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An Overview of Renewable and Non-Renewable Energy Demand as Well as Development Status in Malaysia

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Abstract

In the past few decades, Malaysia has experienced a rise in economy with steady growth of gross domestic product (GDP) yearly. As a fast-developing nation, this country is in its final stages toward the goal of high-income status. This economical and development boost also signal the rise in energy demand. As such, securing energy sustainability is essential for any nation, especially for one developing as fast as Malaysia. Malaysia has seen a huge growth in energy demand for the past few decades, and that growth is expected to continue into the future. This ever-growing demand within Malaysia has mostly been met by non-renewable energy sources such as fossil fuels, due to the fact that the nation has an abundance of availability of these resources. However, the threat of climate change and depletion of these non-renewable sources has forced the government of Malaysia to look towards alternative clean energies for future energy security, mainly renewable energy. Many policies have been enacted to develop and promote the use of renewable energy; researches for nuclear technology and infrastructure have also been made for the possibility of another source of clean energy. This report aims to discuss the energy demand and sustainability development of renewable and non-renewable energy in Malaysia through the projects and policies enacted, as well as future plans. Nuclear energy will also be covered in the report to analyze the potential and issues regarding the production of nuclear energy.

Keywords

Renewable; Non-renewable; Energy sources

Introduction

The development and sustainability of modern society relies heavily on the availability of energy. As a key input to nearly every other consumptions and production processes, energy is an essential element in determining and controlling growth of every nation through social and economic development, and with it an improved quality of life. With an ever-continuing global modernization, the growth in consumption and demand for energy is expected to follow suit. In 1990, an estimated 1 billion gigawatts were consumed worldwide; in 2014, almost 10 billion gigawatts of energy were consumed [1]. In 2017, the energy demand globally increased by 2.1%, more than double the rate recorded in 2016 [2]. Thus, as globalization continues, energy consumption and demand will grow with it. In general, the sectors of the world that consume and demand energy can be differentiate to: industrial, residential and commercial, transportation, and others [3]. The sources of energy which supply the world's, and by that these sectors' demand can be categorized into two main groups: renewable and non-renewable. Non-renewable energy is generated from a source that would eventually deplete.

The most common source for non-renewable energy is fossil fuels; while many in abundance, are of finite availability [4]. On the other hand, Renewable energy is produced from sources that are naturally and continuously replenished. These sources include wind, solar, hydro, geothermal, and other natural processes that occur on the planet [5]. In 2015, the World Energy Council reported that oil, coal, and natural gas accounted for 32.94%, 29.20%, and 23.85% respectively to the global energy consumption. Nuclear accounted for 4.44% and the rest from renewables, with hydro the highest at 6.79%, followed by wind and solar at 1.44% and 0.45% respectively [6]. It is clear that the world still relies heavily on fossil fuels to meet its high demand; however, with the threat of climate change due to emissions from fossil fuels, the transition to renewables is vital. As such, there has been a significant growth within the renewable energy sector. The IEA reports that the share of renewables to meet the global energy demand will increase by a fifth each year until 2023, with 12.4% of the total energy demand met by renewables by the end of the forecast period [7]. China and India will lead the swift deployment of solar photovoltaics (PV). Through this, it is expected that by 2040 solar will be the biggest source of low-carbon capacity. In the EU (European Union), 80% of new energy capacity comes from renewables,

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with wind power to become the primary source of electricity after 2030 from the high growth of onshore and offshore technologies [8]. However, renewable energy is still not able to sustain the high and ever-growing energy demand of the world. It is estimated within the next two decades the global energy demand will rise by 30% in comparison to today. Thus, the energy demand from fossil fuels will still be strong, albeit at a decreasing rate with the expected rise of renewables.

South-East Asia is a region with high energy demand, its energy needs increasing at a rate double that of China [9]; Malaysia as a developing nation contributes to this. An abundance and sustainable energy supply are fundamental aspects to establish and ensure stable economic growth and societal progression, especially for a developing nation such as Malaysia with a goal towards high-income status. In South-East Asia, one of the fastest growing economies within this region is Malaysia [10]. Between 1990 and 2011, a steady growth at an average of 5.8% annually was observed for Malaysia's gross domestic product (GDP). As a fast-developing nation, the growth of energy demand will follow the trend set by the growth of GDP. Within the mentioned period, the primary energy supply has increased steadily; with future energy demand in the next 20 years expected to grow at a rate of 5 to 7.9% annually [11].

This report aims to analyze renewable and non-renewable energy demands in Malaysia, as well as its sustainability and development. Section 2 will discuss the energy consumption and demand of Malaysia, by sources and sectors. This section will also examine non-renewable and renewable energies in Malaysia, covering their current projects and productions, as well as future developments and sustainability. Section 3 will conclude this report with the nuclear debate; whether nuclear energy is a viable option as a source for future implementation.

Overview of Energy Demand and Consumption in Malaysia

Non-renewable energy

Malaysia is a country blessed with natural resources such as fossil fuels, it should come to no surprise that the primary energy supply in Malaysia is mostly generated by fossil fuel sources. However, the dependence on these sources has raised issues within the Malaysian government in terms of future sustainability. In 1981, the Four-Fuel Diversification Strategy was enacted to counter the heavy use of oil for primary energy generation. This policy was introduced to reduce the nation's overdependence on oil for energy supply by adding coal, natural gas, and hydropower into the fuel mix [12]. Oil energy supply has been significantly reduced due to this act. In 1990, crude oil generated 61.1% of the total energy supply; by 2008, the number has dropped down to 38.2%. Natural gas has compensated the energy supply gap left by crude oil, and became the main energy supplier with 43.4% of total energy generation in 2008. In the same year, coal contributed 15.3% and hydropower at 3.1% [11]. Even with the decrease in energy supply, crude oil still dominate the energy generation market in Malaysia alongside natural gas, and both are still expected to majorly contribute to the primary energy supply mix; as evident by Figure 1 and Figure 2.

Figure 1 shows the primary energy supply in Malaysia between 2010 and 2016, while Figure 2 shows the percentages of the primary energy supplies generation by 2016. Both figures show the heavy dependence Malaysia has on crude oil and natural gas to supply its energy. However, with increasing oil prices, the nation has recently further shifted its focus from oil towards coal. Since 2010, around 80 to 90% of energy capacity installation comes from natural gas and coal. Malaysia's reliance on coal for energy supply is apparent by its constant growth in primary energy supply, as evident in Figure 1. This dependence is expected to continue as a demand growth of 9.7% yearly is forecasted until 2030. This is due to the future projection of reducing reliance on natural gas, with steady gas turbines retirement as well as developments for new generation coal plants [13].

Dependence on fossil fuels has consequences towards future energy sustainability and security, as well as the high contribution to climate change. Climate change is considered one of, if not the greatest threat the world is facing today. It is defined as the steady change in the planet's climate and physical geography that follows the rise in Earth's average temperature [14]. Most climate scientists agree that the cause is due to human activities, such as the combustion of fossil fuels [15]. As such, the switch towards renewable energies is necessary, especially considering the highest renewable source contributing to Malaysia in 2016 was not even 5% (Figure 2). In 2002, the Four-Fuel Diversification Strategy was expanded to the Five-Fuel Diversification Strategy by adding renewable energy as a fifth fuel of the mix. Under the Third Outline Perspective Plan (2001-2010) and the 8th Malaysia Plan (2001-2005), this policy was introduced to boost the switch and use of renewable energies, such as solar and biomass [16].

The energy demand in Malaysia is split into four main sectors: industrial, residential and commercial, transport, and agriculture. The non-energy sector meanwhile covers those that use the energy sources as raw materials and are not utilized as fuel or converted into one [8]. Figure 3 shows the energy demand between 2006 and 2016 by gigawatt hour (GWh), while Figure 4 shows the final energy demand in 2016 by percentage.

In any developing or developed nation, the energy consumption has always been mostly dominated by the industrial and transportation sectors, Malaysia is no different. There was a significant growth in energy demand by the transportation sector between 2006 and 2016, as shown by the graph in Figure 3; from 172,000 GWh in 2006, to 280,000 GWh in 2016, an almost 62% increase of demand within this period. By the end of this period, it dominated the final energy demand in Malaysia with 42% utilized within the transportation sector alone, as evident in Figure 4. This is partly due to Malaysia's growing economy, which allows the population more affordable and accessible ways for private vehicle ownership. In the industrial sector, the manufacturing companies contribute heavily to Malaysia's energy demand.

In 2014, the industrial and manufacturing sectors consumed a whopping total of 132,861 GWh of energy [17]. Figure 5 shows the segregation by sub-sectors within the industrial sector. Iron and steel, and non-metallic mineral comprise nearly half of the total consumption within the industrial sector, which is to be expected

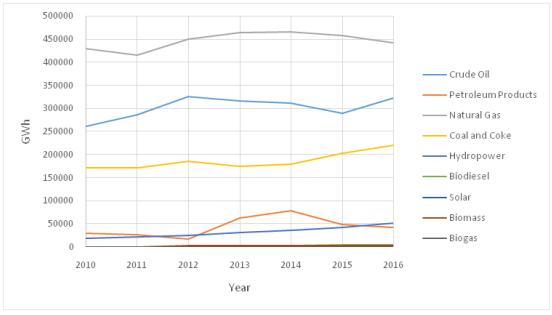

Figure 1: Primary Energy Supply in Malayasia 2010-2016

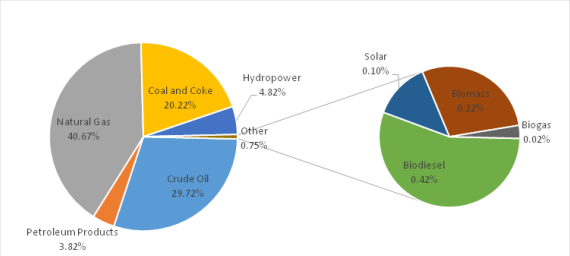

Figure 2: Final Primary Energy Supply by Percentage in 2016

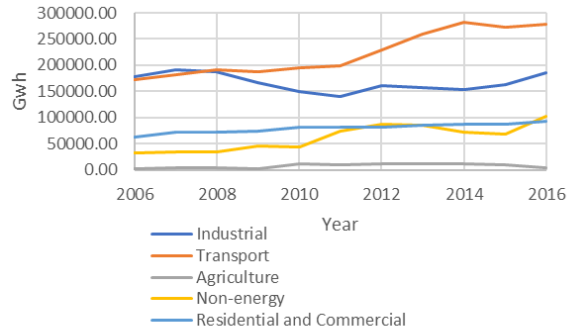

Figure 3: Energy Demand by Sectors in Malaysia 2006-2016

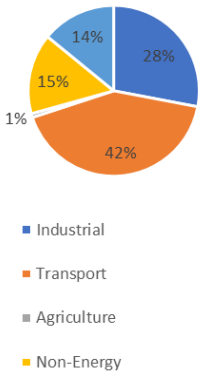

Figure 4: Energy Demand by Sectors in 2016

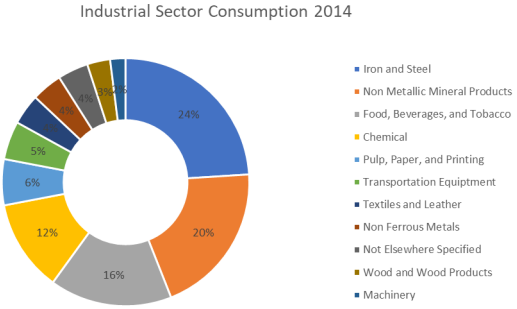

Figure 5: Industrial Sector Consumption 2014

as these processes are very energy intensive. The expansion of the manufacturing and industrial sectors goes hand in hand with a growing economy; with increasing GDP, growth in the manufacturing sector is expected to follow suit, thus increasing energy demand [18].

Renewable energy in Malaysia

Fossil fuel depletion and climate change has forced nations around the world to seek out alternatives to secure future energy sustainability. Renewable energy is seen as the best alternative to solve this growing problem globally, Malaysia included. Renewable energy sources are free from greenhouse gas emissions. It is also able to provide energy to off-grid rural areas in an otherwise situation where grid extensions would be impossible. The Malaysian government has made pushes for renewable energy through numerous policies and initiatives, in an effort to further develop and integrate renewable energy significantly to the energy mix [19]. The three main renewable energy sources with very high potential in Malaysia are hydro, solar, and biomass. This is to be expected with Malaysia's geographical advantages (abundance of sunshine and many rivers), as well as the big agriculture sector that the country is renowned [18].

Notable policies

To achieve energy sustainability, the aforementioned Five-Fuel Diversification Policy was implemented to introduce renewable sources into the energy mix. This policy was initially proposed with the intent to obtain 5% of the total energy generation from renewable sources by the end of the 8th Malaysia Plan, which was 2005 [20]. Alongside this policy, the Small Renewable Energy Power (SREP) program was launch on mid-2001. This policy was introduced to encourage private sectors to develop renewable energy projects, and thereby assist the progress for the expansion of renewable energy generation in Malaysia [21]. The Five-Fuel project disastrously failed, with only 0.3% achieved by the end of the target year [22]. Under the 9th Malaysia Plan, the policy was reimplemented with goal of achieving an energy output of 500 MW from renewables by the end of 2009. The end result was unfortunately similar, with only 41.5 MW produced, 8.3% of the target and a miniscule 0.19% of the total energy generation [23]. This policy could have failed due to the fact that it faces huge barriers, such as the subsidization of traditional and conventional energy (i.e. oil and gas). This subsidization is a huge challenge for renewable energy, as it diminishes the benefit of low operating cost in renewables. The lack of political support, financing, and technical understanding further stunted the ambition and awareness of the potential and advantages of renewable energy [24].

As a result of this failure, the National Renewable Energy Policy and Action Plan was introduced in 2010 under the 10th Malaysia Plan as a step towards rectification. This policy was launched with the purpose to enhance the application of renewable energy into the energy mix, increase the growth the renewable energy sector, assuring renewable energy generation to be available at feasible cost, and to boost the awareness of the masses on the vitalness of sustainable energy. In 2011, the Renewable Energy Act and the Sustainable Energy Development Authority (SEDA) was introduced as an extension to the previous policy, with a Feed-in Tariff (FiT) program implemented under the supervision and management of SEDA as a way to increase the awareness and use of renewable energies [16].

Hydro and Mini-Hydro

Hydropower is the only renewable source that has a significant contribution to Malaysia's energy mix, small as it may be. In 2016, hydro contributed less than 5% to Malaysia's primary energy supply, as evident in Figure 2, a far cry from 1988 when it reached a peak contribution of 29.3% [25]. Nevertheless, hydropower in Malaysia is still very promising. Due to the country's geographical location, with the vast availability of rivers, access to the sea and coastlines such as the Straits of Malacca, and high rate of rainfall, the sources for hydro in Malaysia are plentiful. It is estimated that the electrical generation potential for hydro in Malaysia is 29,000 MW annually [26]. Presently, Peninsular Malaysia has five major hydropower plants owned by Tenaga Nasional Berhad (TNB), with a total combined capacity of 2507 MW. These plants are located in: Sungai Perak with a capacity of 1220 MW, Kenyir with 400 MW, Ulu Jelai with 372 MW, Hulu Terengganu with 265 MW, and Cameron Highlands with 250 MW. Two more plans are underway in Neggiri and Tekai, with capacities of 300 and 156 MW available respectively. On the other side of the country in Borneo, the Bakun Dam and the Murum Dam in Sarawak, has capacities of 2400 MW and 944 MW respectively. Development for hydro is expected to continue, particularly in Sarawak alongside the Sarawak Corridor of Renewable Energy (SCORE) initiative, a target of 4 GW of hydro capacity is expected to achieve by 2025 [18].

There are many benefits to hydropower plants, such as flood control, electricity to rural areas, irrigation farming, social infrastructure, and local job opportunities. However, it is not without its disadvantages [10]. Large scale hydropower plants have a high initial capital cost. The building of dams also upsets the environment and ecology surrounding it, such as fish migration disruption, changes in water temperature, and many more [27]. As such, small and mini-hydropower appear to be more attractive. Small and mini scale hydropower differ from large scale hydro. Large scale hydropower

plants are able to produce more than 100 MW of electricity, such as the examples mention before. Whereas small and mini scale hydropower plants produces up to 25 MW and less than 1 MW respectively [28]. In Malaysia, mini-hydropower falls in between the small and mini scale classifications, and is defined as (here in Malaysia) a hydro plant that is able to generate up to 10 MW of electricity. These mini-hydro plants reduce the environmental impacts at lower capital and operating costs as compared to the conventional large-scale hydro plants, and is beneficial to communities situated far from electric grids, simultaneously supplying clean and sustainable energy. As of 2016, there are 26 authorized mini-hydro projects with a total capacity of 102 MW. By 2020, the target capacity for mini-hydropower in Malaysia is set to be 490 MW [16].

Solar PV

Solar photovoltaic (PV) is considered an energy source with very high potential in Malaysia, with its strategic location at the equator. Due to this, there are no shortages of solar radiation in Malaysia, with an average of 1643 kWh/m^2 of energy penetrated a year, and more than 10 hours of solar availability daily [29]. With such high promises, the Malaysian government aims to exploit this potential through photovoltaic technology. Between 1998 to 2002, the first six on-grid PV systems were installed by TNB in Malaysia, with capacities varying between 2.8 to 3.8 kWp (peak power output). The first one was fitted on the rooftop of UNITEN (University Tenaga Nasional) in 1998, with a capacity of 3.15 kWp. In the year 2000, the very first Malaysian Building Integrated Photovoltaic (MBIPV) was installed in Port Dickson with a capacity of 3.15 kWp. In November of the same year, another BIPV system was installed with a capacity of 3.24 kWp. By 2005, the on-grid PV systems installed has a total combined capacity of 470 kWp, while off-grid systems have a capacity of about 3 MWp [30].

To facilitate the growth of solar energy in Malaysia, the Malaysia Energy Commission introduced the MBIPV project in July of 2005, which was funded by the United Nations Development Program. The aim of the project was to reduce the cost of BIPV technology in the long term by accomplish a widespread installation of BIPV utilization through building designs and envelopes [31]. The project was allowed to run for five years, and at the end of the period in 2010, BIPV system cost was reduced to RM 19/kWp from RM 28/kWp in 2005 [16].

However, the price of BIPV installation then was still relatively high, with a total system cost of RM 135,000 for a 5 kWp capacity [13]. To combat this, the Malaysian Government implemented the FiT (Feed-in Tariff) scheme to promote the use of renewable energies, not just with photovoltaic [32]. Under this scheme, renewable energy producers are able to sell the electricity produced at a set rate to the national grid [29]. Between 2011 and 2016, this scheme has reduced the overall cost of a PV system from RM 9000/kW to RM 6900/kW, a 23% decrease due to high demand [18]. Between 2012 to 2018, the total installed solar PV has a combined capacity of 381.47 MW [33].

Biomass

Biomass is fuel created from organic material; a source of renewable energy that is able to produce electricity and other types of power [34]. Biomass resources can be found vastly in nature, and can be divided into three categories: wastes (agriculture production wastes, municipal solid wastes, etc.), forest products (wood, trees, logging residues, etc.), and energy crops (starch crops, sugar crops, oilseed crops, etc.) [35]. Malaysia is one of the leading nations in the agriculture sector, with crops ranging from oil palm, rubber, rice, coconut, and cocoa. As such, biomass from agriculture wastes is a very promising source of renewable energy for Malaysia, specifically oil palm. Malaysia is one of the biggest oil palm producers in the world, processing about 71.3 million tonnes of fresh fruit bunch every year. This results in crop residues of about 19 million tonnes yearly, which consists of fiber, shell, and the husk of fruit bunch. It is estimated that Malaysia has the potential of 1300 MW from biomass through oil palm wastes [36].

In 2011, the National Biomass Strategy 2020 (NBS 2020) was launched, marking the commitment from the government for biomass applications. Biomass was also promoted under the FiT scheme, to further enhance the widespread utilization of biomass as a source of renewable energy. By 2015, the installation target for biomass was 330 MW; this was achieved much earlier by 2012, with 504 MW of capacity installed. By 2014, there was a total of 24 major biomass-based power plant installed, with a combined capacity of 729 MW [18].

Summary of renewable energy

There is a vast amount of potential in renewable energy in Malaysia. Through the various policies and initiatives implemented by the government in regards to renewable energy, there seems to be vision for sustainable energy in the future. Explorations into other renewable sources are also being done (such as wind and tidal) to meet the ever growing and future energy demands, with ongoing researches and experimentations in these new potential sources in an effort to bring them into the energy mix [19]. Table 1 shows the general overview of the three main renewable energy sources discussed.

Nuclear

When energy security and future energy sustainability is concerned, nuclear power will be in the conversation due to its high energy output and low harmful emissions. Nuclear energy is produced by steam turbines, heated by the energy released from nuclear fission [37]. Nuclear fission occurs when an atom captures a neutron and is then split apart, which generates energy. This fragmentation also releases neutrons, which would then break apart other atoms, thus creating a chain reaction [38]. Figure 6 illustrates an example of this reaction.

	Hydro	Solar Photovoltaic	Biomass
Electricity supplied as of 2016 (approx.)	50,000 GWh	1000 GWh	2000 GWh
Suitability	Big scale/small scale for rural areas	House/ industry	Industry
Advantages	Flood control, irrigation farming, social infrastructure, etc.	Diverse applications, electric bill reduction, low maintenance costs	Readily available from renewable sources, waste material usage would lead to reduction in landfill disposal
Disadvantages	High initial capital cost, surrounding environmental and ecological impacts	Weather dependent, high space usage	Releases methane gas, inefficient as compared to fossil fuels

Table 1: General overview of hydro, solar, and biomass energy

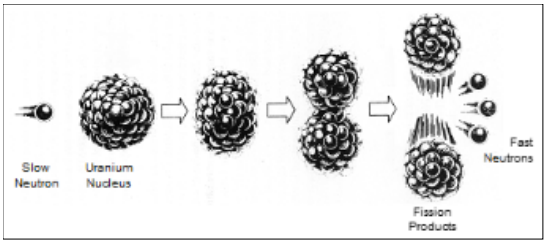

Figure 6: Nuclear fission

The controlled, sustained chain reactions of these fissions generate the energy needed for a nuclear power plant. The most common fuel used for a nuclear power plant is uranium-235, which is abundantly found in the planet's crust [39].

One of the advantages of nuclear energy is the fact that its entire project process (which includes construction, operation, etc.) is incredibly clean. Its greenhouse gas (GHG) emissions is comparable to that of renewable energies [38]. Nuclear power plants are also able to operate for months without any interruptions, unlike its renewable counterparts where the weather may affect its reliability [37].

Controversies for nuclear energy are aplenty to justify the fear of its use, particularly its safety and waste management issues. The Fukushima incident in 2011 and Three Mile Island in 1979 are looked back as arguments against nuclear energy, and with good reasons. The melt downs occurred consequently released radioactivity into the environment, which are incredibly harmful and fatal to human health. The most infamous nuclear accident happened in Chernobyl in 1986, where an explosion happened and released a very large amount of radioactivity, spreading several thousand kilometers. While modern generation nuclear reactors are designed to be safe and avoid past disasters, the fear will be ever present if its safety rate is not a full 100% [39]. While the generation of energy through nuclear has little to no impact towards the environment, its radioactive waste does. At present, there are no proper solutions to handle nuclear waste. Currently the waste is either stored in specifically-built disposal facilities or buried a few hundred meters underground, or attempt and reuse it as fuel. The former solution poses a very high risk to the environment should it accidentally be exposed [40].

Despite the fact that none of the Southeast Asian countries own any nuclear power plants, there are ambitions and developments toward nuclear energy within this region, including Malaysia [41]. Malaysia is one of the only five ASEAN nations to possess a nuclear power research reactor. In 1982, the TRIGA PUSPATI Reactor (TPR) was operational, and to this day remains the only nuclear research reactor existing in the country, which is ran by the Malaysia Nuclear Agency (MNA). While there are no immediate plans for addition of research or nuclear power facilities, the development for infrastructure continues [42]. In 2017, it was reported that Malaysia had adequate knowledge and preparation for nuclear energy, even announcing the introduction of nuclear plants in 2030, which was postponed from 2021 mainly due to the Fukushima incident [43]. In September 2018 however, Prime Minister Tun Dr Mahathir Mohamad has stated that Malaysia is against nuclear power, primarily due to its radioactive waste [44]. While nuclear energy seems very attractive to reduce emissions, the controversies and issues are very apparent. In addition of the public's negative perception and attitude towards nuclear, there seems to be no reason for Malaysia to pursue nuclear energy for the time being, especially considering the high potential in renewable energy yet to be utilized [18].

Conclusion

The demand for energy seems to be ever growing, especially coupled with the growth of economy expected within Malaysia. As of now, the majority of the demands are met by non-renewable sources such as fossil fuels; due to the fact that there is an abundance of these sources available to the country, this trend is expected to continue within the next decade or so. However, the continuous use of these non-renewable resources would cause vulnerabilities in future energy security and sustainability, on the grounds that these sources would eventually deplete as well as the direct impacts it has toward climate change. The threat of these issues has forced the government of Malaysia to implement policies for renewable energy in an effort to develop and integrate them to the nation's energy mix, primarily towards hydro, solar, and biomass. Renewable energy is seen as the future of energy generation, not just in Malaysia but globally as well. There are essentially no emissions when it comes to renewables, and its sources would not deplete. While there is progress in the current and for future developments, it is painstakingly slow even with the vast amount of potential Malaysia have for renewables; it seems that renewables will still have to play a complementary role to fossil fuels within the next coming years.

Embracing and developing alternative clean energy like renewables must take precedence within Malaysia to achieve energy security and sustainability. While the current development and policies in regards to renewables are promising, there needs to be more urgency and awareness for a push towards these energy sources. Investment towards these energies is vital for the future development of renewable energy; not just for hydro, solar, and biomass sources, but other new potential sources as well such as wind, tidal, or even nuclear should Malaysia decides to one day harness its energy.

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