Journal of Technology Management and Business (ISSN: 2289-7224)
Vol 03, No 02, 2016

RENEWABLE ENERGY ADOPTION FOR ENERGY COMPLEMENTARY: APPLICATION OF OFFSHORE WIND TURBINES IN SABAH, MALAYSIA.

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Abstract

Nowadays, the world electricity requirements are increasing at an alarming rate and the power demand is running ahead of supply. It is widely recognized that the fossil fuels such as coal, petroleum and natural gas are presently being used for electricity. Therefore, in future it may not be sufficient to keep pace with ever increasing demand of the electrical energy of the world. The renewable energy can provide clean sources of energy which is reliable and secure to society. This paper analyzed renewable energy adoption, focusing on offshore wind turbines. In this case study, Labuan, Sabah has been selected as a location to install the offshore wind turbines because of the geographical advantage of the South China Sea. The technology is expected to provide great power energy with the least environment impact and high sustainability as it is located within the windy area with no terrain features, buildings or other obstruction. This study used qualitative methods for both data collection and data analysis. This study proved that the application of offshore wind turbines in the South China Sea, Sabah produced the complementary energy to fossil fuels and resulted in the acceptance of Sabah residents towards the installation of the offshore wind turbines. Hence, the offshore wind turbines might become one of the main energy sources in Sabah. The application of the offshore wind turbines to Sabah residential area develops a lot of benefit and support the Malaysian government goal which is to be more competitive in renewable energy generation while sustaining national economic growth.

***Keywords**: Offshore wind turbine, Renewable energy adoption, Energy complementary*

1.0 Introduction

In this modern era, Malaysian government focus is to encourage the entire industry sector to adopt green environment and one of the initiatives is to implement renewable-based electricity generation module in industry. The Malaysian government will be the sector that ensures all the electricity generations from renewable energy are well-planned. The main goal is to reconcile characteristics of the new technologies with the needs to maintain supply reliability. The wind power which includes onshore and offshore wind farms has created expectations among policy makers and the industry alike that these technologies will make a major contribution in meeting the growing electricity needs. While the onshore wind adoptions refer to wind farms that are installed on land, the offshore wind adoptions refer to wind farms that are installed off the coast. The offshore wind turbines adoption is emphasized in this study because it complements the fossil energy in powering electrical grid. Zuhairuse et al. (2009) state that Malaysia has been considering wind energy as one of the alternative sources of power generation and Chiang et al. (2003), state that a study is conducted to gauge the potential of offshore wind energy in Malaysia. Hence, the offshore wind turbines adoption needs windy areas and for this purpose, Labuan Island at the South China Sea is being selected.

1.1 Research questions

The research questions for this study are as follows:

(a) What are the factors which contribute to offshore wind turbines adoption?
(b) How does the Malaysian National Petroleum Corporation (PETRONAS) adopt the o ffshore wind turbines in Labuan Island, Sabah at the South China Sea?
(c) What are the innovative solutions in order to enhance offshore wind turbines adoption in Labuan Island, Sabah?

1.2 Research objectives

The objectives of this study are:

(a) To identify factors which contribute to the offshore wind turbines adoption.
(b) To investigate the ways PETRONAS adopt offshore wind turbines in Labuan Island, Sabah at the South China Sea.
(c) To propose innovative solutions to enhance offshore wind turbines adoption in Malaysia.

1.3 Scope

Labuan Island, Sabah has been selected as the location to install the offshore wind turbines because of the geographical advantage of the South China Sea. The location which is situated in the South China Sea has the most promising site. Meanwhile, 30 respondents are mainly divided into two groups; the group of 20 executives of the Malaysian National Petroleum Corporation (PETRONAS). The PETRONAS executives are selected for their expertise which can provide much information regarding the renewable energy sources as they are the pioneers in managing energy consumption in Malaysia. This group of respondents is also the group that will be involved in renewable energy development in the future. The second group consists of 10 residents of the Labuan Island. In short, opinion from the experts and local residents will enrich data on the offshore wind turbines adoption.in Labuan Island, Sabah.

1.4 Limitation

Two limitations are identified in this research. Firstly, the case study is to investigate how the offshore wind turbines can be adopted only at the South China Sea of Labuan Island. Secondly, the researcher has to assume that all respondents provide honest and correct answers.

2.0 Literature review

2.1 Overview of technology adoption of offshore wind turbines

According to Marcus (2004), technology adoption is an emerging discipline that integrates market, design and user research with ergonomics and usability to help people become active users of technology. Meanwhile, according to Bridges (2005), technology adoption is a consistent process that enables hesitant user to successfully adopt and use the technology. Hall and Khan (2002) define it as the choice of users to acquire and use a new invention or technology. Furthermore, the culture for a new technology adoption is defined as the success of users in using new technology (Cjaza et. all., 2006). Hence, the contribution of adoption of renewable technology to economic growth can only be realized when and if the new renewable technology is widely diffused and used.

2.2 Factors of technology adoption

Technical factor is the first significant factor in the adoption of offshore wind turbines. This factor consists of demand and usage, competitive advantage and technology life cycle. Meanwhile, environmental factor is the second significant factor. This factor is explained clearly through factors of PESTLE analysis which comprise political, economic, social, technological, legal and environmental.

According to Linn (2006), renewable technology adoption plays a central role in the relationship between demand and usage for technical factor. The demand and usage of renewable technology appear because nowadays the world is highly dependent on fossil fuels (Paul, 2013). This study also looks into the competitive advantage through the speed of renewable technology adoption in society. According to Rogers (2003), five key areas that have defined the speed of renewable technology adoption in society are relative advantage, compatibility, complexity, trialability and observability. A diagram of technology life cycle whereby it comprises the stages of technology development, application launch, application growth, mature technology and technology substitution and obsolescence (Morse and Babcock, 2010) is featured in Figure 2.0.

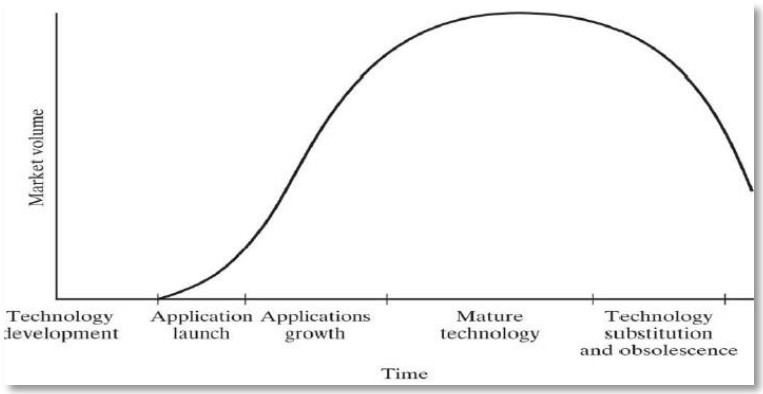

Figure 2.0: Technology adoption life cycle

Source: Morse and Babcock (2010)

In environmental factor which consists of PESTLE Analysis, political factor enlightens on energy tax incentives and subsidies (Sherlock, 2013). According to PricewaterhouseCoopers (2010), the energy tax incentives for green technology adoption are given to companies which generate energy from renewable sources and for energy conservation activities. The economic performance has also been affected through the renewable technology adoption (Ministry of Industrial Development Authority, 2010). According to Biz (2007), economic performance measurements are relying on five key areas which are inflation, unemployment, gross domestic product, balance of payments and exchange rate. Thus, social acceptance plays important roles in measuring the success of the adoption. If the technology is not being acceptable among the society, it leads to lost of the investments and failure of the adoption. According to Wustenhangen et. al., (2007), state social acceptance is the term used in practical policy literature and the Energy and Policy Context (2013), claims that social acceptance refers to the responses of communities and stakeholders to a specific adoption of a new technology.

In renewable technology adoption, two important key areas in technological factors are technology availability and technology cost (Sung, 2010). Technology availability is defined as when and how the new technology adoption is required by authorized users (Pathak, 2005). Meanwhile, technology cost is defined as the total direct cost and induced cost of new technology adoption (Verburg et. all., 2006). In legal issue, technology adoption describes the rule of law as the guaranty of the government to

protect society and environment (Donnelly, 2008). According to Webb (2013), the rule of law in renewable technology adoption is accurately defined through a five-stage plan. The five-stage plan is listed as follows:

(a) To introduce a legal and regulatory framework
(b) To provide a conducive business environment for renewable energy
(c) To intensify human capital development
(d) To enhance renewable energy research and development
(e) To create public awareness and renewable energy policy advocacy program

Next, Table 2.1 is the summary of the external environmental factor mentioned in literature that affects technology adoption in organization.

Table 2.1: External environmental factors that affect technology adoption

Literate	External environmental factor
Bur'ca, Fyner and Marshall (2005)	• Customer demand • Supplier perspective
Kim and Galliers (2004) Santarelly and Daltri (2003)	• Business environment • Global market • Dynamic market
Scupola (2003)	• Competitors • Suppliers • Customers
Sadowski, Maitland and Van Dongen (2002)	• Competitive pressure • External supports • Incentives

Among the external environmental factors that relate to technology adoption, Murad and Thomson (2011) found the external environmental factors such as customer demand, supplier perspective, competitors, dynamic markets, government support and government regulation are common in renewable technology adoption.

2.3 Strategies of technology adoption

Three key areas are explained clearly by Coutler, (2005) for the strategies of technology adoption:

(a) Organizational culture and attitude strategy
Organizational culture and attitude strategy are the culture and attitude of organizations that want to adopt new technology.

(b) Coordination and collaboration strategy
Coordination and collaboration strategy refer to other potential groups that enable organizations to support and adopt new technology.

(c) Technology investment strategy
Technology investment strategy refers to ways that organizations go through acquisition or mergers for the adoption of new technology.

2.4 Theoretical framework of technology adoption of offshore wind turbines

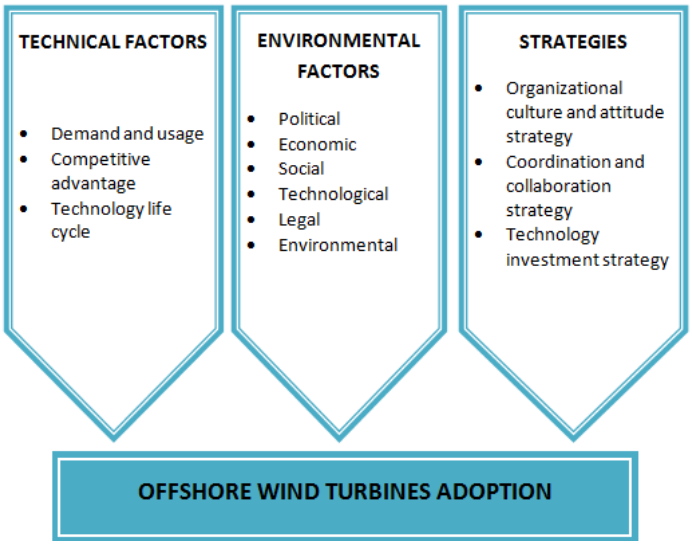

Figure 2.2: Theoretical framework of technology adoption of offshore wind turbines

3.0 Research methodology

Case study was conducted as the main strategy for this study. Eisenhardt and Graebner (2007) clarify that case study strategy will be relevant if a rich understanding of the context of the research and the processes being enacted was gained. This means the case study strategy in adoption of offshore wind turbines led to an exploratory study whereby the answers to the research questions and objectives would be clearly unfolded.

The Malaysian Petroleum National Corporation (PETRONAS) and Labuan residents have the conditions to provide appropriate and high quality of information in the study of offshore wind turbines in Labuan Island, Sabah. Case study was the main strategy to conduct this research. Thus, case study strategy in the adoption of offshore wind turbines led to an exploratory research whereby an in-depth understanding about technology adoption of offshore wind turbines in Malaysia would be gained In-depth interview with the experts in PETRONAS gave more insights on real-life scenario of the adoption of renewable energy sources in Malaysia especially the adoption of offshore wind turbines as the experts had gained experience in renewable energy field. There were four steps of methodology applied in this case study. Firstly, the literature reviews had to be generated to understand the theory of technology adoption of offshore wind turbines. In generating the literature reviews, the researcher could gain in-depth understanding of offshore wind turbines adoption. Secondly, the study was explored through secondary data. Secondary data were used to gain information from books and journals about the facts of wind energy and renewable energy sources as complementary energy in the future. Hence, these supportive methods were valuable to understand more about the background of the scenario. Thirdly, a qualitative method was adopted in this research. The in-depth interview sessions with experts in renewable energy developments for future from the PETRONAS and respondents from Sabah residential were conducted. Fourthly, data analysis of the qualitative method was applied. These four steps of methodologies worked as catalysts to guide the completion of the case study.

4.0 Data Analysis and Discussions

All data were collected through in-depth interview sessions with both categories of respondents. Hence, the results of the case study were divided into three sections based on the research objectives. Section 4.1 is about the first research objective, the factors which contribute to the adoption of offshore wind turbines. Next, section 4.2 is about the second research objective, the strategies of PETRONAS to adopt offshore wind turbines and social responses. Section 4.3 is about the third research objective, the innovative solutions in the adoption of offshore wind turbines in Labuan Island, Sabah.

4.1 Factors that contribute to the offshore wind turbine adoption in Labuan Island

Based on the data analysis, two key points were highlighted for the factors that contributed to the offshore wind turbine adoption; technical factor and environmental factor. Each was divided into relevant sub-factors. Hence, conclusion could be drawn based on those data.

4.1.1 Technical factor of offshore wind turbines adoption

There are three sub-factors which have been discussed and analyzed; demand and usage, competitive advantage and technology life cycle. Each factor is discussed below.

4.1.1.1 Demand and usage of offshore wind turbines adoption

Every year, the demand and usage of fossil fuels are higher than renewable energy sources. The fossil fuels become scarce as people are highly dependent on it. As a result, the fossil fuels price is increasing yearly. The adoption of offshore wind turbines can also act as an alternative in generating new and clean electricity generation. In comparison, the use of fossil fuels in generating the electricity still does not produce zero carbon emission.

The installation of offshore wind turbines is costly as it comprises high capital cost. But for a long term goal and mission, the adoption will benefit society and the Government of Malaysia in conserving the natural resources, preventing the environment and atmosphere from pollution and also helping Malaysia towards competency and globalization in renewable energy industry. According to Manager 1, this project was also classified as a risky project because PETRONAS had no experience in managing the renewable energy adoption project. However, it would be a guidance for future generation in conserving the natural resources and preventing the environment and atmosphere from continuously polluted due to our high dependent on fossil fuels. Hence, the adoption of offshore wind turbines would decrease the demand and usage of the fossil fuels and support in conserving the natural resources.

4.1.1.2 Competitive advantage of offshore wind turbines adoption

As the renewable energy sector is still new in Malaysia, the adoption of offshore wind turbines can help in the development in renewable energy technologies and provides the clean electricity generation. Next, this project will benefit tourists and investors from outside Malaysia to do business in Malaysia. Meanwhile, according to Manager 5, the adoption of offshore wind turbines would also influence the Government of Malaysia to lower the electricity bills tariffs and the cost of fossil fuels.

The renewable energy adoption will also create awareness among the Malaysians in conserving the natural resources and increasing job opportunities among the academics, technical and managerial area. However, Manager 4, Manager 5, Engineer 4, Engineer 5 and Engineer 6 claimed that this project did not only because high cost but also high risk project as the rate of success could be measured for a long time and it would change the environment of the coastal zone and create disturbance on the wildlife

habitat. The offshore wind turbines project needed to be managed-well as it could bring both positive and negative results from the adoption.

4.1.1.3 Technology life cycle of offshore wind turbines adoption

Technology life cycle comprises the stages of technology development, application launch, application growth, mature technology and technology substitution and obsolescence. However, offshore wind turbines adoption in Malaysia is the most significant stage of technology development. Both Manager 7 and Manager 8 shared the same opinion that the fastest time that PETRONAS was able to adopt offshore wind turbines was by year 2060. However, the predicted time to adopt this project also depended on the economic condition of Malaysia. Thus, PETRONAS needed to conduct economic tests before adopting this renewable energy adoption.

The managers and engineers stated that they would outsource to experts from European countries, executing joint ventures with Tenaga National Berhad and collaborating with the Malaysian Meteorology Department and the Ministry of Science, Technology and Innovation in the adoption of offshore wind turbines. Therefore, PETRONAS has enough time and capabilities to continuously put efforts to adopt offshore wind turbines before they reach the predicted years of adoption for this project.

4.1.2 Environmental factor of offshore wind turbines adoption

For environmental factor, there were six sub-factors for discussion and analysis; political, economic, social, technological, legal and environmental.

4.1.2.1 Political factor of offshore wind turbines adoption

PETRONAS does not involve politically in the government policy formulation in supporting green culture because PETRONAS prefers to focus on the realization of the vision to become a "Leading oil and gas multinational of choice". They are responsible for the effective management of Malaysia's oil and gas resources, adding value on this national asset and ensuring the orderly and sustainable development of the Malaysian petroleum industry.

However, according to Manager 7, PETRONAS was wholly-owned by the Government of Malaysia. Hence, the funding for the adoption of offshore wind turbines project must come from the Government of Malaysia. PETRONAS had to expand its business activities by entering renewable energy sector to be visible globally in the energy market.

4.1.2.2 Economic factor of offshore wind turbines adoption

In Malaysia, there are two government-linked companies which are Petroliam National Berhad (PETRONAS) as the main oil and gas industry in Malaysia and Tenaga National Berhad (TNB) as the largest electric utility company in Malaysia. Tenaga National Berhad has already implemented renewable energy in its business activities by hydropower stations. But, PETRONAS is still yet to implement renewable energy sector in its operation. Therefore, according to Manager 10 and Manager 11, TNB was their competitor.

In adding values to business activities, PETRONAS has its business strategies. The business strategies include the implementation of integration strategy in each of the business activities, strategic deployment and application of technology and expansion of business activities through strategic alliances. Based on these business strategies that PETRONAS has already practiced, PETRONAS has high potentials to adopt offshore wind turbines because its business strategies are capable in handling the renewable energy adoption project even with no prior experience.

4.1.2.3 Social factor of offshore wind turbines adoption

Social acceptance has been analyzed through five Labuan residents. All of them gave positive feedback towards the adoption of offshore wind turbines project. In general, nowadays most Malaysians are aware that our natural resources are limited and the price of energy is getting high every year. Thus, Malaysia needs alternative ways to conserve the natural resources and prevent the environment from being polluted. The answer lies in the offshore wind turbines adoption which will bring benefit to society and environment.

4.1.2.4 Technological factor of offshore wind turbines adoption

For technological factor, PETRONAS is continuously harnessing and developing new technologies to maximize opportunities and strengthen the capabilities to become a leading global exploration and production player. However, as the experience in renewable energy adoption is lacking, it has not had enough strength to adopt offshore wind turbines. Based on the data, the managers and engineers explained technological factors through the 8M's step. As a result, PETRONAS current situation did not permit it to adopt offshore wind turbines because it needed a solid foundation of skills and knowledge.

4.1.2.5 Legal factor of offshore wind turbines adoption

In terms of legal factors, PETRONAS has shown some efforts towards green culture although it is still not involved in renewable energy adoption activities.. Activities such as influencing the society for environmental conservation by community projects and practicing responsible environmental management in all its business activities have been conducted. In general, PETRONAS has the abilities to adopt offshore wind turbines due to its efforts in renewable energy capacities.

4.1.2.6 Environmental factor of offshore wind turbines adoption

Labuan Island was chosen for the location of offshore wind turbines adoption. Based on the data, Manager 3 agreed with the location. However, he claimed that it was difficult to decide the location of adoption of offshore wind turbines and research needed to be conducted on the desired location. The research activities should focus on the wind speed, the environment of marine living, the size of coastal zone and the condition of seabed. All of these activities need to be carried out to ensure that the desired location is the most suitable location for the offshore wind turbines. Meanwhile, Engineer 6 and Engineer 10 both claimed that this project needed to gauge people with experience and depth knowledge in renewable energy technologies. PETRONAS is capable to conduct this project as they always plan strategically in every business activity.

4.2 Ways of PETRONAS adopts offshore wind turbines in Labuan Island

The managers and engineers listed several effective ways to adopt offshore wind turbines in Labuan Island. First, they planned to get expatriates from PETRONAS subsidiary. PETRONAS needed expatriates from their subsidiaries rather than getting expatriates from outside in order to minimize cost.. Second, they planned to hire expatriates from European countries. PETRONAS could use these expatriates' experience, skills and knowledge in adopting this project. They could also be good consultants in the adoption strategies too.

Third, they planned to get cooperation from the group of companies owned by PETRONAS. Hence, it could get manpower for building and conducting the offshore wind turbine project. Fourth, they

planned to send the PETRONAS team to attend structured training and programme that were related to renewable energy adoption. Hence, everyone in renewable energy team in PETRONAS was exposed to the engineering, technologies and the project management to conduct the offshore wind turbines project. Finally, they planned to involve the research and technology team of PETRONAS to do research and explore towards the adoption of offshore wind turbines project. These were all the effective ways that PETRONAS managers and engineers suggested towards the adoption of offshore wind turbines in the future.

4.3 Innovative solutions to enhance offshore wind turbines adoption in Malaysia

These were the challenges in the adoption of offshore wind turbines from the managers and engineers' perspective. First, PETRONAS was lacking of expertise in managing the renewable energy adoption as its part of business activities. Second, the research on location of adoption took time and very costly. Third, PETRONAS was lacking of technology in terms of renewable energy engineering and technologies of renewable energy adoption. Fourth, the safety of workers in building the offshore wind turbines needed to be taken into account as this project was considered high risks. Finally, PETRONAS needed to compete for materials in global supply chain. Based on the data, innovative solutions to enhance offshore wind turbines adoption in Malaysia were proposed.

For lacking of expertise in managing the renewable energy adoption, the management team of PETRONAS needed to organize a well-planned time frame for adopting the offshore wind turbines. It ought to send its teams for structured training and programmes for renewable energy adoption and the Government of Malaysia could encourage for new courses especially in renewable energy engineering in every institution in Malaysia in order to instill skills and knowledge in renewable energy engineering and technologies for the young generation. For research on location of adoption challenge, the time needed for the research on the location could be shortened and the cost could be decreased by involving the Malaysian Meteorology Department with PETRONAS research and technology team and hiring the experts.

For lacking of technology in terms of renewable energy adoption, PETRONAS had to outsource the technology from countries that have greater experience in renewable energy adoption. Thus, PETRONAS is able to explore more in this technology and get guidance to generate electricity from the wind energy. For workers safety, PETRONAS had to prepare the training for workers about safety on construction of offshore works and make sure all the workers were covered with life insurances. Finally, competing for materials in global supply chain matter, PETRONAS had to hire consultants in supplying all the materials and technology for the adoption of offshore wind turbines and a strategic plan must be devised to get quality materials.

5.0 Conclusion

In conclusion, the findings of this study are discussed in relation to technical and environmental factors, ways of PETRONAS in adopting offshore wind turbine in Labuan Island and innovative solutions to enhance offshore wind turbine adoption. The most significant sub-factor that contributes most to technical factor is the demand and usage, followed by competitive advantage and technology life cycle. For environmental factor, the most critical sub-factor and least critical sub-factor are determined through PESTLE analysis. The most critical sub-factor in supporting the environmental factor is the economic. Meanwhile, the least sub-factor in supporting the environmental factor is technological. The other sub-factors in PESTLE analysis which are political, social, legal and environmental will be the other contributors to the environmental factor and the data can be used by PETRONAS in organizing their strategic plans in offshore wind turbine adoption. For the ways of PETRONAS in offshore wind turbine adoption, the most effective ways of PETRONAS to adopt offshore wind turbines are by hiring

expatriates from European countries whereas the least effective ways is the involvement of the research and technology teams of PETRONAS in researching and exploring towards the adoption of offshore wind turbines. Other effective ways such as getting expatriates from subsidiaries, collaborating from group of companies owned by PETRONAS and attending structured training and programme related to renewable energy adoption will also contribute to the ways PETRONAS adopts offshore wind turbines in future. Finally, the innovative solutions are proposed ; organize a well-planned time frame for adopting offshore wind turbines; send project team for structured training and programmes for renewable energy adoption; develop new courses in renewable energy engineering in universities; cut short the time for research on suitable location in adopting offshore wind turbine by involving the Malaysian Meteorology Department with PETRONAS research and technology team under experts' supervision; outsource the technology from countries that have greater experience in renewable energy adoption in order to explore more in this technology and get guidance to generate electricity from the wind energy; provide training for workers about safety on construction of offshore works and hire consultants to get quality materials in supplying all the materials and technology for offshore wind turbines adoption. In all, this study would benefit the Malaysian government in diversifying the renewable energy portfolio by the year 2020 and to promote a Green Malaysia. In future, this study should explore other aspects such as types of technology of offshore wind turbines that are suitable for Malaysia.

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