2.00). The suggested FiT for marine renewable energy is higher than that for solar energy and hydroelectricity by taking the maturity and popularity into account. The policymakers should give more supports to new technology so that the developers may find interest in investment and development.

As shown in Table 4.5, the FiTs of marine renewable energy have been calculated based on the Net Present Value. The proposed FiT of wave energy is RM2.61 in the first year of installation. The degression rate is unpredictable yet because it mainly depends on the policymakers by considering the factors of inflation and technology downgrading. Therefore, the proposed FiT is only applicable to the first year of implementation. Meanwhile, the potentially implementable tidal stream is believed to have the proposed FiT of RM1.228 per kWh. It is near to the implemented FiT of solar PV which is 1.23/kWh.

Table 4.5: Proposed feed-in tariff of different marine renewable energy technologies based on the Net Present Value Approach

Technology	**Proposed FiT (RM/kWh)**
Wave	2.61
Tidal Range	0.254
Tidal Stream (Shallow)	1.228
Tidal Stream (Deep)	2.032

4.3.2 VALIDATION OF RESULTS

The results require validation as the proposed FiTs of marine renewable energy technologies as presented in the previous section are merely estimation based on the Net Present Value Approach. The proposed FiTs of tidal energy in Malaysia had been compared to that of other countries as shown in Table 4.6. Tidal stream (shallow) is the most viable technologies among all marine renewable energy technologies due to its energy performance consistency and reasonable project costs. It follows that this technology was chosen for the comparison. All of the FiT of various technologies was converted into €/kWh prior to the comparison. At the time of study, 1 EURO is equal to RM4.38.

Table 4.6: Comparison of ratio of feed-in tariff rates of marine renewable energy to electricity tariffs and feed-in tariff of other renewable energy technologies in different countries

Country	[9]Ratio of Marine Renewable Energy FiT to				
	Electricity Tariff	Solar FiT	Biogas FiT	Biomass FiT	Hydro FiT
France	1.07	2.03	1.54	3.33	2.47
German	0.60	0.88	3.82	1.77	1.19
Ireland	1.05	-	-	1.47	-
Italy	1.62	1.43	-	-	-
Korea	0.15	0.12	-	-	1.2
Malaysia[10]	2.55	1	4.67	4	5.6
Portugal	1.21	0.79	-	-	-
Scotland	0.63	-	-	-	-
Spain	0.41	0.26	0.53	0.53	0.88
UK	0.67	0.53	-	-	1.66

Ratio of the proposed FiT of tidal energy to the electricity tariff in Malaysia is 2.55, which is considered as high among the countries. This is due to the fact that the electricity tariff of Malaysia is the lowest when compared to the other countries, which ranges from €0.05/kWh to €0.11/kWh. As a comparison, the electricity tariffs of France, Germany and UK are €0.14/kWh, €0.25/kWh and €0.15/kWh, respectively. In Malaysia, the FiT of solar energy is similar to the proposed FiT of tidal energy while the FiT of biogas, biomass and hydro are four times less than them.

[9] When the ratio is more than 1, it means that the FiT of marine renewable energy is higher than that of the compared tariffs. Contrarily, when the ratio is less than 1, it means that the FiT of marine renewable energy is less than that of the compares tariffs. Ratio of 1 means that the two compared tariffs is the same.

[10] The proposed FiT of marine renewable energy in Malaysia is calculated from the Net Present Value Approach. FiT of tidal energy is used to compare with other tariffs.

Among all countries, France has the most generous marine renewable energy FiT system when compared to the other technologies. This is resulted from their relatively high marine energy targets among the European countries, for instance, 256 MW for 2012, 302 MW for 2015 and 380 MW for 2020 (Leeney et al., 2013). Italy has the highest ratio of marine renewable energy FiT to electricity price (1.62) among the countries resulted from the high confidence of the Italian government towards their ocean which is believed to become a promising energy resource. France, Ireland and Portugal also have ratio of marine renewable energy FiT rates to electricity price more than 1. As a comparison, Germany, Korea, Spain, Scotland and UK have ratio of marine renewable energy FiT rates to electricity less than 1.

Note that the above-mentioned countries have higher renewable energy shares in their energy markets if compared to Malaysia. For instance, renewable energy in Italy accounts 16.8 Mtoe (10%) out of total primary energy consumption of 172 Mtoe (BP Statistical Review, 2011). Increase in consumption of renewable energy could bring down tariff rates as it fulfils the theory of supply and demand in economical perception. Moreover, the proposed FiT rates of marine renewable energy in Malaysia were calculated based on the data in Scotland. The CAPEX and OPEX are expected to be brought down as fabrication and installation of the marine renewable energy devices can be conducted by local expertises.

4.4 BREAKEVEN POINT OF THE PROJECT COSTS

Project costs of the tidal stream (shallow) can be reduced through the involvement of carbon credits and the proposed FiT of marine renewable energy. The tidal stream (shallow) was chosen as an example. The cash flows including inflow and outflow of the project costs has been shown in Table 4.7. Assumptions of the scenarios are as shown below:

- Project lifetime :21 years
- Rated power:100 MW
- Emission reduction: 315,440 tCO_2e/year
- CERs: RM15/tCO_2e

Table 4.7: Assumption of the cash flows of the tidal stream shallow project

	Cash Flows	Amount
-	CAPEX (RM/MW)	17,000,000
-	OPEX (RM/MW/year)	800,000
+	Carbon Credits from CDM (RM/year)	4,700,000
+	Feed-in Tariff (RM/MW)	1,228

Throughout the 21 years of operating period, the project is expected to reach the breakeven point by 3 years and 2 months. The accumulated inflows of the project are possible to be three times more than the accumulated outflows of the project. In other words, the project could bring revenues in the fourth year of project operation and the investors might need to allocate some money into the project in the first 3 years without earning. Figure 4.2 has illustrated the line graph of accumulated cash flows of tidal stream shallow project in 21 years of lifetime.

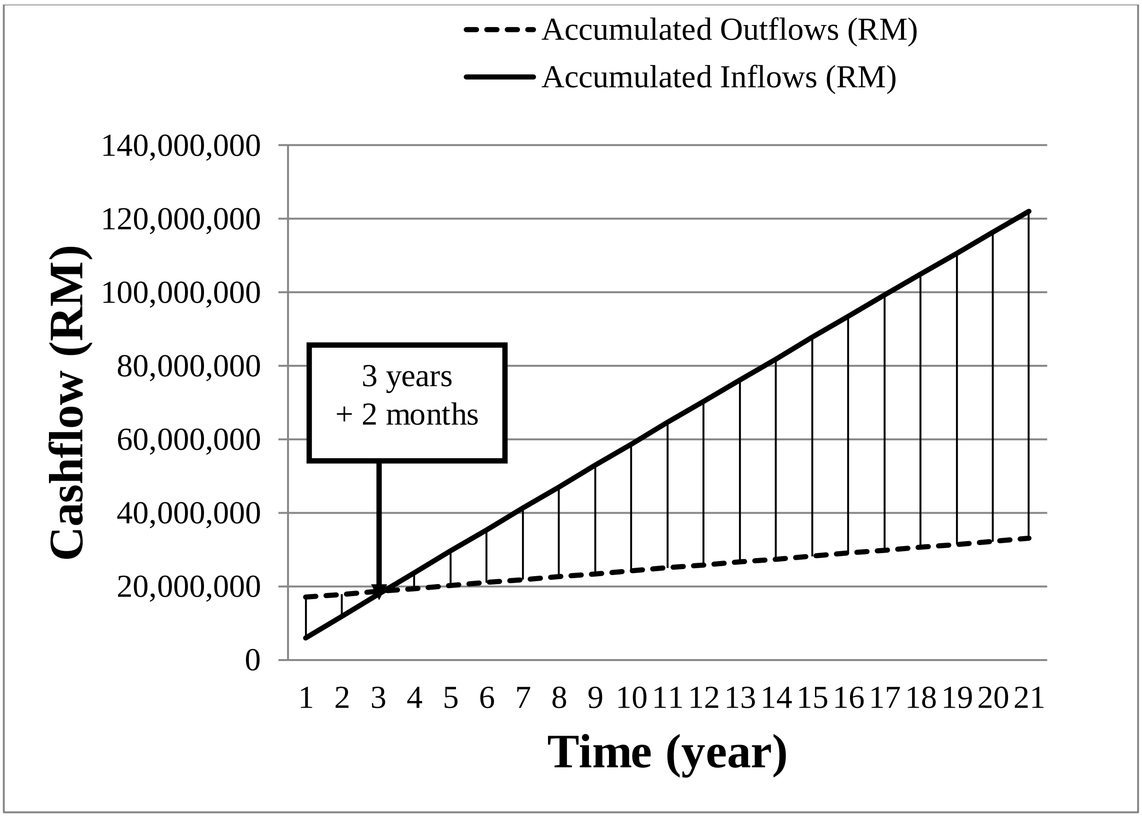


Figure 4.2: Graph of accumulated cash flows (in Ringgit Malaysia) of tidal stream shallow project

4.5 THE SURVEY

The following sections discuss the findings of questionnaire survey as a result of data analysis by using IBM SPSS Version 20.

4.5.1 SOCIO-DEMOGRAPHIC VARIABLES

As shown in Table 4.8, the sample of 250 respondents was largely formed by respondents of 24 years old and below, female, Chinese, single, undergraduate and monthly income of RM1001-3000.

Table 4.8: Characteristics of the respondents

Demographic variables	Groups	Frequency	Groups with highest frequency	Mean	Median	Standard deviation
Age (years old)	24 and below	100	24 and below	2.09	2	1.217
	25-34	84				
	35-44	26				
	45-54	23				
	55 and above	17				
Gender	Male	110	Female	1.56	2	0.497
	Female	140				
Races	Malay	90	Chinese	1.75	2	0.654
	Chinese	134				
	India	24				
	Other	2				
Marital status	Single	141	Single	1.29	1	0.456
	Married	64				
Education level	Primary	4	Undergraduate	3.79	4	0.854
	Secondary	23				
	High school	30				
	Undergraduate	158				
	Postgraduate	35				
Monthly income (RM)	1000 and below	80	1001-3000	2.11	2	0.979
	1001-3000	89				
	3001-5000	54				
	5001 and above	27				

It can be seen that 40.0% of the entire respondents aged below 25 years old while 33.6% of them aged 25-35 years old. Next, respondents in the 35-45 and 45-55 age groups made up 10.4% and 9.2% respectively out of the total respondents. The age group with the least involvement in the survey was 55 years old and above (6.8%). This is because *SS2* is a common residential area for several campuses nearby. For instance, the University of Malaya and private institutes such as *MAHSA*, *UTAR* and *KDU* are located within 5 kilometres from the boundary of *SS2*. This may also explain the fact that more than half (63.2%) of the respondents were undergraduates.

In the sample, the percentages of females and males were 56.0% and 44.0%. A majority of the respondents were Chinese, constituting 53.6% out of the total. It was followed by Malay (36.0%), Indian (9.6%) and other (0.8%) ethnic groups. In terms of monthly incomes, the number of respondents with RM1001-3000 monthly income was the highest, recording 35.6%. It was followed by the respondents with monthly incomes of RM0-1000 (32.0%), RM3001-5000 (21.6%) and RM5001 and above (10.8%). In addition, 56.4% of the respondents were single while another 43.6% were married.

4.5.2 OPEN-ENDED QUESTION

The respondents were required to guess the functions of the turbines as shown in Figure 3.3. This is to test the awareness and understanding of the respondents towards marine renewable energy. It shows that 49.2% of the respondents were answered correctly while the remaining 50.8% answered wrongly or did not answer. It can therefore be said that almost half of the total respondents could relate the turbines with marine renewable energy. This result was as expected because marine renewable energy is considered as a new technology in Malaysia. The examples of answers of the respondents have been shown in Table 4.9.

Table 4.9: Examples of answers of the respondents when answering the question 'What can you relate from the pictures?' as shown in Figure 3.3

Examples of correct answers	Examples of wrong answers
• Energy generation	• Research equipment
• Clean energy	• Tsunami
• Hydroelectricity generator	• Exploit petroleum
• Supply energy	• Construction
• Power plant	• Submarine for petrol oil
• Energy electricity generator	• Don't know
• Renewable energy	• Underground water factory
• Create free energy from nature	• Ship
• Electricity power generator	
• Energy	

4.5.3 CLOSE-ENDED QUESTIONS

This section consists of the results of analysis from all close-ended questions, which are polar questions and MCQ. The analysis can be categorised as descriptive analysis.

4.5.3.1 POLAR QUESTIONS

Table 4.10: Results of polar questions

No.	Questions	Percentage	
		YES	NO
1	Do you know what renewable energy is?	87.2%	12.8%
2	Have you heard of marine renewable energy?	38.8%	61.2%
3	Do you agree that marine renewable energy should be implemented in Malaysia?	82.8%	17.2%
4	Do you think the Malaysian government should support the implementation of marine renewable energy?	80.4%	19.6%
5	Have you taken any steps to reduce your electricity consumption?	46.4%	53.6%
6	Do you think using renewable energy is a better alternative?	96.0%	4.0%
7	Are you currently considering the installation of any renewable energy system(s)?	29.6%	70.4%
8	Would your household be willing to pay an additional amount of electricity bills for the next 5 years for raising the level of consumption of green electricity?	43.2%	56.8%
9	Do you think the electricity generated by marine renewable energy is stable and reliable?	68.0%	32.0%

According to Table 4.10, a majority (87.2%) of the respondents claimed that they know what renewable energy is. This finding is important because basic understanding of renewable energy may lead to the tendency of accepting the implementation of marine renewable energy. Approximately 61.2% of the respondents had never heard of marine renewable energy. This indicates that they have not realised the existence of marine technologies such as tidal barrages, tidal turbines, wave energy, OTEC and salinity gradients in Malaysia. These results were as expected since the development of marine renewable energy is still at an early stage of development. Hence, it is reasonable that the majority of the respondents were unaware of the existence of this new technology.

It shows that 82.8% of the respondents agreed that marine renewable energy should be implemented in Malaysia. Coupled with the results which show that 96.0% of the respondents think that using renewable energy is a better alternative, it can be said that the respondents welcome the introduction of marine energy in Malaysia. This might be because majority of the respondents tend to welcome environmentally friendly technology which promotes sustainable development. Even if they might not be familiar with marine renewable energy, the concept of renewable energy does give people the impression of clean, green and low negative environmental impacts. Therefore, the respondents were prone to accept marine renewable energy as an alternative energy source. Furthermore, the high acceptance level among respondents towards marine renewable energy implementation in Malaysia might be attributed to governmental efforts to promote the renewable energy market. The five-fuel policy was introduced in 2000, putting renewable energy as the fifth energy to be utilised in the energy system besides oil, gas, coal and hydropower. The share of renewable energy in the total energy mix is expected to hit 5.5% by 2015 and 11% by 2020. As a result, the respondents were generally supportive towards implementation of new technology.

Note that 80.4% of the respondents think that the Malaysian government should support the implementation of marine renewable energy. This high percentage of agreement is probably due to the fact that most of the big decisions such as policy are usually depending on the government in the public's perspective. Malaysia is a federal representative democratic country, in which the executive and legislative powers are practiced by the federal government and the 13 state governments. The Malaysian government would make decisions which reflect local needs and priorities. Therefore, it explains why majority of the respondents think that the involvement of government into the implementation of marine energy is of utmost importance.

Despite of the high acceptance of public towards marine renewable energy as discussed earlier, the respondents do not seem like taking initiative in using renewable energy. More than half of the total respondents (53.6%) have not taken any steps to reduce electricity consumption. Besides, 70.4% of the respondents are not considering the installation of any renewable energy system(s) in current stage. In addition, 56.8% of the respondents are reluctant to pay green electricity.

It compromises with the other researches which explain this scenario with the justification of NIMBY (Not in My Backyard). It means that the people are supporting the green agenda without actually participating, or supporting green development without wanting to pay for it. NIMBY is a way of thinking regarding public acceptance which suggests that those opposing developments are motivated by concern 'for their backyard'. They would prefer developments to be sited elsewhere, despite being supportive of them in principle (Devine-Wright, 2007). The idea that the NIMBY attitude leads to a low willingness to pay for green electricity was supported by Burningham, 2000. People who take a NIMBY line often appear to be self-interested, uninformed and unrepresentative of the community (Barnett et al., 2012). They might be supportive of the implementation of a new technology which is advantageous to the environment, yet they are reluctant to support it physically or financially. They choose energy without considering the impact on the environment and based only on the cheaper price. This may be because Malaysia currently relies on an electricity supply which is mainly sourced from conventional power plants. Most Malaysians do not bother about the types of energy sources as long as the electricity supply is stable and sufficient to support their daily lives. Subsequently, Malaysians generally do not question or request information on energy sources, but take it for granted.

4.5.3.2 INFLUENCE OF SOCIO-DEMOGRAPHIC DEMOGRAPHIC VARIABLES TO THE RESULTS

The acceptance level of marine renewable energy implementation varied in different age groups. Surprisingly, the acceptance level decreased with the increasing age of the respondents, as shown in Figure 4.3. The highest acceptance level was from the respondents aged below 25 years, followed by the 25-34 years old group. These age groups recorded 32.8% and 28% of the total respondents respectively. Approximately 8%, 7.2% and 6.8% of respondents aged 35-44, 45-54 and 55 and above respectively accepted the implementation of marine renewable energy.

This result disagreed with the previous studies which showed that younger people are more likely to oppose renewable energy projects than older people (Devine-Wright, 2005; Vorkinn & Riese, 2001). This may be attributed to two reasons. First, the younger respondents are more open-minded and friendly towards new technology implementations. This is due to their higher exposure compared to the older people towards new technology through education and internet. This might lead to their sensitivity towards the issues of renewable energy. Second, majority of the working adults are above 25 years old. They are more likely to be the one who pay the electricity bill and are aware of the money issue. Meanwhile, renewable energy technology is more costly than non-renewable energy technology. They would rather choose the one with the lower price.

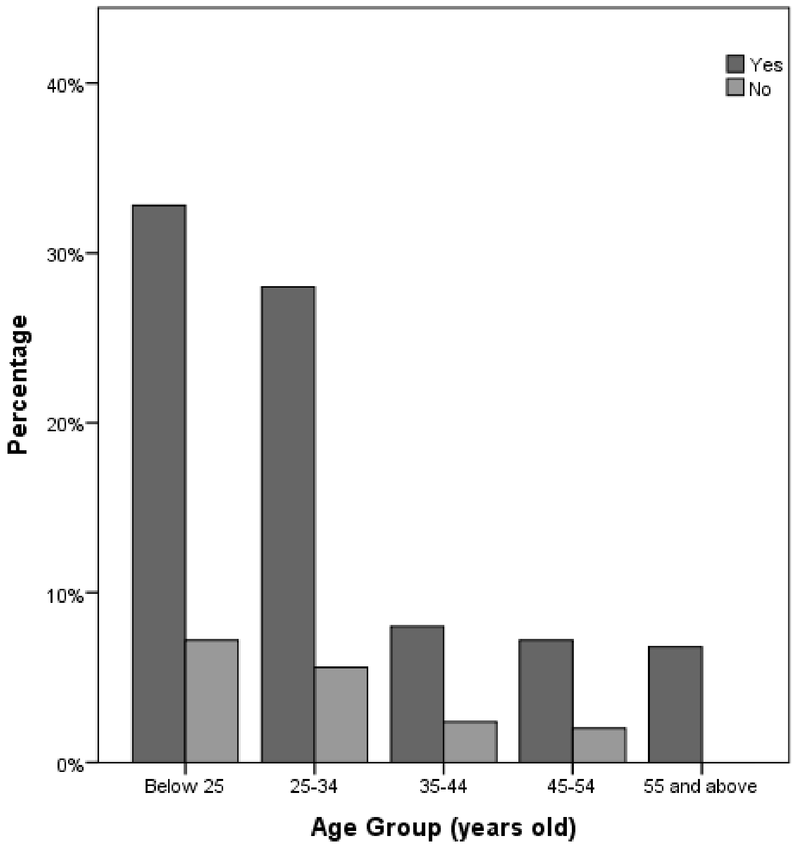


Figure 4.3: Public acceptance of marine renewable energy implementation among different age groups[11]

11 Note: 'Yes' indicates that the respondents accepted marine renewable energy implementation in Malaysia; 'No' indicates that the respondents rejected renewable energy implementation in Malaysia.

Next, the monthly income of the respondents might be an influential factor to the level of public acceptance of marine renewable energy implementation. Figure 4.4 clearly shows that most of the votes of acceptance came from respondents with a monthly income of RM1001-3000, which recorded 30.8% of the total respondents. This was followed by respondents earning below RM1000 (25.6%), RM3001-5000 (17.6%) and RM5001 and above (8.8%). No significant correlation between monthly income and acceptance of the implementation of marine renewable energy can be identified. This result is similar to the findings of Bergmann et al., 2006. Contrarily, the acceptance level of marine renewable energy implementation decreased among respondents with higher monthly incomes. This result agreed with the findings from a case study on a tidal project in Ireland, which proved that people with higher incomes were more likely to oppose renewable energy projects (Devine-Wright, 2011). The reason is similar to the justification in the last paragraph. This might be due to the fact that most of the higher income people are the one who pay the electricity bill and are aware of the money issue.

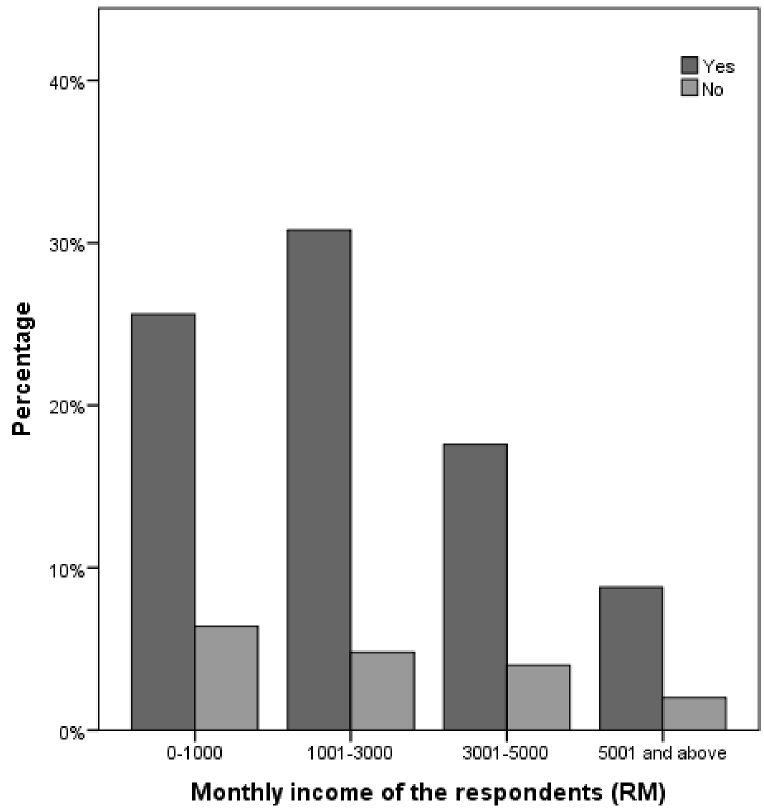


Figure 4.4: Public acceptance of marine renewable implementation among respondents with different monthly incomes[12]

Notwithstanding the encouraging results obtained on the public acceptance of marine renewable energy implementation, the willingness to pay for green electricity might disappoint the relevant authorities. Overall, the respondents were less supportive of paying for green electricity compared with their acceptance of marine renewable energy implementation in Malaysia. Around 56.8% of the total respondents refused to pay more for their electricity bill. As shown in Figure 4.5, the willingness to pay for green electricity showed a negative relationship with the age of respondents. The highest willingness to pay for green electricity was in the age group below 25 years old, which recorded 20.0% of the total respondents. This was followed by the 25-34 years

12 Note: 'Yes' indicates that the respondents accepted marine renewable energy implementation in Malaysia; 'No' indicates that the respondents rejected renewable energy implementation in Malaysia.

old age group (13.6%), 45-54 years old (4.8%), 35-44 years old (2.8%) and 55 years old and above (2.0%).

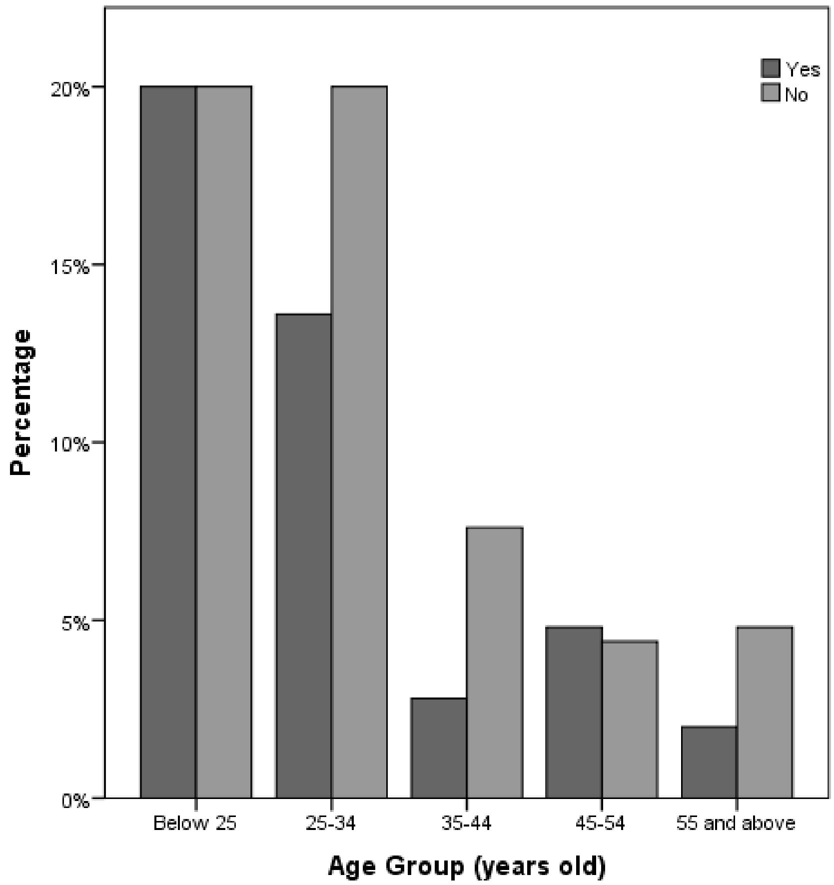


Figure 4.5: Willingness to pay for green electricity among different age groups[13]

This result agreed with the finding of a previous study conducted in China that willingness to pay for green electricity decreased with individual age (Liu, 2011). The reasons that a large number of young people are willing to pay for green electricity is attributed to the combined effect of several reasons. Renewable energy technology is well-known for its low adverse impacts towards the environment. Young people are more likely to have lower financial burden, higher environmental awareness and higher

13 Note: 'Yes' indicates that the respondents agreed to pay for green electricity; 'No' indicates that the respondents declined to pay for green electricity.

education level. These make the young people to be easier to compromise with paying green electricity.

Surprisingly, a negative relationship between the monthly income of the respondents and their willingness to pay for green electricity was observed, as presented in Figure 4.6. Higher monthly income of the respondents leads to lower willingness to pay for green electricity. This result contradicts the outcomes of previous studies in the US and China (Liu et al., 2013; Wiser, 2007; Yuan et al., 2011). The greatest willingness to pay for green electricity was in the group earning a monthly income of less than RM1000 (16.8%). Decreasing willingness to pay for green electricity was noticed throughout the group of respondents having monthly incomes of RM1001-3000 (14.8%), RM3001-5000 (6.8%) and RM5001 and above (4.8%).

A possible explanation of the low willingness to pay for green electricity in the higher monthly income group is that the electricity expenditure of a household rises as one’s income increases due to one’s economic ability. The person who pays the electricity bill would rather choose a cheaper energy source. It is noteworthy that respondents with a monthly income of RM1001-3000 were the most unwilling to pay for green electricity, which represented 20.8% of the entire sample. This might be because this group of people were paying the household electricity bills and so were more aware of the electricity prices.

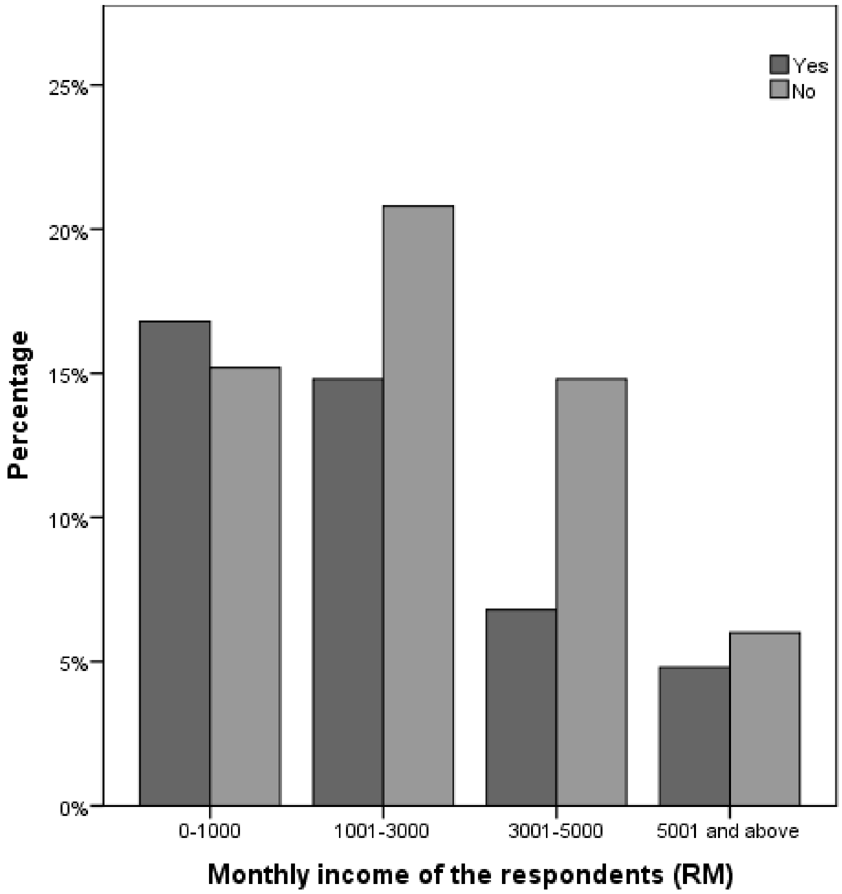


Figure 4.6: Willingness to pay for green electricity among respondents with different monthly incomes[14]

4.5.3.3 CHI-SQUARE TEST OF POLAR QUESTIONS

Chi-square test was conducted to test the association between socio-demographic variables and the polar questions. As shown in Table 4.11, chi-square test was used to determine the relationships in between the polar questions with socio-demographic variables. It is noticeable that education level is the most influencing factor to the knowledge of renewable energy, willingness to take steps in reducing electricity consumption and agreement on the fact that renewable energy is a better alternative.

14 Note: 'Yes' indicates that the respondents agreed to pay for green electricity; 'No' indicates that the respondents declined to pay for green electricity.

Table 4.11: Chi-square test of polar questions[15]

No.	Keywords of questions	Age	Gender	Race	Marital status	Education level	Monthly income
1	Know what is renewable energy				S	S	
2	Heard of marine renewable energy		S	S			
3	Agree that marine renewable energy should be implemented						
4	Think that Malaysia government should support						
5	Take steps in reducing electricity consumption			S		S	
6	Think that renewable energy is a better alternative					S	
7	Consider to install renewable energy system(s)						
8	Willingness to pay						
9	Think that marine renewable energy is stable and reliable						

This results agree with the findings of Sardianou and Genoudi (2013) which stated that educational status does explain consumers' acceptance of the adoption of renewable energy. It is believed that people with higher education level are more aware of the environmental issues and know about the importance of renewable energy in reducing carbon emission, which pollute the environment.

[15] Blanks which are labelled with 'S' denote that the socio-demographic variables and the polar questions have significant relationship.

4.5.3.4 MULTIPLE-CHOICE QUESTIONS

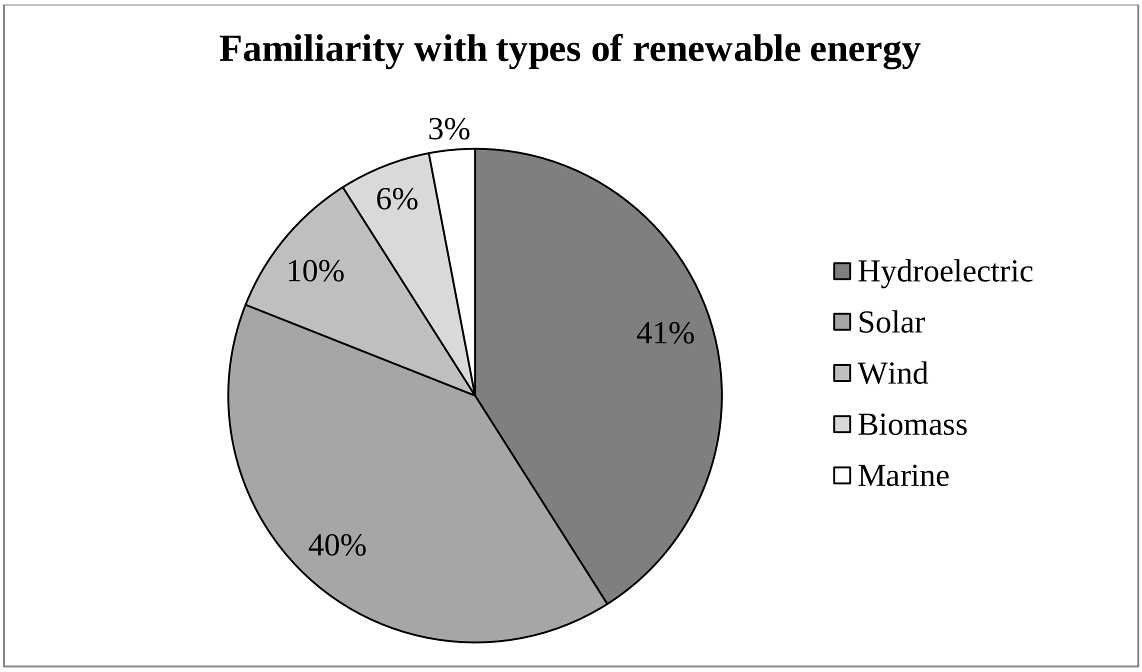


Figure 4.7: This question is designed in order to know the most popular renewable energy technology in the respondents' current perspective

Figure 4.7 has shows various types of renewable energy technologies which are available in Malaysia in the current stage. The technologies include hydroelectricity, solar, wind, biomass and marine energy. Around 41% and 40% of the total respondents thought that they are familiar with hydroelectric and solar energy respectively. This means that the popularity of hydroelectric and solar energy was relatively high compared to other renewable energy technologies. This might be due to longer history of the two technologies in the energy system of Malaysia, which makes the respondents feel familiar with them.

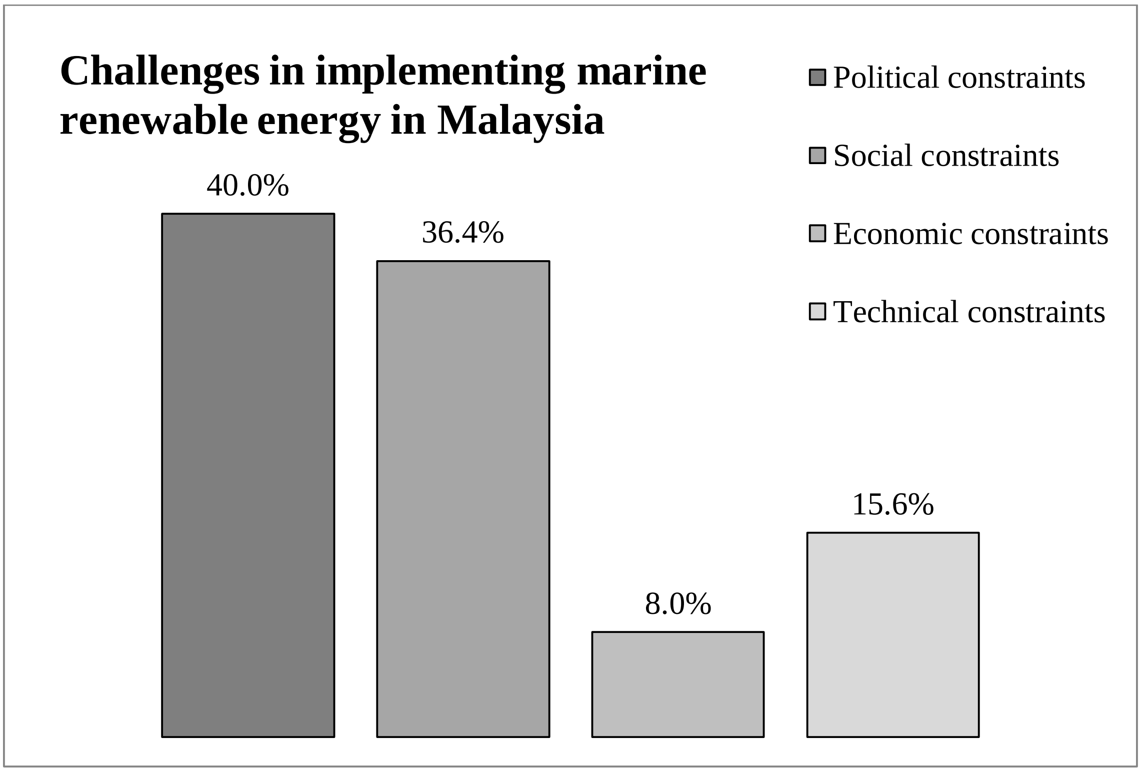


Figure 4.8: This question is designed in order to know the perspective of respondents towards the challenges in implementing marine renewable energy in Malaysia

The success of any renewable energy project is limited by various barriers. Respondents were asked to anticipate the most likely challenge in implementing marine renewable energy development in Malaysia. The majority of the respondents thought that political (40.0%) and economic (36.4%) constraints would be the two main challenges, as illustrated in Figure 4.8. Technical (15.6%) and social (8%) constraints were predicted to be the greatest obstructions in implementing marine renewable energy by a minority of the respondents.

Government intervention plays a vital role in investment behaviour and financing conditions (Cull et al., 2013). Fuel subsidies by the government are claimed to be the most popular barrier facing the renewable energy technology market in Malaysia in which enormous subsidies lead to cheap electricity prices from the national grid (Ahmad et al., 2011a). In association with the high production cost of renewable energy compared with conventional energy, investors are reluctant to take the risk of financial loss. As a comparison, the capital costs of wave and tidal energies are approximately RM 15,400/kW and RM11,600/kW (Trapani et al., 2013), while the capital cost of a coal power plant ranges from RM8,500/kW to RM9,700/kW (EIA, 2010). Marine renewable energy implementation is not viable without huge economic support. It is claimed that renewable energy technology is hindered by the scarcity of investment and manpower owing to a lack of enthusiasm from commercial investors, where there is no security given by any act or policy (Ahmad, et al., 2011a). Communication together with coordination between government agencies and the private sector are urgently needed to move the renewable energy market forward (Prasertsan & Sajjakulnukit, 2006).

Furthermore, some respondents thought that technical constraints may be a hindrance to marine renewable energy implementation. This is especially true in the context of a developing country. Limited local expertise on efficient practices and equipment handling is a common phenomenon in developing countries. Other technical constraints faced by the countries are defined as a lack of standards, codes and certification, as well as a lack of training on O&M and facilities management (Painuly, 2001). Social constraints make a minor contribution to obstacles to marine renewable energy implementation in Malaysia too. Households find it particularly difficult to obtain information and knowledge on renewable energy technologies. It is believed that consumers are less confident in and trusting of the information provided (Reddy & Painuly, 2004).

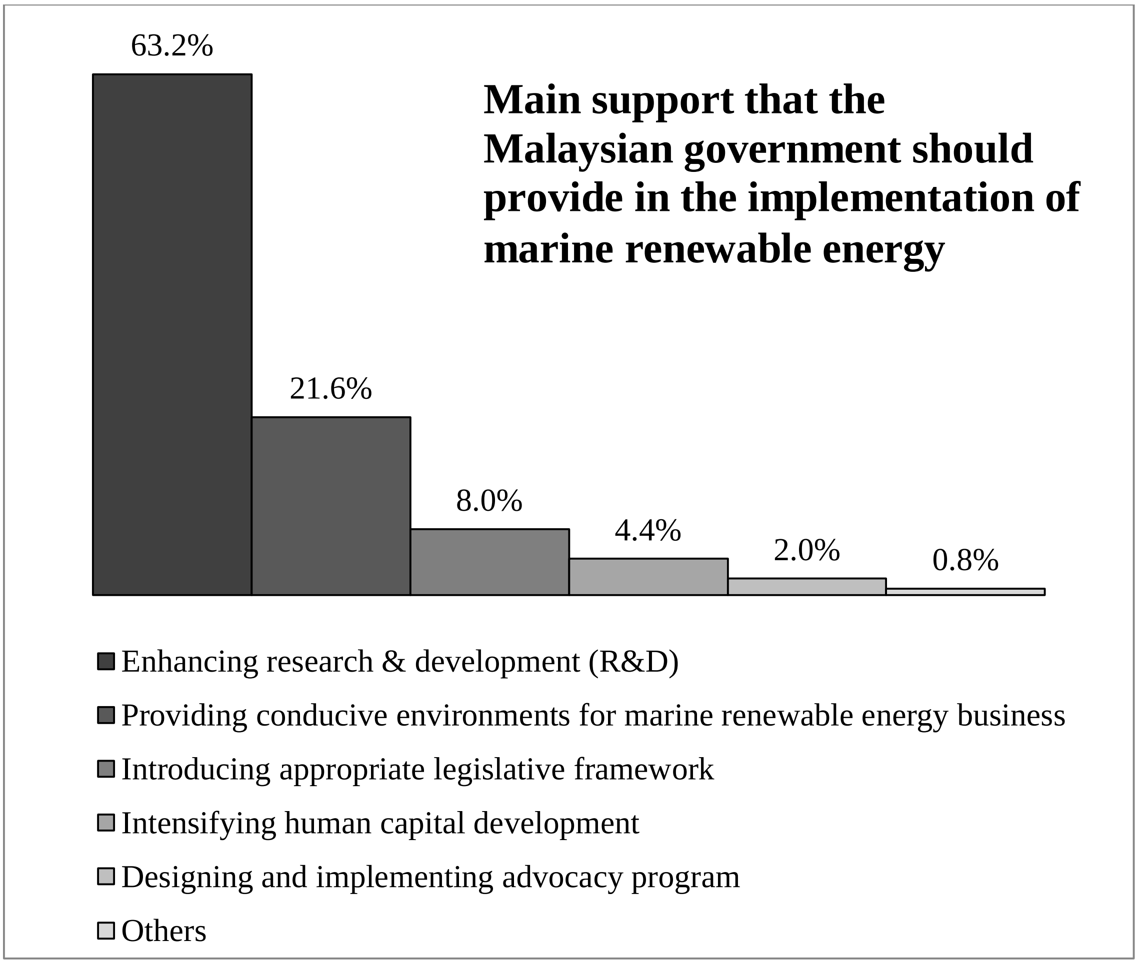


Figure 4.9: This question is designed in order to know the perspective of respondents towards the main support of the Malaysian government in the implementation of marine renewable energy

Next, the respondents were asked to choose the main support that the government should provide in implementing marine renewable energy. More than half of the respondents (63.2%) thought that enhancing R&D on marine renewable energy is the most crucial of all the options as presented in Figure 4.9. Another 21.6% believed that providing a conducive environment for marine renewable energy business is the most important choice. It should be noted that another 8%, 4.4% and 2% chose an appropriate legislation framework, human capital development intensification and advocacy program design respectively as the main concern for the government.

Nowadays, marine renewable energy is extensively used in European countries, the United States, Korea and China. This technology might be regarded as an emerging technology to most Malaysians compared to solar power, hydropower and biomass, which have long histories of usage and larger capacities in the country (Ahmad, et al., 2011b). In this case, continuous and rigorous R&D has to be carried out with the cooperation of different parties including government agencies, institutions and local universities. Examination of the potential of harnessing energy from marine resources will be followed by pilot projects which are foreseen to create a preliminary evaluation of the adaptability of marine renewable energy technology in Malaysia.

Majority of the respondents (33.2%) felt that conserving the environment for future generations is the most difficult aspect faced by the government in marine renewable energy implementation, as illustrated in Figure 4.10. Next, 25.2% and 22.0% thought that increasing the contribution of marine renewable energy in the mixture of national power generation and facilitating the growth of MRE are the most challenging problems faced by the government. Furthermore, 14.4% believed that the government will face difficulties in enhancing awareness of the role and importance of marine renewable energy.

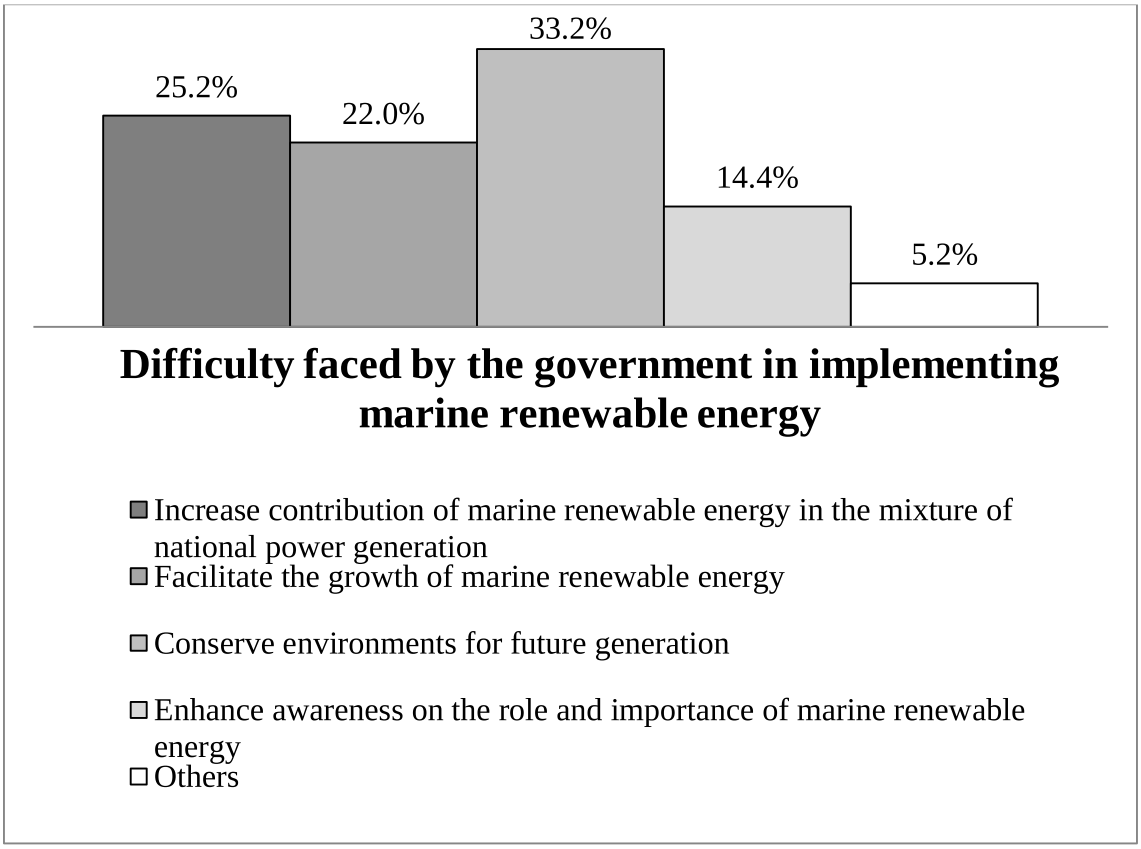


Figure 4.10: This question is designed in order to know the perspective of respondents regarding the difficulty faced by the Malaysian government

Awareness of environmental issues among the public is generally increased nowadays. A number of studies were carried out and suggested that marine renewable energy installation is a potential threat to the environment and biodiversity. Negative ecological impacts including habitat loss, collision risks, noise and electromagnetic field are potential hazards to the marine environment (Gill et al., 2012; Inger et al., 2009; Shields et al., 2011). Therefore, it is advisable that a detailed environmental impact assessment be carried out prior to any marine renewable energy implementation so that the energy mixture increases without imposing an unbearable burden on nature.

According to Figure 4.11, majority of the respondents (74.8%) are willing to pay RM0.10 to RM0.50/kWh for the electricity generated by marine renewable energy. On the other hand, 17.0% of the respondents are willing to pay RM0.51 to RM1.00/kWh for the electricity generated by marine renewable energy and followed by 5.2% of the respondents who are not sure how much are they willing to pay. There are a minority of the respondents who are willing to pay more than RM1.01/kWh. In short, most of the respondents chose to pay the lowest tariff for green electricity. This tariff is near to the current conventional electricity tariff which ranged from RM0.218 to RM0.454 per kWh. This finding is reasonable as people usually would choose the option which gives lowest financial burden to them.

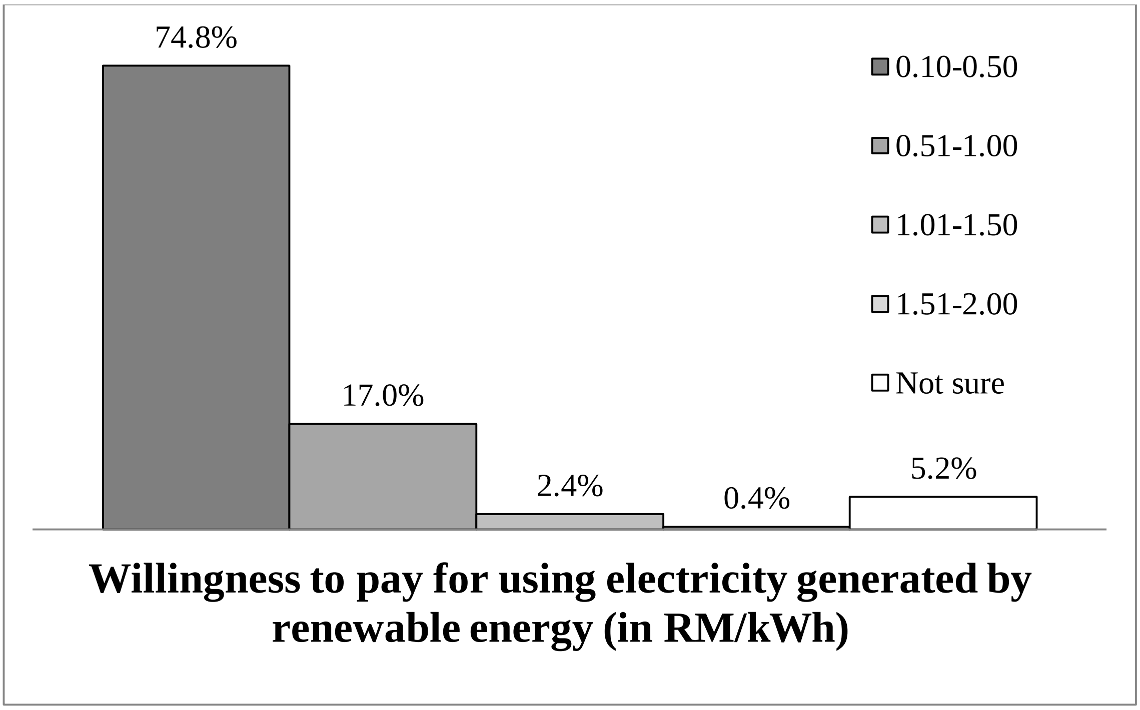


Figure 4.11: This question is designed in order to know the willingness to pay of respondents for using electricity generated by renewable energy

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

The final chapter of the thesis contains conclusion drawn from the results analysed and compiled in Chapter 4. There are also recommendations for future study.

5.2 CONCLUSION

The data gathered in three parts of the study has concluded that marine renewable energy is feasible to be implemented in Malaysia, albeit with a certain amount of limitations. The limitations are primarily related to the successfulness of recognition of marine energy project in CDM and FiT systems.

CDM can be an important driving force for the development of marine renewable energy in Malaysia. A majority of the CDM projects are categorised under the category of renewable energy, which makes up 69% of all projects. The energy-related CDM projects in Malaysia have recorded an emission reduction of 1,790,108 tCO_2e in 2012. One of the CDM projects, Sihwa Tidal Power Plant, was commenced in 2011 and has managed to reduce carbon emission by as much as 591,870.9 tCO_2e in the monitoring period from July 2011 to September 2013. The good performances of renewable energy projects in Malaysia and tidal energy project in CDM have portrayed bright future for marine renewable energy in Malaysia.

The proposed FiTs of tidal range, tidal stream (shallow), tidal stream (deep) and wave are RM0.254, RM1.228, RM2.032 and RM2.61 per kWh respectively. The proposed FiT of tidal stream (shallow) is similar to the implemented FiT of solar power, which makes it a worth investigating technology. Comparatively, the proposed FiTs of tidal stream (deep) and wave energy are higher than the implemented FiT of other forms of renewable energy and conventional electricity price. High ratio of FiT of marine renewable energy to the conventional electricity tariff has been obtained. Nevertheless, the conventional electricity price in Malaysia is under market value when compared to the other countries.

For the third part of the study, it can be seen that the majority of the respondents agreed that renewable energy is a better alternative to be used and welcomed the implementation of marine renewable energy in Malaysia. However, they were reluctant to bear the cost of green energy or install any renewable energy system. This consolidates the NIMBY phenomenon as discussed by Devine-Wright, 2007 and Burningham, 2000. Education is a fundamental key to improve the level of acceptance of renewable energy. The Malaysian government plays a key role in pushing forward the development of marine renewable energy. Substantial R&D of the above-mentioned technology should be financially supported by the government.

5.3 RECOMMENDATIONS

For the study on project costs reduction through CDM and FiT, many assumptions were made by using the data from the existing tidal energy project in other country. Although the results do not necessarily reflect the real scenario, they do give an idea to the reader on how project costs can be reduced. Therefore, it is suggested that a proper financial feasibility study should be conducted as a follow-up to this study. If any marine renewable energy project is initiated, GreenTech Malaysia should be a key authority to ensure the registration of CDM. In order to introduce marine energy into the existing FiT system in Malaysia, SEDA or future researchers should carry out further resource assessment as an extension of the study.

For the study on public acceptance, there are two distinct extensions of future research paths as a follow-up to this study. Firstly, the study can be extended to involve more representative respondents and interviewees in the same study area. The current conclusion is based on a satisfactory number of respondents and a single interviewee. A bigger sample or the inclusion of more interviewees might improve the quality of the data. Secondly, the conclusion of the current study is based on responses in an urban area. This may not be directly applicable to the conditions in island communities. It is noteworthy that the prime stakeholders, including islanders and fishermen, would experience the most direct impact once marine renewable energy technology is installed. Therefore, further study carried out on an island is necessary in order to understand the acceptance of MRE by islanders and fishermen. In this context, Pangkor Island is proposed as the next investigation site due to its potential for harnessing tidal energy, as indicated by Chong and Lam (2013) and Sakmani et al. (2013). Continuation of these research works is expected to contribute useful knowledge to the community.

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LIST OF PUBLICATIONS AND PAPERS PRESENTED

No.	Publications
1	Lim, X. L., Lam, W. H., & Shamsuddin, A. H. (2013). Carbon credit of renewable energy projects in Malaysia. *IOP Conference Series: Earth and Environmental Science*, *16* (1), 012058.
2	Lim, X. L., & Lam, W. H. (2014). Review on Clean Development Mechanism (CDM) implementation in Malaysia. *Renewable and Sustainable Energy Reviews*, *29*, 276-285.
3	Lim, X. L., & Lam, W. H. (2014). Public acceptance of marine renewbale energy in Malaysia. *Energy Policy*, *65*, 16-26.