

The Potential of Renewable Energy Sources for Sustainable Energy Demand of Malaysia: A Review

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Abstract: As a result of rapid economic growth of Malaysia there is a remarkable growth in energy demand. The energy sources for undertaking socio-economic activities highly rely on fossil fuel energy. On the other hand, the stock of conventional energy resources is limited and it is accounted as major source of CO₂ emissions. The issue of energy resource scarcity and CO₂ emissions lead to look for the alternative sources of energy. Furthermore, the limited financial access of rural population and the difficulty of electricity distribution due to topographic difficulties in some areas like in Sabah and Sarawak states of Malaysia lead to the need for local alternative sources of energy. To this end renewable energy sources introduced as a plausible energy sources to curb the complex interdependent issues of resource and environment. Moreover, renewable energy source is very important to minimize regional disparity of rural-urban development. The study reviews the plausibility of renewable energy sources as key player for the regional development in general and improvement of rural livelihood in particular.

Key words: Energy, policy, renewable energy, sustainable development, CO₂

INTRODUCTION

The definition of sustainable development with wide acceptance is “development that meets present needs without compromising the ability of future generations to meet their own needs” (WCED, 1987). The concept needs to be emphasized, implying that the basic needs of the world’s poorest countries and the needs of the future should be a priority (Siwar and Islam, 2012). The concept of sustainable development is recent and emerged to represent a more comprehensive approach to the interaction of the economic activities with the environment (Michael, 1991).

Sustainable development’s goal is a development strategy that manages all assets, natural resources and human resources as well as financial and physical assets to improve long-term wealth and well-being. It is a goal that rejects policies and practices that favor current living standards by depleting the productive base to the cost of next generation by exposing them to a greater risk than the current generation (Repetto, 1986). According to, sustainable development cannot be achieved and materialize into reality unless special attention is given to the provision of energy services. An emphasis on resource management and energy needed, especially to solve the energy problem in rural areas.

Industrial progress and the growing world population cause an increasing demand for energy resources. The natural environment is being polluted due to rapid industrialization with the tremendous type of development in the pursuit of economic growth. The protection of the natural environment has been neglected, resulting in depletion of resource and gradual deterioration of environmental quality. Problems of pollutions and depletion of non-renewable resources are significantly critical issues with an earlier and larger effect on human life (Michael, 1991). These are how global issues like climate changes, global warming and emission of Greenhouse Gases (GHGs) being raised tremendously. Besides, the fact that fossil fuel resources are becoming scarce and the environmental issue that is related to carbon emission has increased interest in energy efficiency and environmental protection (Vine, 2008).

In recent years, however, the horizon widened and people started to concern about the environmental condition thereby begin to contribute in the protection and conserving the environment. The awareness about the functions of environment and the adverse impacts of pollutions on human being and planet is showing progress. This leads people to change their way of thinking, actions and their perception towards the environment. Furthermore, world has begun attitude

change to move towards green. This view was triggered when people began to realize that the earth is too old to receive, absorb or process toxic materials, materials that are not needed.

Energy problems, particularly the lack of reliability in power source to the rural population, particularly to low-income residents trigger negative impact on quality of life and socio-economic conditions (Wamukonya and Davis, 2001; Gustavsson, 2007; Cherni and Hill, 2009; Kaygusuz, 2011). The effect of this situation can be witnessed by the lack of development in the area where the number of poor exacerbated, the migration of people to other areas or to major cities soared and low level of education in the area (Pereira *et al.*, 2010). The breakdown for the low-income households in income seems modest representing 40% (Fig. 1) also proves the burden in addressing energy issues in 10th Malaysia Plan.

Electricity supply is still low in some rural states like Sabah and Sarawak which implies strong and continuous efforts should be done to supply power to the states, particularly in rural areas. For instance, the supply for Sabah and Sarawak is 67.05 and 66.91%, respectively (Table 1).

The energy issue again became worse with rising in energy prices by surging energy demand, particularly electrical energy in the global market as well as Malaysia. This situation has resulted absence of particular energy sources of electricity in rural population especially in low-income developing countries. Further, efforts needed to find environmental friendly alternatives. This is because the use of fossil fuel-based sources leads to high production of Greenhouse Gases (GHG) mainly carbon dioxide which causes global warming. Consequently, renewable energy is seen as a key element that should be promoted and enhanced due to its vital role in the reduction of fossil fuels consumption level.

The issue of carbon emissions was emphasized that other alternatives should be explored by Malaysia to not just rely on fossil fuels (Sovacool and Drupady, 2011); reveal that the amount of fossil fuel consumption ranks Malaysia among the top ten countries in producing

carbon dioxide with an annual rate of about 7.9% from 1990-2006. According to them, the consumption of high amount of fossil fuels causes Malaysia to become as the second highest carbon dioxide emitter among these top ten countries. Similarly, Oh (2010) shows the increasing trend of total carbon dioxide emission in Malaysia (Fig. 2 and 3).

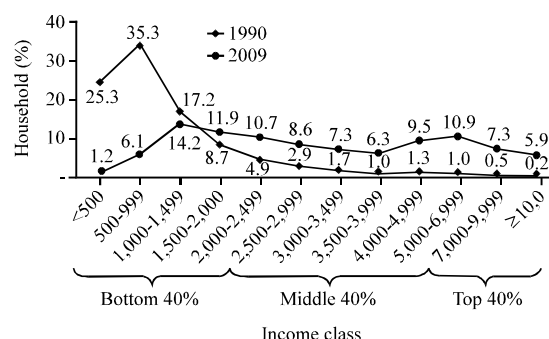


Fig. 1: Distribution of households by income class, Malaysia, 1990 and 2009; 10th Malaysia Plan

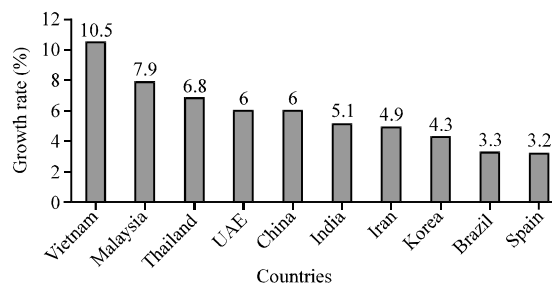


Fig. 2: Growth rate of carbon dioxide emissions from 1990-2006 (%) (Sovacool and Drupady, 2011; National Khazanah, 2010)

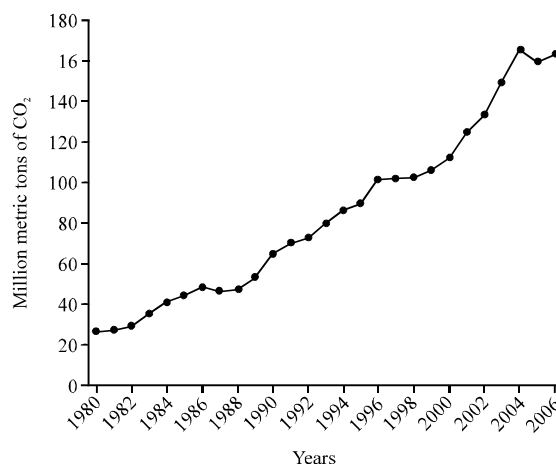


Fig. 3: Increasing total carbon emission in Malaysia (Oh, 2010)

Table 1: Electricity supply for city and rural areas in Malaysia

States	Urban area (%)	Rural area (%)
Johor	99.53	98.22
Kedah	99.84	98.58
Kelantan	99.52	97.50
Melaka	99.90	99.28
Negeri Sembilan	99.61	98.60
Pahang	99.63	93.96
Perak	99.64	96.11
Perlis	99.63	99.17
Pulau Pinang	99.84	99.16
Sabah	89.65	67.05
Sarawak	93.96	66.91
Selangor	99.39	97.92
Terengganu	99.65	98.24
W.P. Kuala Lumpur	99.76	-

EPU, 2004

ENERGY DEMAND FOR SOCIO-ECONOMIC DEVELOPMENT

Energy is an essential element in our daily lives. The demand of energy is kept increasing around the world. The demand of energy has increased with the world population and economic growth in developing countries during the recent years (Bhattacharya, 2002; Panwar *et al.*, 2011). The demand for energy is expected to increase at worldwide both in the industrialized countries and developing countries over the next two decades. Most of these countries are depending on fossil fuel for energy to meet their energy demand. According to the International Panel on Climate Change, fossil fuel energy consumption is a major contributor for global warming and accountable for 26% of global carbon emission in 2005 (EIA, 2012). The reliance of people on fossil fuel as source of energy contributed to the declination of the stock. According to Mastapa *et al.* (2010) in Malaysia, energy had become the main factor for rapid growth and have been increased almost 20% from 13,000 MW in year 2000-15,500 MW in the year 2009. Furthermore, the challenge how to fulfill the increasing energy demand exacerbated the issue of energy resource scarcity (Kaygusuz, 2011; Ahmad and Byrd, 2013). This is because stock of the fossil fuel has decreased, although, energy demand is growing. Therefore, people today recognize that reliance on non-renewable resources should be minimized and alternative energy sources should be developed and customized.

Renewable energy is one of the best options to consider for replacing the fossil fuel energy. This type of energy is safe and has the potential to minimize adverse effect towards environment. It is not only sustaining energy but also benefits as alternative for major transformation technology (Chaurey and Kandpal, 2010; Harris, 2010; Kaygusuz, 2011). The developing countries are taking initiatives to divert energy from fossil fuels to alternative and renewable sources for reduction of carbon emissions and sustainable energy uses. The need for energy resources is necessary to achieve ecological sustainability.

Electricity demand: The demand for energy has become an important agenda to Malaysia since decades, the power generation capacity has increased almost 20% from 13,000 MW in 2000-15,500 MW in 2009 (Mustafa *et al.*, 2010). Electricity generation in Malaysia is expected to grow at an average annual rate of 4.7% from 85 kWh in 2005-265 kWh in 2030 and the rate of consumption of coal in electricity generation is projected to increase from 27%

in 2005 to 37% in 2030 (APEREC, 2009). In addition, since the provision of electricity to meet the energy demand of remote areas required a lot of efforts; renewable energy is believed to be the best alternative in generating energy for the remote area.

Many and most of the activities or daily activities depend on the energy source of electricity. Cooking, bathing, washing and other activities, especially at night and carry out small-scale industries are examples of things that rely on electricity. Electrical energy plays very important role to accelerate socio-economic activities. So, much so that in some countries there is a need of electricity as an indicator to assess the progress of a nation. However, the increasing cost for electricity and declining fossil fuels resources cause various negative impacts to the people and environment.

POTENTIAL OF RENEWABLE ENERGY RESOURCE TO EXCEL SUSTAINABLE DEVELOPMENT

Renewable energy sources are resources that are environmental friendly having non-depleted resource base and has a potential to reduce the heavy dependence on fossil fuel resources. According to, renewable energy refers to sources of energy that can be recycled in nature while maintaining clean environment. In addition, energy security and eradicating rural poverty in the region as well as it increase the availability of energy to the development of a system as alternative to increase green economy. Now, renewable energy becoming alternative sources of energy for the conventional sources (Panwar *et al.*, 2011; Shafie *et al.*, 2012). Malaysia has endowed with renewable energy sources like biomass, solar, hydropower and wind. The country has been looking the possibilities of other alternative energy sources the annual utilization of solar, hydrogen fuel cells, biomass, landfill gas and municipal solid waste (Rahman and Lee, 2006).

On the other hand, Malaysia is among countries that signed the Kyoto Protocol on Climate Change (UNFCCC) in the United Nations Framework Convention. As a result, the country has committed to take initiatives to reduce Greenhouse Gas emissions (GHGs) to achieve sustainable development. Malaysia has embarked seriously and use of renewable energy since the Eighth Malaysia Plan (8MP) (Malaysia, 2001; Mustapa *et al.*, 2010). Since then, Malaysia has been promoting developing renewable energy sources progressively. Furthermore, Malaysia has shown a paradigm shift in order to stay competitive and improve the strategies and efforts in promoting renewable energy as clearly stated under the 8-10 MP. Malaysia has also listed the renewable energy including solar energy

resources and hydropower as a potential source of fuel to meet the demands and needs of energy in Malaysia (Chua and Oh, 2012).

Studies done in Nepal showed that the use of renewable energy is one of the green initiatives which has positive impact in provision of electricity to low-income and poor rural population. To address the scarcity of fossil fuel resources, the international community, particularly rural population has begun to use renewable sources such as solar and biomass. This is mainly because rural areas have limited financial access to electricity grid and sometimes the nature of the land in rural areas can be a reason for non-accessibility of electricity supply (Pandey, 2009; Chaurey and Kandpal, 2010). In such a case, the role of renewable energy is vital in generating energy in the area. This is key factor for regional development that leads to sustainable development.

Findings of many studies have shown that renewable energy has a lot of economic benefits such as substantial job creation, enhance income level and improve productivity (Karekezi and Kithyoma, 2002; Cosmi *et al.* 2003; Khan *et al.* 2007). Malaysia government motivated to develop renewable energy not only due to its economic advantage but also due to its potential to sustain of ecological and human habitat in achieving sustainable development. However, the Malaysian climate of uncertainty and the still low level of technology lead renewable energy not to be utilized optimally.

Solar: Besides biomass, biogas, mini hydro and municipal waste, solar is one of the potential renewable energy that could be taken into account for the development purposes. It also shows significant potential in satisfying the increasing demand of energy in the world (UNDP, 2007; Muhammad-Sukki *et al.*, 2012). Malaysia's weather condition which is the tropical region located around the equator (Ahmad *et al.*, 2011) and her strategic geographical location which has abundant sunlight with average irradiance per year of 1643 kWh/m² become promising condition for the development of solar energy (Haris, 2008).

Malaysia has high yearly average solar energy which its range mostly started from 1600-1900 kWh/m². Solar radiation is estimated to have the potential to provide four times of energy compared to the world fossil fuel resources and also relatively high based on the world standards (Azhar *et al.*, 2008; Borhanazad *et al.*, 2013). Thus, Malaysia has big opportunity to generate solar energy.

Around the world, the trend of solar energy market is developing and this has huge potential for sustainable

energy supply. It is becoming popular and considered as one of the best alternative of energy source due to its less maintenances, quick times to install (MBIPP, 2011). Moreover, its source is infinite and available. Two types of solar energy that always being referring to which are Solar Photovoltaic (PV) and Solar Thermal System. In Europe, especially Germany had become a leading country in terms of PV installation with a total cumulative installation of >9 GW and followed by Japan and US which accounted 2.1 and 1.2 GW, respectively (Fig. 4) (Bundesnetzagentur, 2011; Masson *et al.*, 2013).

In Malaysia, solar PV is the highest potential energy among other renewable energy. Based on Table 2, solar contributes the highest potential which is 6500 MW compare to other sources of renewable energy such as biomass, biogas, mini hydro and municipal waste. Based on theoretically calculated by Haris (2008), solar panels installed in an area of 431 km² in Malaysia could generate enough electricity to fulfill the electricity demand of the country in 2005 (Fig. 5).

Biomass: Biomass is one of the potential renewable energy sources which can contribute to the energy needs. Most of the Asian countries give emphasize on biomass as an important energy sources. Malaysia established her target to use biomass as an alternative renewable energy sources (Mahlia *et al.*, 2001).

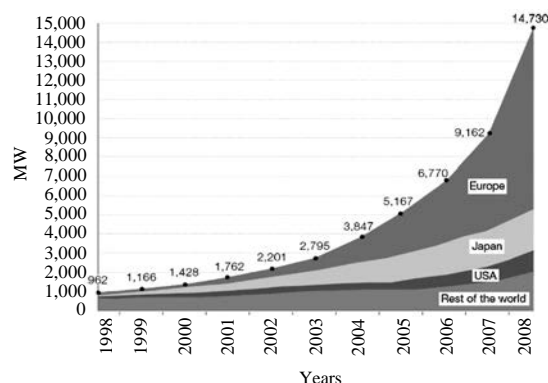


Fig. 4: Global Cumulative PV power installed per region (EPIA)

Table 2: Renewable energy resource potential in Malaysia

Renewable energy	Potential (MW)
Biomass	1,340
Biogas	410
Mini hydro (ttal hydro potential is 22,000 MW)	500
Solar	6,500
Municipal waste	400
Total	9,150

Mustapa *et al.* (2010)

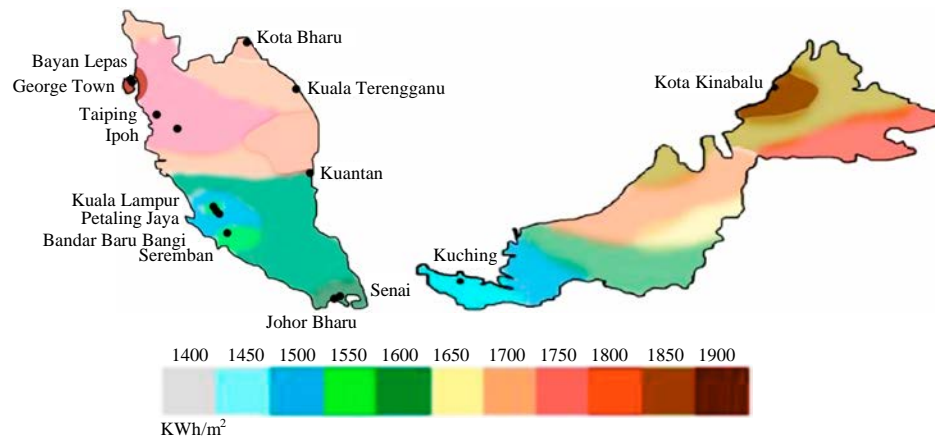


Fig. 5: The yearly average solar energy in Malaysia (Haris, 2008)

Biomass residues create high potential energy generation for Malaysia. The most usable biomass residues are empty fruit bunch fiber and shell of palm oil and industrial residues. The experience of tropical country with hot and wet weather encourages the cultivation of oil palm in Malaysia. As a result, oil palm plantation covers about 73% of the agriculture land in Malaysia and makes a major producer of oil palm biomass (Ng *et al.*, 2012). Biomass residues have a potential to secure economic and environmental benefits for Malaysia (Shafie *et al.*, 2012).

Malaysia has driving motive to develop its biomass production to become a major hub in the South East Asia. The country set up various agencies and policies to develop and control the palm biomass industry. These agencies and policies facilitate and develop the palm biomass industry in terms of technology, product improvement, process synthesis and supply chain optimization (Ng *et al.*, 2012). To this end, Malaysia's national economic plan already introduced the National Biomass Strategy 2020 for sustainable energy development in the country (AIM, 2011).

Compared to other renewable energy sources, biomass can be converted directly into liquid fuels for the transportation purpose. The two most common types of biofuels are ethanol and biodiesel. Biodiesel is the potential renewable energy derived from vegetable or animal oils and palm Fats. It serves as substitute to petroleum-derived diesel for energy production (Panwar *et al.*, 2011). Malaysia is one of the top countries in the world in terms of income and costs of biodiesel production. Table 3 shows the top 10 countries in terms of absolute biodiesel production in 2007. According to this table, Malaysia is the highest volume (14,540 mL) of biodiesel producer in the world in that particular year. The production cost (\$0.53) per liter of biodiesel also

Table 3: Top 10 countries in terms of absolute biodiesel production in 2007

Countries	Volume (million liters)	Production cost (\$/L)
Malaysia	14,540	\$0.53
Indonesia	7,595	\$0.49
Argentina	5,255	\$0.62
USA	3,212	\$0.70
Brazil	2,567	\$0.62
Netherlands	2,496	\$0.75
Germany	2,024	\$0.79
Philippines	1,234	\$0.53
Belgium	1,213	\$0.78
Spain	1,073	\$1.71

Johnston and Holloway (2007)

considered cheaper in Malaysia compared to the production cost of other countries (Johnston and Holloway, 2007). This scenario of less production cost shows the economics potential that Malaysia has in terms of biodiesel production.

Malaysia is the biggest palm oil exporter with 14.21 million metric tons which accounts for 41% of world palm oil production. A total of 4.5 million hectares of land are engaged in oil palm production in Malaysia. In 2008, the country produced 17.73 million tons of palm oil and earned about RM (RM is Currency of Malaysia) 65.19 billion from exported palm oil. The palm oil production is providing large quantities of processing residues which has potential to become biomass resource. As a result, palm oil residue is one of the promising alternative energy sources for Malaysia. Table 4 shows that the palm oil biomass components and potential energy generated. The highest amount of biomass component comes from empty fruit bunch with 17 million tons.

Palm oil is one of the most efficient crops in terms of land utilization, efficiency and Productivity (Hosseini and Wahid, 2012). Malaysia is generating huge quantities of biomass by cultivating palm oil in million

Table 4: Palm oil biomass components and potential energy generated

Biomass components	Quantity (million tons)	Calorific value (kJ kg ⁻¹)	Potential energy generated (Mtoe)
Empty fruit bunch	17.00	18,838	7.65
Mesocarp fiber	9.60	19,096	4.37
Shell	5.92	20,108	2.84
Palm kernel	2.11	18,900	0.95
Total	34.63	-	15.81

Shuit *et al.* (2009)

hectares of land in the country. As a result, palm oil biomass residuals recognized to be a potential alternative source of renewable energy in Malaysia. Malaysia has approximately, 362 palm oil mills, producing 19 million tons of crop residues per year in the form of empty fruit bunch, fiber and shell (Shuit *et al.*, 2009). Palm oil biomass is the most potential energy source in Malaysia to fulfill the increasing energy demands. Moreover, biomass is preserving the environmental well beings and reducing carbon emissions. In the future, Malaysia will be able to exert and significant green by potential of developing a solid network connection for proper biomass supply and demand (Ng *et al.*, 2012). As a result, biomass can play a vital role in greening energy sector through proper utilization.

Micro hydropower: Micro hydro energy is obtained from the fraction of hydropower resources. Micro which means small shows how resources are available. Micro hydro is a hydro power resulting from a small river flows. However, alteration or change of kinetic energy into electrical energy that can supply electricity generated from 5-100 kW (Raman *et al.*, 2009). River which usually exist in rural or remote areas are likely to provide an alternative energy source to the residents, depending on the requirements for a limited power source grid. Micro hydro, unlike other hydro resources, particularly for large-scale hydro resources does not require large areas for watershed where logging and forest clearance had done great. This can threaten the ecological sustainability. However, the application of micro hydro energy can solve the threat of environmental non-sustainability issue.

Micro hydro has been used to generate and supply power in remote areas as it has been done in Nepal, Bangladesh and Iran (Ghadimi *et al.*, 2011). Determination of micro hydro development depends on three main aspects: the demand for energy; accessibility to the established system and in the profile or the river (Raman *et al.*, 2009). This selection of the river is generally made based on the river with a flow speed to drive the turbine (Ghadimi *et al.*, 2011; Raman *et al.*, 2009).

Besides, micro hydro resources preferred for the rationale of the cost and installation time for this system

works is cheap and fast. Micro hydro has also been used as mechanical energy directly to small industries and agriculture such as generating energy for welding workshop, processing and milling wheat crops in developing countries (Penche, 1998). Further, the facility to choose the potential to generate a micro hydro energy is easier than others because the hilly terrain and natural water was available and ideal sites for micro hydro system developed (Wazed and Ahmed, 2008).

According to Razan *et al.* (2012), the presence and use of micro hydro has been able to bridge the gap between the demand and the amount of energy that can be provided to people living in remote areas. In fact not only the micro hydro power can provide energy in remote areas, however, this energy is able to overcome the problems and needs of the population in the hilly regions when generating electricity grid are found to be economical to use (Raman *et al.*, 2009; Adhau *et al.*, 2010). The study, conducted by Pigaht and van der Plas (2009) showed that education is growing and the increased generation and aims to produce skilled manpower in the field of energy generation in particular expertise in micro hydro as in Rwanda after using micro hydro resources. Drinkwaard *et al.* (2010) also added that micro hydro has the greater potential than other renewable energy sources such as wind power or solar energy. These factors imply that micro hydro is sustainable source of energy resource. Micro-hydro resource has great potential as an alternative to meet energy requirements. In addition, Greenhouse Gases (GHG) emissions are very low throughout the operating micro hydro system is Drinkwaard *et al.* (2010). If this potential is fully utilized, micro hydro has capacity to generate environmental friendly energy types so that can maintain ecological sustainability.

POLICY AND STRATEGIES IN PROMOTING RENEWABLE ENERGY SOURCES

The Malaysian energy sector mainly depends on fossil fuels as energy sources. However, these energy sources are significantly contributing to the emission of greenhouse gases (Rahman and Lee, 2006). Moreover, fossil fuels reserve is not long lasting. The scarcity of fossil fuel motivates the Malaysian government to shift the energy policy towards the alternative sources of energy. The energy security and environmental issues encourage the government for utilizing various sources of energy (Sebitosi, 2008; Kaygusuz, 2011).

As a result of Malaysia introduced the "Four-Fuel diversification strategy" in 1980 in order to address the concern of energy security. The strategy aimed to

Table 5: Share of energy sources in the energy sector

Sources	1980 (%)	1990 (%)	2000 (%)	2003 (%)
Oil	87.9	71.4	53.1	6.0
Natural gas	7.5	15.7	37.1	71.0
Hydro	4.1	5.3	4.4	10.0
Coal	0.5	7.6	5.4	11.9
Biomass	-	-	-	1.1

BioGen (2003)

develop this alternative energy and encourage the use of natural gas and coal so that reduces a heavy dependency on oil (Hashim and Ho, 2011). As a result of this strategy, the contribution of oil in the energy mix has drastically dropped from 88% in 1980 to 6% in 2003 while the share of natural gas, hydro and coal increased to 71, 10 and 12%, respectively. This scenario shows that Malaysia has reduced energy dependency on oil during this period (Table 5).

Renewable energy was introduced in Malaysia by the government through “Five Fuel Diversification Policy” during 8th Malaysia Plan (2001-2005). It is a way and strategy to introduce renewable energy as the fifth fuel and as an alternative for energy supply to replace traditional energy sources (Mustapa *et al.*, 2010). Malaysia also put initiative by introducing Renewable Energy Act 2011 in 27 April 2011 by establishing and implementing tariff system mechanism to enhance renewable energy generation (SEDA, 2011).

Government of Malaysia (GoM) has taken some initiatives and incentives to support renewable energy development. To this end, project such as Small Renewable Energy Programme (SREP) was formulated as a key project in 8th Malaysia Plan (Mustapa *et al.*, 2010). SREP was introduced to utilize renewable energy resources including biomass, biogas, municipal waste, solar, mini hydro and wind energy (Sovacool and Drupady, 2011; Muhammad-Sukki *et al.*, 2011). One of the objectives of SREP is to identify the waste energy potential from the palm oil industry which is one of the largest agricultural sectors in the country. Then, the project functioned as a technological learning in promoting innovation for Malaysia like small scale hydro, solar photovoltaic panels and waste incineration.

Similarly, one of the popular initiatives in renewable energy development is FiT scheme or FiT mechanism which had been implemented under SREP. The FiT can be defined as electricity export promoter and as a good investment (Chua and Oh, 2012). According to SEDA (2011), some of the advantages of using FiT mechanism are getting the benefits which related to economic issues such as creating employment opportunity and increasing gross national income of the country from renewable energy industry (Table 6).

Table 6: Advantages of FiT

Variables	Description
Economic	Green jobs creation Drive economic development Create stable conditions for market growth
Political	Demonstrate commitment to RE deployment Create mechanism for achieving RE and emissions reduction targets Increase the stakeholder base supporting RE policies
Social	Increase energy security and autonomy Fairer wealth distribution and empower citizens and communities Increased public support for renewables through direct stake and increased exposure to renewables Encourage citizen and community engagement in activities protecting climate and environment Make RE a common part of the landscape and cityscape
Environment	Encourage energy efficiency measures Reduce dependency on fossil fuels Reduce carbon emission and pollutions

Mendonca *et al.* (2009)

CONCLUSION

Renewable energy resource is a key player for sustainability of energy supply alongside with preserving environmental well-being and reducing carbon emissions. Moreover, the development of renewable energy source is the best alternative for improvement of rural livelihood. Furthermore, the sector considered as the plausible potential energy sources in Malaysia that can fulfill the increasing energy demand of the country with huge potential to be developed. The potential of this energy source can be further enhanced through research and development (R&D) and provision of cheaper technology for the sector. In addition to R&D, initiatives such as financial support and adequate policy could attract more investment in renewable energy and increases participation of private sectors. The participation and synergy of private sectors, NGOs and local community is needed for proper utilization of renewable energy resource and realization of sustainable environment. To promote renewable energy sources in addition, increasing public awareness plays a vital role.

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