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Future Green Energy for Environmental Sustainability and Energy Efficiency

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Abstract: The shortage of primary energies has had a significant impact on industry players, especially in the energy sector. To achieve environmental sustainability and improve energy efficiency, energy sector players must plan for green energy resources. Hence, the utilization of renewable energy in electricity distribution for future green energy is a popular topic worldwide. As a result, there will be less need for coal, oil, and natural gas. Additionally, renewable energy sources can replace fossil fuels with less negative environmental effects and naturally replenished supply. Malaysia is striving toward implementing green energy in an effort to handle the problems and challenges, ensure a steady supply of energy, and prevent negative effects on the population and the environment. This paper discusses the potential of solar, biomass and wind energy as Malaysia considers the long-term risk to the sustainability of the environment. In order to safeguard green technology for future generations, challenges and concerns regarding renewable energy would inspire more participation from individuals, researchers, policymakers and utility businesses.

Key words: *Green Energy, Renewable Energy, Environmental Sustainability, Energy Efficiency*

1.0 Introduction

Energy is a critical factor in environmental sustainability as well as social and economic growth. The level of energy consumption is an indication of the economic prosperity and modernization of a nation. However, increasing energy consumption has an adverse impact on the environment. In addition, the uncertain prices of primary energy resources have been growing as a major issue and challenge. Therefore, in an effort to sustain economic growth, Malaysia eats up a huge portion of the practice of green technology towards achieving environmental sustainability. Clearly, the introduction of more renewable sources has become essential for energy planning, resource optimization and environmental protection (Mustapa, Peng, & Hashim, 2009; Smith, Sen, Kroposki, & Malmedal, 2010)

Malaysia is fully dependent on fossil fuels that generate enormous amounts of pollution. The depletion of energy resources has shifted the current approach to green technology methods. Appropriate planning based on green energy technology must be taken to continuously develop a country. Therefore, to promote the use of renewable energy (RE), the fifth fuel diversity policy was introduced in 2001. Since there are readily available resources and crucial geographical factors, Malaysia has given the emphasis on RE such as biomass, wind, and solar as well as including marine resources along the coastline of the South China Sea and Straits of Malacca (Kai et al., 2021; Moghavvemi et al., 2017; Mushtaq, Maqbool, Mat, & Ani, 2013). Energy sources are considered renewable sources that can be replaced in short term. In 2020, the energy industries have to cater for continuous demand and supply in achieving a target to develop green building and to stimulate green growth (Amran et al., 2020). A growth rate of 5.3% is projected for energy output from 2005 to 2030 (Tan, Maragatham, & Leong, 2013). For the benefit of humanity, aggressive efforts should seriously alter the economy and population.

In accordance with the Renewable Energy Act of 2011, the Malaysian government takes action by implementing the National Energy Policies to reduce its reliance on fossil fuels (Jalal & Bodger, 2009). The National Green Technology Policy and the Renewable Energy Policy and Action Plan were then introduced. In Renewable Energy Act, the Small Renewable Energy Project (SREP) and Feed-in-Tariff (FiT) programme have been promoted. Therefore, this paper discusses the solar, wind and biomass energy that are identified as high potential and commercially viable to apply in Malaysia.

2.0 Malaysia energy status

Malaysia increased its overall commercial energy supply from 2003.1 petajoules (PJ) to 2526.1 PJ from 2000 until 2005. According to Table 1, it is anticipated to reach 3127.7 PJ in 2010. In 2005, crude oil and petroleum products (46.8%), coal and coke (9.1%), and hydro (2.8%) were the main sources of energy supply (fuel mix).

According to the Fuel Diversification Policy, the share of crude oil and petroleum products dropped to 44.7% in 2010 while the share of other energy sources rises. The situation is the same for electricity generation, which depends on oil dropped to 0.2% in 2010 while dependence on coal rises to 36.5%. From 69,280 GWh to 137,909 GWh, total power generation is projected to rise dramatically (nearly double), as shown in Table 2.

Table 1
Primary commercial energy supply by source, Malaysia, 2000-2010

Source	Petajoules			Average annual growth rate	
	2000	2005	2010	8MP	9MP
Crude oil and petroleum products[a]	988.1 (49.3%)	1181.2 (46.8%)	1400.0 (44.7%)	3.6%	3.5%
Natural gas[b]	845.6 (42.2%)	1043.9 (41.3%)	1300.0 (41.6%)	4.3%	4.5%
Coal and coke	104.1 (5.2%)	230.0 (9.1%)	350.0 (11.2%)	17.2%	8.8%
Hydro	65.3 (3.3%)	71.0 (2.8%)	77.7 (2.5%)	1.7%	1.8%
Total	2003.1 (100%)	2526.1 (100%)	3127.7 (100%)	4.7%	4.4%

Source: 9MP 2006-2010, Table 19-3.
[a] refers to supply of commercial energy that has not undergone a transformation process to produce energy.
[b] excludes flared gas, reinjected gas and exports of liquefied natural gas.

Table 2
Fuel mix in total electricity generation, Malaysia, 2000-2010

Source	2000	2005	2010
Oil	4.2%	2.2%	0.2%
Coal	8.8%	21.8%	36.5%
Gas	77.0%	70.2%	55.9%
Hydro	10.0%	5.5%	5.6%
Other	0.0%	0.3%	1.8%
Total (GWh)	69,280 (100%)	94,299 (100%)	137,909 (100%)

Source: 9MP 2006-2010, Table 19-5.1

According to C.S. Chyi et al. (2010), the oil and gas reserves of Petronas (the national oil corporation of Malaysia) in Malaysia were 20.18 billion barrels equivalent. The government of Malaysia predicts that oil will be produced for up to 18 years and gas for 35 years. As a result, Malaysia's oil reserves would run out around 2030, having an impact on energy-related industries including transportation and industry. Furthermore, by the end of the 2030s, Malaysia is predicted to become a net energy importer (ASM Advisory Report, 2013). The government is considering boosting the use of coal in the electricity generation industry due to the depletion of primary energy resources. However, it is anticipated that carbon emissions will increase as coal replaces natural gas because burning any carbon-containing material, including fossil fuels, produces greenhouse gases. In order to keep the atmospheric concentration of carbon dioxide from rising more than 2 degrees Celsius, a cap on carbon dioxide was imposed at 450 ppm (parts per million). The amount of carbon dioxide in the atmosphere has surpassed 400 ppm over this century, nevertheless.

Malaysia maintains its promise to reduce carbon intensity by 45% in 2030, subject to restrictions on technology transfer and financial support. Prior to that, Malaysia pledged to cut its CO2 emissions by 40% by 2020 (Jurutera, 2016). In addition, a cleaner or greener alternative energy source aids in having distinct aims for the problems. In order to ensure sustainable development, vigorous efforts must be made to increase the amount of renewable energy in the energy mix (Zhang & Li, 2014). Therefore, the government is encouraging industries to commit to creating renewable energy technologies for sustainable life in order to promote a better environment and achieve energy security in the nation. Accordingly, the Malaysian government has created a number of initiatives and programmes to encourage energy efficiency. The Malaysia National Energy Policy directs Malaysian energy development based on supply, usage and the environment.

Economic Planning Unit (EPU) estimates that Malaysia's electricity growth climbed to 3.52% from 3.48% in 2012 and 2011 correspondingly. Until 2020, 3.2% growth is anticipated. The expected rise in Malaysia's energy production from 87,306GWh in 2005 to 314,984GWh in 2030 is 5.3% per year (EPU, 2012). Given that Malaysia wants to become a developed nation by 2020, there is a good chance that Malaysia will have a significant impact on how much energy is used in the nation. Planning for RE technology is essential if Malaysia is to advance new technologies and prosper more quickly, and Malaysia should give considerable consideration to renewable energy sources.

The government made a limited commitment to energy policy in the Tenth Malaysia Plan (10MP) 2011-2015 by placing a strong emphasis on energy efficiency, which is intended to increase energy security and reliability. About 332 MW of installed RE capacity was reached. 2015 saw a 43% coal, 40% gas, 14% large hydro, 2% renewable energy, and 1% oil energy mix.

The development of renewable energy was then accelerated by the construction of a new generating capacity in Peninsular Malaysia under the Eleventh Malaysia Plan 2016–2020 (11MP). The target RE capacity is to be 53% coal, 29% gas, 15% big hydro, and 3% RE by 2020. As depicted in Figure 1, Peninsular Malaysia has implemented RE resources such as biomass, biogas, solar PV, and micro hydro.

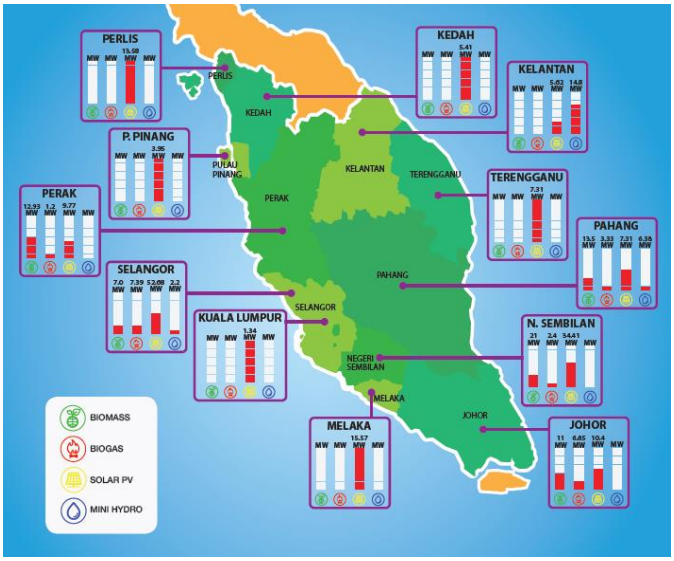

Figure 1: *Peninsular Malaysia RE projects*

More than 90% of Malaysia's energy is derived from fossil fuels (coal, oil, and natural gas), with the remaining 10% or so coming from renewable resources including hydro, biomass from oil palm plantations, and biogas from palm oil mills (Norhalim et al., 2020). According to the International Renewable Energy Agency, a global shift toward RE sources is required to meet the growing demand for energy worldwide. Since the share of non-RE sources will drop to 15% while the RE share rises to 85% by 2050, access to the RE portion of the generating mix is crucial for more affordable electricity and ongoing progress in the nation's electrical infrastructure (Gielen et al., 2019).

For this, it is anticipated that between 2020 and 2040, there will be an increase in the population of between 33 million and 41.5 million, which will be required for the provision of energy necessary for a sustainable way of life. Malaysia is motivated to research RE technology and save the environment with finite resources (Choong, Ang, & Ng, 2014). With this enormous estimate, Malaysia's government will be forced to take action to lessen its reliance on fossil fuels. In recent years, hydropower (12%), solar PV (22%), and wind (36%) have been the main contributors to RE. Malaysia has the potential to embrace the global transition to more sustainable and clean renewable energy (Energy Malaysia, 2018). Recently, MESTECCs' 2019 has announced a pledge to increase the share of renewable energy (RE) in electricity generation from 2% to 20% by 2025, thereby expanding the green and efficient energy industry

(MESTECC, 2019).

3.0 Renewable energy potential in Malaysia

The world has to consider the various forms of natural energy that are currently available. Our energy-hungry lifestyle may be contributing to global warming, so we should investigate more environmentally friendly energy sources. Malaysia has taken a number of measures to support the growth of renewable energy. Due to price volatility, resource depletion, and environmental concerns, careful thought is required. A general definition of renewable energy is energy sources that never run out.

On the other hand, because they are resources that are almost unaffected despite being used consistently and in vast quantities, renewable sources offer a good chance for sustainability. Additionally, as shown in Figure 2, Malaysia has a wealth of renewable energy resources that can be developed using the appropriate power producing methods. However, some of these RE resources, such as wind, wave, and tidal power generation, have very little capacity or no potential in Malaysia. Therefore, to reduce the use of fossil fuel power plants, vigorous research and development (R&D) need to investigate alternative energy. In the future, RE will be able to provide a significant amount of energy to meet the daily peak load (Farret & Simões, 2006).

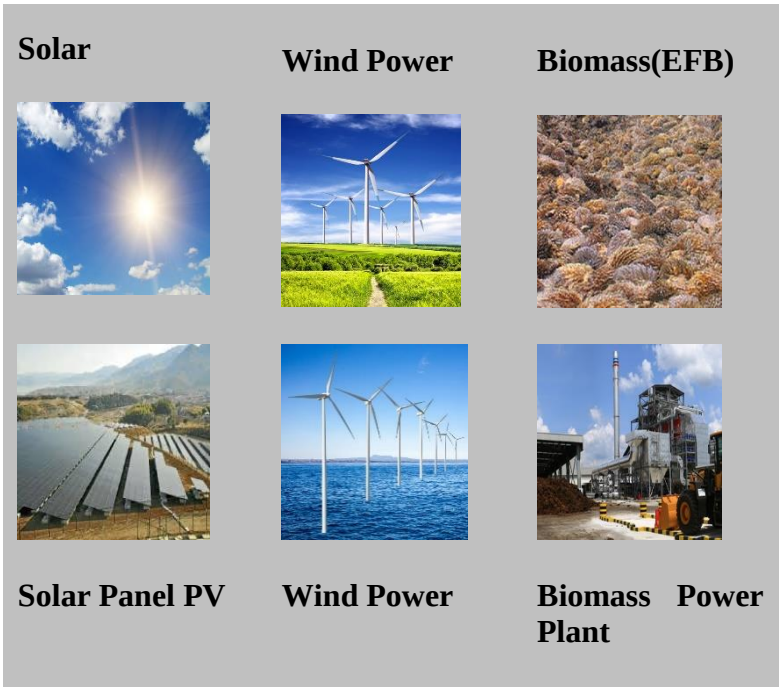

Figure 2: *Among RE resources available in Malaysia*

Table 3 displays the potential for renewable energy resources in Malaysia as determined by a recent research study. By 2040, it is anticipated that renewable energy sources will provide 50% of the world's energy (Mustapa et al., 2009).

Table 3
Renewable energy potential in Malaysia (http://www.wisegeek.com)

Renewable Energy Resources	Potential (MW) (Annual)
Solar PV	6,500
Biogas	410
Municipal waste	400
Total	7,310

4.0 Malaysia turn to a greener environment in electricity production

In order to reduce our heavy reliance on fossil fuels, it is crucial to shift to greener forms of electricity generation. A sustainable greener environment can be built on the foundation of green energy. Green energy is energy that is produced with less harm to the environment than other energy sources, such as fossil fuels, which are frequently produced with negative side effects. The earth can be preserved for a longer period of time with as little pollution as possible produced as a byproduct.

Activities including the creation of alternative fuels, the generation of renewable energy, and the application of technologies to lessen the environmental effects of conventional energy are all considered to be part of clean energy. For homeowners, companies, and governmental organisations, green energy offers all-encompassing energy solutions that help them cut utility costs, lessen their negative environmental effects, and increase their energy independence and reliability. In addition to providing an alternative to fossil fuels, renewable energy technologies like wind turbines, solar photovoltaics (PV), and biomass heaters can also assist in cutting CO_2 emissions.

Making existing fossil fuel energy technology cleaner so it may be produced more cleanly is one of the objectives of green energy technology. Scientists are attempting to find ways to obtain energy from coal and other fossil fuels without all of the negative side effects. This is one such example of clean coal technology. The capacity to remove undesirable byproducts from fossil fuels while being both energy and financial efficiency is essential for the success of various kinds of green energy (ESSPA, 2009). There are also financial advantages. Investing in renewable energy technologies now essentially amounts to pre-purchasing electricity at current rates for a time when energy prices may be significantly higher.

The fossil fuel model is no longer viable. We are compelled to switch to a new energy system. It's time to take this seriously and be unreasonable and implacable. However, this restriction must only be selective because the creation of a new system, which requires intellect and order, is our top priority. A high and consistent price for carbon is necessary, but a worldwide market is also required for that price to produce solutions for renewable energy, carbon capture, and avoided emissions. If not, we will be left alone to wait out the super-hurricanes and rising waters in the frigid darkness.

4.1 Solar Energy

The sun generates solar energy, which is then converted into electrical current. Solar energy is one of the most significant renewable energy sources that not emit CO_2 in the process of electricity generation. According to the Ministry of Energy, Water, and Communications (MECW), solar energy has good potential for about 1.25 GW is the target for solar PV by 2020. Malaysia is seeking for alternate methods to power their lives by using solar energy as Malaysia receives an abundance of sunlight throughout the year. This is because of the current concerns about global warming and the rising cost of electricity.

According to statistical research, Klang Valley in Peninsular Malaysia has the lowest solar radiation measurements, whereas the northern and central regions of the country have the greatest values. Despite having some of the lowest levels of solar radiation in the world, Malaysia's government has implemented policies and incentives to encourage the use of solar energy, including solar PV, the Feed-in Tariff, and a programme on solar energy for the future because of its potential for energy security and sustainability.

Photovoltaic (PV) and solar thermal systems are two distinct technologies that convert solar radiation into electrical current. To encourage the use of solar electricity in the generation of electricity, Malaysia has announced the Malaysia Building Integrated Photovoltaic (MBIPV) project under the Renewable Energy (RE) Policy. The most significant end-uses that provide cost-effective prospects to replace electricity with solar energy are lighting, space heating, and water heating. PV-generated energy has some uses, including as lowering peak demand and, to a limited extent, serving as a beneficial choice for the nation.

4.2 Wind Energy

Wind energy is one of the RE resources that available in Malaysia. Wind is a form of solar energy. The uneven heating of the atmosphere by the sun, the imperfections of the earth's surface, and the earth's rotation all contribute to wind. Wind turbines are necessary for the process of producing wind energy because they transform kinetic energy into mechanical power, which is then transformed into electrical energy by a generator. In Malaysia, the speed of wind energy is thought to be less than 5.9 m/s. East Peninsular Malaysia has the highest wind speeds. Even though Malaysia only has light and erratic wind flow, this wind flow pattern offers a significant deal of potential to meet the needs in energy generation.

According to Malaysian Meteorological Department, the wind flow patterns is depend on the changes of four seasons, namely the southwest monsoon, northeast monsoon and two shorter periods of inter-monsoon seasons. It is estimated about 50% of the household load requirement can be fulfill by using this system. However, this system is employ high cost. Thus, sufficient information is necessary before installing a large scale of wind turbine system. One of the designs for the turbine known as HAWT is shown in Figure 3.

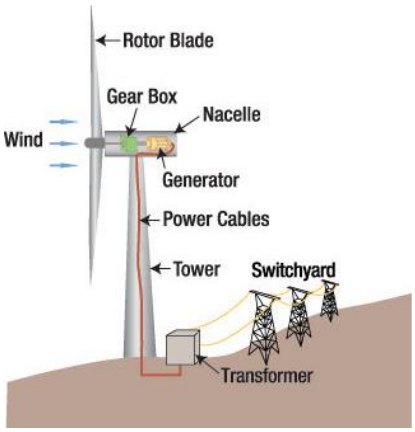

Figure 3: *Horizontal axis wind turbine*

4.3 Biomass Energy

There are numerous waste types in the world that can be used to create energy. In general, more than 10 different types of garbage can be used as biomass resources to provide renewable energy that is useful for transportation, heating, and lighting. Biomass is defined as biological material that comes from living things like plants, animals, microorganisms, by-products, leftovers, and waste from the agricultural, industrial, and municipal waste streams. Over 20.8 million tonnes of biomass waste are generated in Malaysia every year. The three methods of thermal, chemical, and biological conversion can all be used to turn biomass energy into biofuels.

The second-largest producer of crude palm oil worldwide is Malaysia. Pahang, Johor, Sarawak, and Sabah account for more than 75% of the world's oil palm plantations, which produced 10% of the oil and 90% of the biomass. Around 80 million dry tonnes of biomass were produced by the palm oil sector in 2010. Empty fruit bunches from palm oil plants are Malaysia's main source of biomass. EFBs, or empty fruit bunches, made up almost 70% of the overall production, or 16.6 million tonnes. These waste materials might be converted into liquid fuels or burned to create power. As a result, the Malaysian government supports biomass energy systems with producing capacities of up to 300 MW and 100 MW, respectively, as indicated in the 10 Malaysia Plan.

The 14MW TSH Bioenergy Sdn Bhd, located in Tawau (Sabah), is the largest biomass power plant in Malaysia and uses waste fruit bunches, palm oil fibre, and palm kernel shell as fuel sources. Teluk Intan is home to a second biomass power plant (Perak). Rice husk fuels the 1.5 MW Titi Serong power station in Parit Buntar (Perak), whereas the 10 MW Perlis biomass power plant also employs rice husk as its primary fuel source.

5.0 Discussion and Conclusions

There is no more room for fossil fuels. From 2005 to 2030, the expected growth rate for energy production in Malaysia is 5.3%. As a first step, Malaysia must make more active efforts to improve the use of energy in our household, commercial, transportation, and industrial processes. At the same time, we must make the switch to more renewable energy in order to guarantee sustainable cities and a variety of fuel sources. The use of renewable energy

technology helps to reduce carbon dioxide emissions, which greatly prolongs the life of the planet and enhances living standards. The findings of this study indicate that Malaysia has the most exciting potential for the development of renewable energy. The government has offered numerous incentives to encourage investment in renewable energy in order to support green technology programmes. Our objective is that the potential and opportunities for RE in Malaysia would spur increased involvement from people, researchers, decision-makers, and utility corporations in the use of renewable energy sources for a balanced approach to development. To achieve sustainable development and improve energy efficiency, it is necessary to be innovative and resilient. In addition to this study, green cities have been promoted to all Malaysian citizens, including institutionalised groups, in order to achieve the goals of energy efficiency and reduced environmental effect. We can exert our own efforts in order to succeed by using strategies like:

i. Disconnecting electronics while not in use.
ii. Upgrading appliances 5-star5 star energy efficient.
iii. Insulating the roof will help reduce energy costs and keep the house cooler.
iv. Reserving the use of air conditioners for extremely hot or humid days.
v. Using ceiling fans can save money and the environment.
vi. Use compact fluorescent (CFL) or light-emitting diode (LED) lamps in place of incandescent ones.
vii. Conserve water by turning off the faucets and washing automobiles with a bucket rather than a hose.
viii. Use a laptop rather than a desktop
ix. Reduce printing.

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