MALAYSIAN ENERGY OUTLOOK

by

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Malaysian Energy Outlook

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DEDICATION

This thesis is dedicated to my parents, Kent and Linda Sue Gardiner, for providing me the opportunity to be myself and to let me grow into the person I am today.

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LIST OF ABBREVIATIONS

Tenth Malaysia Plan	10 MP
Eleventh Malaysia Plan	11 MP
Asia Pacific Economic Cooperation	APEC
Billion Cubic Feet	Bcf
British Thermal Unit	Btu
Copenhagen 21	COP21
Electrical & Electronics	E&E
Energy Information Administration	EIA
Economic Planning Unit	EPU
European Union	EU
Feed-In Tariff	FiT
Gross Domestic Product	GDP
Greenhouse Gases	GHG
Gigawatt Hour	GWh
Human Development Index	HDI
Kilogram	kg
Kilowatt Hour	kWh
Millennium Development Goals	MDGs
Malaysia Plans	MP
First Malaysia Plan	MP1
Megawatt	MW
National Aeronautics and Space Administration	NASA
Net Energy Metering	NEM
Organization of the Petroleum Exporting Countries	OPEC
Photovoltaic	PV
Renewable Energy Directive	RED
Sustainable Development Goals	SDGs
Sustainable Energy Development Authority	SEDA
Trillion Cubic Feet	Tcf
United Kingdom	UK
United Nations	UN
United Nations Development Program	UNDP
United States Dollar	USD

ABSTRACT

MALAYSIAN ENERGY OUTLOOK

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This thesis aims to assess the degree of alignment of the United Nations' seventh Sustainable Development Goal with the Malaysian government's national agenda when it comes to the twin, but potentially conflicting, goals of advancing both clean energy and economic growth. The thesis examines what the Malaysian government has done about energy policy from the country's founding in 1963 to May of 2018 and looks forward into the Eleventh Malaysia Plan for energy policies up to 2020. Analysis of how Malaysia has adjusted its policies over time will allow insight into potential solutions for moving away from using fossil fuels as a source of electricity generation. The Sam Peltzman model is discussed regarding energy policies to gain understanding of social and political perspectives. The Peltzman model evaluates the risk versus reward for a policymaker to support or resist a policy. Interviews are held to gain unique perspectives on the issue and to provide a more comprehensive picture of potential issues for utilizing renewable energy and the challenges for its implementation. Dimensional analysis for

land space compared to energy output is used to determine the feasibility of using palm oil biofuel instead of fossil fuels. Solar energy is considered for its potential towards a cleaner energy profile as well as the potential barriers to implementation such as cost to the consumer. Dimensional analysis will also be used to help determine whether solar energy can meet the domestic demand for the near future.

INTRODUCTION

In the world today, where renewable energy and climate change are constant topics, organizations such as the United Nations (UN) are looking at developing countries, such as Malaysia, for potential blueprints to help achieve the Sustainable Development Goals (SDGs). Both developed and developing countries are encouraged to strive for various indicators laid out for the 17 SDGs to make the world more sustainable for the future (United Nations, 2017). One of those goals, goal number seven, is to incorporate cleaner energy practices by reducing the use of fossil fuels to create electricity and lean more towards renewable energy sources such as solar energy. The UN's course of action stems from two reasons: the first being that as fossil fuel supplies diminish, the price of these energy resources will rise and become a larger burden on developing countries wishing to focus on non-economic factors (UN Energy, 2017). The second reason for the UN's actions is that harmful greenhouse gas (GHG) emissions are produced as fossil fuel energy sources are consumed (UN Energy, 2017). Discourse already exists among international organizations that the world will experience the effects of global warming because of the production of these GHG emissions.

International efforts, such as the Kyoto Protocol and the Paris Agreement, have attempted to bring together countries to combat the overall effects of climate change but no agreement has been accepted by all possible nations. Enforcing the terms of an agreement on this scale will be based on an honor system. These efforts will be easier to complete for some countries compared to others, especially with developing countries

trying to catch up to developed nations on an economic scale. It is this balance between economic drive for national governments and the environmental considerations that will be put to the test soon as the various Sustainable Development Goals will be attempted to help avoid larger climate effects for the future.

Malaysia is a country located in southeastern Asia and borders countries like Indonesia, Thailand, and Brunei. According to the United Nations, Malaysia is a "High Human Development" country which is the second highest ranking given to a country (UNDP, 2015). Factors for the Human Development Index (HDI) include social, economic, and health factors to gauge how a country is developing such as GDP production, lifespan, and education levels. To compete financially with developed countries, the Malaysian government has focused its efforts on using and importing fossil fuels from other countries to focus on their production of electronics and solar panels. Malaysia was chosen as the focus for this thesis because the country can provide a blueprint for other developing nations. The United Nations can observe the challenges Malaysia faces with transitioning away from fossil fuels and incorporate the Malaysian government's actions into future sustainability plans.

Thesis Structure

The takeaway from researching the different Malaysia Plans is to understand where the federal government's priorities lie and how those priorities relate to the current energy and environmental climate. Both sets of priorities come from a resource perspective and an economics perspective. By having parallel policies focused on the promotion of renewable energy, increased science and technology knowledge, and

specialization of economic marketing for exports, the federal government of Malaysia seems to be leaning towards alternative methods of energy production and to distinguish themselves from other trading partners on the international stage. Further in this document is a closer look at how this approach aligns with the prospect of solar panel technology usage, rural electrification, reduction in greenhouse gases, but also how the country's GDP is paramount for both the short and long term. While there is little mention of biofuels over the course of the different Malaysia Plans, palm oil will also be considered in this document due to the abundance of palm oil fields located in Malaysia.

Sustainable Development Goals

United Nations and the SDGs

Beginning in the year 2000, the United Nations along with several other international organizations including the World Bank decided to come together to create a series of goals to achieve by the year 2015 (MDGs, 2015). These goals, also known as the Millennium Development Goals or MDGs, were created to reduce global poverty and focus on better human development (*IBID*). There were eight MDGs in total that range from eradicating extreme poverty and hunger, to achieving primary education, to ensuring environmental sustainability, and to promote gender equality (MDG, 2015). Figure 1 lays out the different MDGs whose goals were intended to be completed by 2015.

Figure 1 - Millenium Development Goals (MDG, 2015)

In September 2015, these organizations came together in New York City for the UN Sustainable Development Summit to not only look back at the MDGs but to also develop a new set of goals to achieve by 2030 (SDGs, 2017). These goals were built on principles agreed in Resolution A/RES/66/288 entitled "The Future We Want" which was a result of the Rio +20 Conference held in 2012 (Future, 2012). The SDGs are a series of 17 goals with 169 indicators very similar to the MDGs but focus on the goals compared to other countries instead of on an overall scale (SDGs, 2017). The SDGs range from those specified in the MDGs but in some parts have split into multiple goals such as separating poverty and hunger, separating clean energy with climate action, and creating multiple goals with regards to sustainable living (*IBID*). Figure 2 shows the 17 SDGs that are aimed to be completed by 2030.

Figure 2 - Sustainable Development Goals (SDGs, 2017)

Goal #7

This thesis will look at the country of Malaysia specifically with reference to how Malaysia's energy resources align with Goal 7 of the SDGs and what steps can be taken to progress forward. The focus of this thesis is looking at goal number 7: "Affordable and Clean Energy" which focuses on increasing the amount of renewable energy in countries across the world which, in turn, reduces the dependence and usage of fossil fuel energy sources to create the energy needed for economic development (UN Energy, 2017). This includes plans to focus on infrastructure support for less developed countries, small islands, and land-locked developing countries that may not have easy access to technology necessary to take advantage of renewable energy resources (UN Energy, 2017). While the focus of Goal 7 may not be on developing countries such as

Malaysia, by looking at the current energy situation, a blueprint can be created for other countries that have a similar makeup to Malaysia.

Malaysia Plans

Every five years, the Economic Planning Unit (EPU) for the Malaysian government creates a plan that aims to progress the country forward in areas that the government wishes to focus on. Like a State of the Union Address in the United States, a Malaysia Plan observes what has been done in the country in the recent past and states where the government aims to take the country for the future. The Plans take place beginning in years ending in '1' or '6' and first began in 1966 after the formation of Malaysia in 1963. Table 1 details the differences between the different Plans as well as showcases the GDP per capita and energy consumption per capita to illustrate the development of Malaysia but also show the growing concern for energy demand going forward. The table shows a consistent theme of economic focus as the primary thrust, but the secondary thrusts shift from economic factors to social and environmental factors. Common themes throughout the policies are GDP growth, progressing to become a developed nation, reducing income and social inequality, and expanding the knowledge base for Malaysian citizens. The GDP per capita shows a trend of growth as the country has developed over the past several decades and with that comes the growth in electricity demand per capita.

Table 1 - Timeline of Malaysia Plans, GDP per Capita, Electricity Demand per Capita (1966 - 2018)

Malaysia Plan	Timeframe	Primary Thrusts	Secondary Thrusts	GDP per Capita (in USD)	Electricity Demand per Capita (1980 – 2016)	Real GDP (2018 BN US$)
1	1966 – 1970	Welfare of all citizens	Living conditions for rural communities	$321.10	N/A	$3.14
2	1971 – 1975	New Economic Policy (NEP)	Reduce foreign dominance in economy	$383.68	N/A	$4.24
3	1976 – 1980	Economic Prospects	Socio-economic Development	$886.22	626 kWh	$11.05
4	1981 – 1985	Macro-Economic Targets	GDP Stability	$1769.13	652 kWh	$25.01
5	1986 – 1990	Socio-Economic Development	Education Reduced segregation	$1728.54	828 kWh	$27.74
6	1991 – 1995	Social and Economic Development	Eradicating poverty National Unity	$2652.14	1206 kWh	$49.14

Malaysia Plan	7	8	9	10	11
Timeframe	1996 – 2000	2001 – 2005	2006 – 2010	2011 – 2015	2016 – 2020
Primary Thrusts	Transforming Economy by upgrading skills	Quest to become a fully developed nation	Recover from Asian Financial Crisis	Increase value of national economy	Economic Green Growth
Secondary Thrusts	Strengthen S&T and R&D Sustainable Development Income distribution Social problems	Eradicate Poverty, Improve knowledge base for citizens, Environmental Sustainable Development	Raise capacity for knowledge, address socio-economic inequalities, Improve standard and sustainability of life	Raise capacity for knowledge, address socio-economic inequalities, Improve standard and sustainability of life	Enhance human capital, inclusivity, become a developed nation
GDP per Capita (in USD)	$4797.29	$3915.12	$6222.98	$10405.12	$9508.23
Electricity Demand per Capita (1980 – 2016)	2068 kWh	2705 kWh	3183 kWh	3693 kWh	4549 kWh
Real GDP (2018 BN US$)	$100.01	$92.78	$162.69	$297.95	$296.54

Trends within the First through Ninth Malaysia Plans

The trends that followed the early Malaysia Plans focused on social inequality, economic growth, and the improvement of the quality of life (Malaysia Plans, 2016). It was not until the Sixth Malaysia Plan (1991-1995) that the environment was mentioned within government text, in part due to the growing international concern for sustainable development and the 1987 release of *Our Common Future* (Sixth Plan, 1991). The subsequent Malaysia Plans focused heavily on continued economic growth, with 6% GDP increase being the target, addressing income inequality amongst the different economic classes that emerged, and advancing knowledge and expertise in research and development. The Ninth Malaysia Plan (2006-2010) was the first plan to put forth that Malaysia should not be so dependent on petroleum and instead look at biofuels and renewable energy sources as potential solutions to reduce the dependency on oil, natural gas, and coal (Ninth Plan, 2006).

Tenth Malaysia Plan

In the Tenth Malaysia Plan, the Prime Minister points out that Malaysia's economic success historically has been due to investment capital, cheap labor, and inexpensive fuel such as natural gas and oil being exported (Tenth Plan, 2011). The shift into being specialized and to increase the knowledge level is apparent with the introduction of the Feed-In Tariff designed to help encourage the use of renewable energy sources but also to reduce the amount of greenhouse gases released into the atmosphere. Within the address of the Tenth Plan the document displays the government's desire to encourage entrepreneurship within Malaysia to increase the

regional and global impact that Malaysian companies can have to showcase the higher knowledge and talent level that the government has worked to foster over the decades. The specialization that is called for within the Tenth Plan specifically mentions "Electrical & Electronics" (E&E) but does not specify which specific goods or services that this entails.

Eleventh Malaysia Plan

The most recent Malaysia Plan is the Eleventh Plan which goes from 2016 into 2020 and coincides with simultaneous plans that the Malaysian government has passed such as "Vision 2020" and a renewable energy focus (Eleventh Plan, 2016). GDP dropped in the time period for the Eleventh Plan due to the dropped value of electronics which are a major export for Malaysia (Eleventh Plan, 2016). Over time the government has created different policies to coincide with the Malaysia Plans but only in a supplemental capacity or to help achieve the goals sought out within the MPs over time. In Eleventh Plan (11 MP), the summary states that a concurring plan, "Vision 2020," aims to have Malaysia be considered a developed nation. It also states that Malaysia will begin to trend more towards strengthening food, water, and energy security by lowering environmental risks. One of these initiatives is to increase the renewable energy capacity in the country and reduce greenhouse gas emissions, most likely to be linked to the international agreements that have been proposed at international gatherings such as the Kyoto Protocol and the Paris Agreement.

LITERATURE REVIEW

This review analyzes existing scholarly literature that examines Malaysia in an energy or environmental capacity. The barriers and the different levels of progress are considered from the different policies. These considerations will help lead to the research questions and offer insights on what factors need to be emphasized going forward. An explanation of Malaysian palm oil will follow as the Malaysian government has considered palm oil to be a viable source of usable energy. Literature for solar energy are explored within Malaysia from both a historical and current perspective to monitor its progress over time.

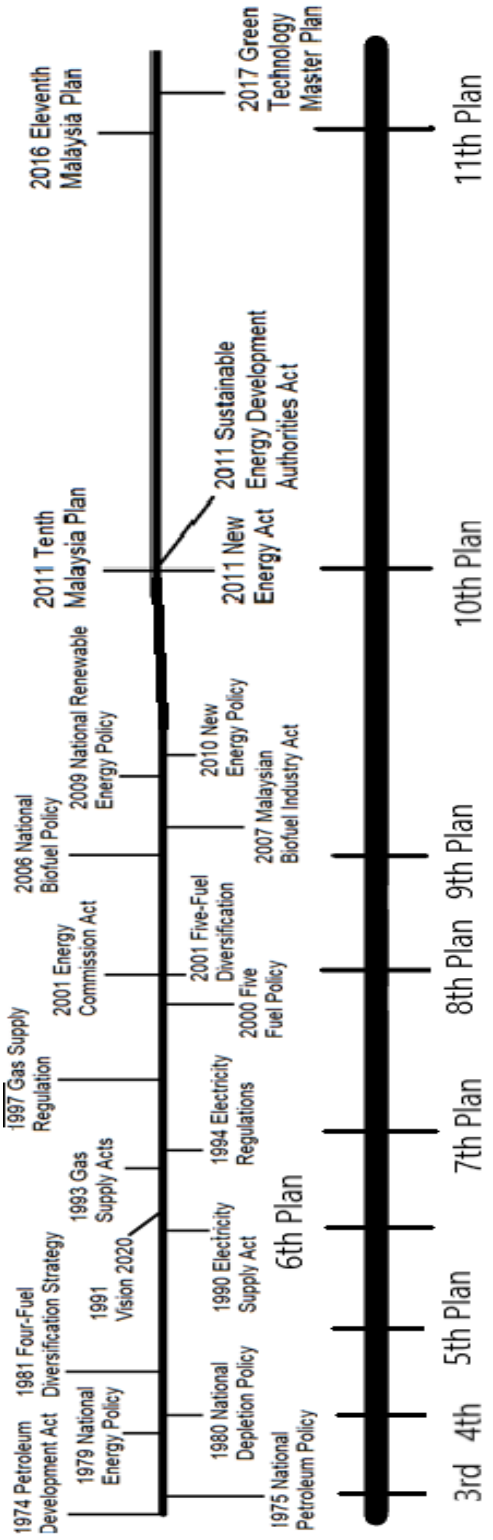

Figure 3 - Series of Energy Policies from 1974 - 2017

Malaysia Plans

The Eighth Plan was the first plan to begin taking steps towards a developed nation by the year 2020 (Eighth Plan, 2001). In Maulud and Saidi, the 8th Plan had "renewable energy included with a target of 500 MW out of the 20,000 MW total generation capacity. The first 10 years (since the start of the 8th Plan) only showed 41.5 MW planning has been achieved." Maulud and Saidi look to re-strategize the Malaysian Renewable Energy Initiatives in large part because the efforts of the Malaysian government were not successful (Maulud and Saidi, 2012). The Fifth Fuel Policy, which looked to incorporate more renewable energy resources, aimed to use landfill gas and empty fruit bunches from the palm oil industry rather than solar energy (*IBID*). The implementation of using renewable energy was harder than originally anticipated by the Malaysian government and could be pointed to three main factors. Per Kardooni *et al*, only two in five individuals they surveyed used renewable energy products due to these three factors: high prices, lack of knowledge and the federal government's program failures (Karoodni, 2018). The challenge to incorporate more renewable energy stems from the National Depletion Policy of 1980 which looks to prolong the lifespan of Malaysia's oil reserves for the future (*IBID*). The 8th Plan also cites the Four-Fuel Diversification Strategy of 1981 which looks to balance the use of oil, gas, coal, and hydropower to also offset the heavy use of domestic resources (Eighth Plan, 2001). Overall the Malaysian government has failed to meet the standards set in the 8th Plan and began importing more energy resources as a result.

The 9th Plan was less focused on renewable energy primarily due to the Asian financial crisis of 2008 and several environmental events such as earthquakes and a tsunami. Malaysia's federal government first focused on rebuilding the country's economy but also invested its resources in promoting knowledge while keeping the 6% GDP growth goal intact (Ninth Plan, 2006). It was not until the 10th Malaysia Plan was brought forward in 2011 that renewable energy started to become more prominent within government policy. Within the 10th Plan is a "goal to attain a developed nation status by 2020" and per Rafindadi and Ozturk, natural gas seems to be the focus of promoting Malaysia's GDP rather than a focus on renewable technology for energy (Tenth Plan, 2011). Rafindadi and Ozturk point to the GDP level reaching a certain level by 2020 instead of all the markings listed by the United Nations Human Development Index (Rafindadi and Ozturk, 2015). While the 10th Plan does look to continue the efforts from previous plans for diversifying energy resources and to conserve the country's domestic supply, there is not as much mentioned within the plan for solar and biofuel energy compared to previous plans (Tenth Plan, 2011).

Ibrahim *et. al.,* discusses Malaysia's commitment from COP-21 where Malaysia aims to reduce its greenhouse gas emissions by 40% compared to 2005 levels, by 2020 and has achieved 33% as of 2015 (Ibrahim, 2016). The combination of the Malaysian government's efforts to achieve a strong economy while doing so sustainably can be best summarized within Ibrahim: "Given Malaysia's vision for a fully developed economy by 2020, it has the unique opportunity to engage in enhanced climate action plan, promote green development and strive to achieve internationally agreed sustainable development

goals (SDGs). Part of the technology required for this must be home grown and part made available through partnerships facilitated by provisions of forthcoming climate and SDG agreements" (Ibrahim, 2016). Ibrahim lays out the coordination needed in Figure 4 for sustainable development to occur. The goals also encapsulate the purpose of this thesis.

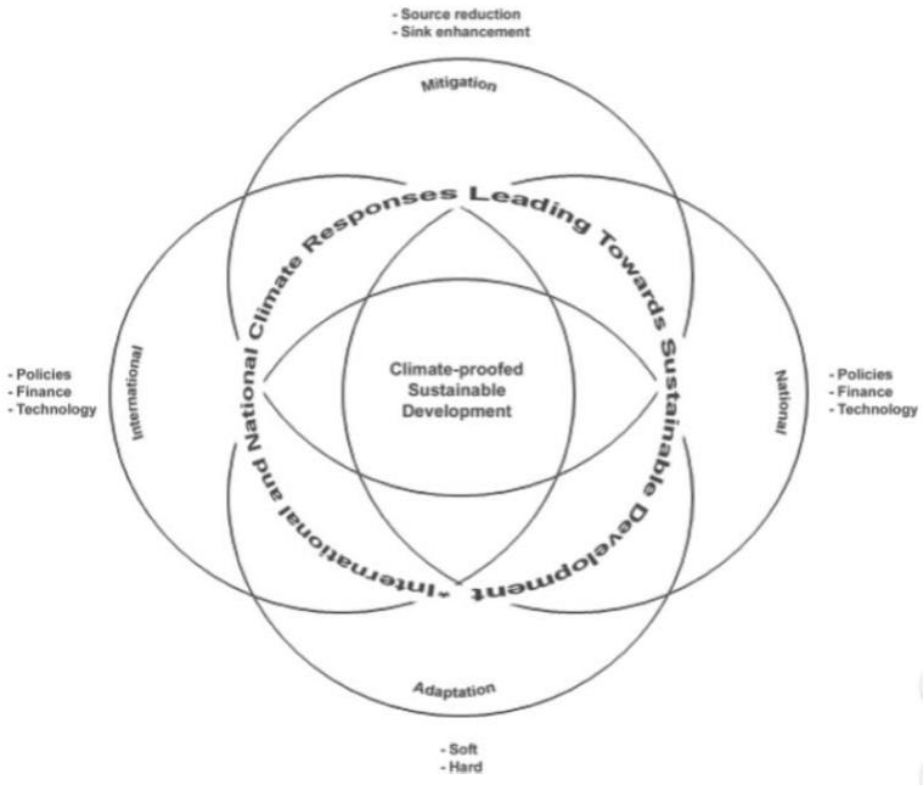

Figure 4 - A conceptual framework for financing climate-proofed sustainable development (Ibrahim, 2016)

Energy Profile

Malaysia's transition to promote energy security and sustainable practices stems from the National Energy Policy of 1979 that sought to address energy concerns from electricity demand, to the conservation of domestic oil reserves, to the promotion of renewable energy practices (Jalal and Bodger, 2009). In Jalal and Bodger, three policies feed into the electricity sector from government policies: The National Depletion Policy of 1980, the Four Fuel Diversification Policy of 1981, and the Fifth Fuel Policy of 2000 (Jalal and Bodger, 2009). Figure 5 shows the different policies that govern the electricity sector starting with the National Energy Policy. The purpose of the National Depletion Policy was to reduce the amount of oil produced to lengthen the lifespan of Malaysia's oil reserves in 1980 once larger oil reserves were discovered. The Four Fuel Diversification Policy, and later the Fifth Fuel Policy, was designed to lessen the use of oil for generating electricity by using coal, natural gas, and hydro power while adding renewables such as biomass and biogas as a fifth fuel option as a supplement in 2000 (Jalal and Bodger, 2009).

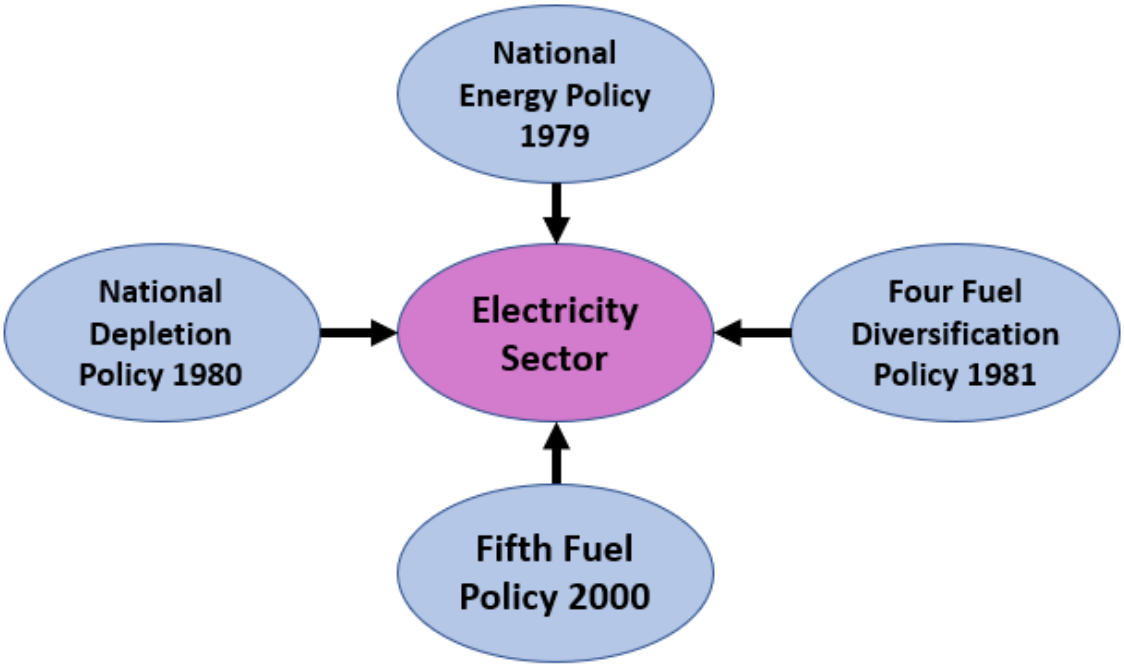

Figure 5 - National energy policies that directly govern the electricity sector (Jalal and Bodger, 2009)

The last relevant energy policy that this thesis will address is the Feed-In Tariff (FiT) that was introduced in 2010 with the Tenth Malaysia Plan. A common term used in solar energy or any renewable energy that can be generated from a location is called "net metering". "Net metering" is when the government, local, state, or federal, requires utility companies to give credit for every kilowatt-hour (kWh) of energy generated on-site by the consumer. The credit is the same amount as the cost of consuming a kilowatt-hour that is pulled from the grid. The Feed-In Tariff created as part of the Tenth Malaysia Plan would be like "net metering," but instead of having the amounts of consuming versus producing be equal, a larger incentive would be in place for producing instead. One example would be if consuming a kWh would cost $0.10, "net metering"

would mean that for each kWh produced into the grid, by the consumer, would net a $0.10 credit. A program like the Feed-In Tariff would yield more than $0.10/kWh. These programs are generally evaluated so that incentives can be properly adjusted based on factors such as participation, material cost, and the capabilities of the electrical grid (Chua, 2011). The government offers utility companies economic incentives for participating in programs like the Feed-In Tariff. The customer receives a credit on their bill based on the rate and amount of energy inserted into the electric grid. Per Chua, Malaysia's FiT applies to biomass, biogas, and solar energy that provide electricity back into the electric grid (Chua, 2011). Table 2 shows the FiT rates that the program provides including the different amounts based on the year and type of energy source (Chua, 2011; Tenth Plan, 2011). One important thing to note is that the table does not have solar energy listed because the first iterations of the FiT did not include solar energy until 2010.

Table 2 - FiT rates (Chua, 2011)

RE Source	Year	Cons. Cost (RM)	Price (RM/kWh)	Price (USD/kWh)
Biomass	2002	20.13	0.17	0.052
	2006	23.66	0.19	0.058
	2007	24.53	0.21	0.064
Biogas	2002	20.13	0.17	0.052
	2006	23.66	0.19	0.058
	2007	24.53	0.21	0.064
Solar	---		---	---
Mini-hydro	2002	20.13	0.17	0.052

In Ahmad *et al.,* the point about "oil reserves will not last very much longer" is both valid and misleading because as domestic oil reserves deplete, the Malaysian government aims to lean less on oil and more on natural gas (Ahmad, 2011). While Malaysia's domestic reserves for all types of fossil fuels are depleting over time, the burden of the diminished reserves becomes more of a motivating factor once the price of these resources begins to increase. Ahmad does mention that the push for renewable energy solutions stemmed from the price of oil reaching $150/barrel (Ahmad, 2011). Despite this notion, steps towards renewable energy resources present a benefit to Malaysia on multiple fronts because they address growing energy concerns, reduce the stress on domestic fuel supplies, meet international agreement goals, address social inequality by providing better quality of life in rural communities, and take advantage of

resources that are readily available. Within Ahmad, points are made regarding solar, biomass and biogas, hydroelectric, and biogas and municipal solid waste as sources of potential renewable energy solutions (Ahmad, 2011). With each of these solutions exist barriers that prevent these resources from being utilized on a macro scale from high cost, to lack of infrastructure, to lack of knowledge that exists within the workforce, to simply being less cost efficient compared to the conventional fuel resources for producing electricity (Ahmad, 2011).

Looking at solar energy specifically, Alam *et al* looks closer at the social acceptance of solar energy which plays as important of a role as the economics behind the technology (Alam, 2016). For any proposed solution, even if the economics of the solution have been resolved, that does not mean that the solution will be accepted and acted upon by people. This requires a level of understanding of what can still prevent individuals or groups from utilizing the solution. Observing the social aspect of solar energy accomplishes utilizing the solution. What Alam discovered can be summarized as a lack of understanding among those that have an interest in using solar technology (Alam, 2016). "User lifestyle, level of awareness and ease of technology use are factors which influence rapid acceptance of renewable energy" (Alam, 2016). Alam concluded their studies by focusing on a three-prong approach on how renewable technology can be incorporated: a combination of government policies, private sector participation, and the users' awareness and acceptance will lead to a wider spread usage of renewable energy (Alam, 2016).

Issues with Malaysian Palm Oil

Deforestation

By far the most common discussion throughout the collected research was related to the deforestation of Malaysia's rainforests to make way for the expansion of larger palm oil fields. Various articles such as Reeb et al, Lim and Teong, Foong and Teruki all point to a growing concern for the palm oil industry since from 1996, "only 11.6 percent of Malaysia's initial forests remain intact" across all of Malaysia (Reeb 2014). The amount of forest has considerably diminished as millions of hectares are devoted to palm oil plantations (Bhagwat and Willis 2008). The numbers for how many hectares are devoted to palm oil vary depending on the source from 4.49 million (Abdullah 2009), 4.3 million (Ahmad 2010) and 5 million (Reeb 2014) which can be partially attributed to different years but also the fluctuation of palm oil plantation contracts in the marketplace. Despite the differences in the number of hectares for palm oil, one trend has been consistent: palm oil fields have increased, resulting in the depletion of forests and related biodiversity. The ongoing debate concerning the deforestation in Malaysia is that the palm oil industry is one of the key contributors to Malaysia's economic growth yielding 60 percent of commodity exports and over 600,000 jobs for Malaysian citizens (Reeb 2014). With growing demand for palm oil across the world, the incentive for the government to expand palm oil plantations is economically alluring but is met with criticism and friction from environmental groups as the long-term effects are heavily discounted and are not quantified in current cost-benefit analysis (Ahmad, 2011).

Greenhouse Gas Emissions

Per Danielsen *et al*, the greenhouse gas discussion on Malaysia's palm oil industry has two different sides: palm oil removing a sizeable amount of carbon dioxide emissions from the atmosphere, and the release of emissions from disturbing the land areas to make way for expanded palm oil fields. From a chemical perspective, the palm oil plant takes in carbon dioxide to make sugar and takes in more carbon dioxide to develop biomass. Therefore, the fruit of the palm oil tree is saturated with so much oil both in the mesocarp and in the center kernel. From Danielsen, the discussion centers around how forests are cleared and what type of land is disturbed that determines how long the palm oil field will need to completely offset the amount of greenhouse gas emissions created from the development of the land. Danielsen discusses the time needed to offset the carbon emissions: "We estimated (carbon neutralizing) would take between 75 and 93 years for the carbon emissions saved through use of biofuel to compensate for the carbon lost through forest conversion depending on how the forest was cleared" (Danielsen 2009). The longest timeframe to recoup the emissions impact so far is when the field was originally peatland. It is estimated to take more than 600 years for the emissions released to be completely offset by palm oil trees absorbing the carbon dioxide in the atmosphere.

The different methods for clearing out forests are logging, forest fires and decomposing organic matter by oxidation. From the research, it will take on average 75 years for a forest cleared via logging, 93 years for a forest cleared via forest fires and 692 years for using oxidation methods for peatland areas (Danielsen 2009). In Malaysia, a

large majority of forests that are cleared are done so by logging due to government regulation but also preservation of timber can be converted into various forms for potential goods. In Indonesia, Malaysia's rival in the palm oil industry, there is less government regulation so plantation companies clear fields using forest fires because it is cheaper from a labor and processing standpoint (Danielsen 2009). From an international standpoint, carbon emissions are a driving force as cooperative agreements are signed such as the Kyoto Protocol and COP21 so actions that release extra emissions into the atmosphere are criticized by potential trade partners for Malaysia and other countries looking to use palm oil (Danielsen 2009).

Fragile in Global Market

With "(palm oil) projections suggesting that its potential use as biofuel will trigger its growth by nearly 150 percent by 2010", both Malaysia and Indonesia seem poised for prime position as demand for that biodiesel will increase dramatically (Danielsen 2009). International agreements for climate change will encourage countries to invest in renewable energy infrastructure, but for those countries that will be unable to match those investments biofuel is a cheap alternative. Despite this economic position that Malaysia is in, there is very little control over the pricing for biodiesel compared to that of crude oil. Lim and Teong indicate that other countries have shown an interest in creating their own biofuel system including the use of algae as the amount in the world has vastly increased over the past few decades (Lim and Teong 2010). With the demand going down, Malaysia cannot control the global price for palm oil as closely which presents uncertainty and fragility for how Malaysia can cope with market forces. The

low cost of crude oil currently prices out the competition of biodiesel since the variable cost for palm oil is so much higher than crude oil (Macrotrends, 2017). The driving incentive for palm oil as a potential substitute is when the price of crude oil goes up to a point where it impacts the national economy for Malaysia. Palm oil can be used as a renewable form of fuel, but the high cost prices Malaysia out of international markets.

Another large barrier with the palm oil market is the European Union's stance on where it receives its biodiesel. In the Renewable Energy Directive (RED) of 2008, biodiesel can only be accepted if it helps save 35 percent on carbon emissions which enables Malaysia to trade with partners in the EU. The percentage of savings increases to 60 percent in savings in 2018 which will phase out Malaysian companies due to how many carbon emissions are created from developing these palm oil fields (Lim and Teong 2010). There is also a high cost when it comes to developing the soft and hard infrastructure for biodiesel overall. Without the help of the Malaysian government, investors will see too many barriers to want to invest in these projects which further jeopardizes the chances that Malaysia will be able to withstand global market forces. The fact that they may not have as many trade partners soon coupled with the high investment needed to begin the process leaves the government in a precarious position with a high amount of risk.

Energy Expansion Concerns

As Malaysia expands its palm oil fields it will need to have the land to expand. Many of the land forces are owned by small villages which are not willing to sell their property (Cramb and Ferraro, 2012). Relocating the citizens in rural Malaysia is a costly

expense that further impedes the investment for making biodiesel Malaysia's path to becoming a developed nation and a force in the fueling industry. Malaysia also has an upcoming dilemma with its fossil fuel resources as the population grows, energy demand increases and the need to import energy resources becomes more expensive over time.

Energy demand will apply pressure to answering the overall question of solar energy compared to palm oil and which potential solution can aid in the growing energy demand. With oil and natural gas supplies depleting, the Malaysian government has begun importing coal from Australia and other neighboring countries to help compensate for the growing energy demand while curbing the consumption of domestic fossil fuels. In 2012, Malaysia imported $356 million USD in coal reserves from Australia making it one of the top products for imports along with crude oil and copper (Australian Government 2012). In 2016, Malaysia imported $392 million USD in coal briquettes from Australia, roughly a ten percent increase over four years (Atlas MIT, 2016).

RESEARCH QUESTION/HYPOTHESIS

The purpose of this thesis is to answer the question: How much does Malaysian domestic energy policy overlap with the United Nations' Sustainable Development Goal #7? The literature review gives proper context on what policies have been utilized to address certain domestic energy concerns, but the question of overlapping between domestic policy and the SDG #7 has not been addressed. Seeing what Malaysia has done domestically to enable organizations and individuals better identifies ways to incorporate new methods and strategies to achieve specific goals for other countries, with goal number 7 of the UN SDGs in mind. This thesis will also aim to analyze what is currently available to Malaysia from the domestic fuel supplies, to the workings of the palm oil industry, to the potential of solar energy technology for the area. While Malaysia is not facing any turmoil or energy crises as of May 2018, the federal government has mentioned on multiple occasions in their Malaysia Plans to be proactive with energy production and consumption to continue economic growth and to eventually join the ranks of developed nations (Eleventh Plan, 2016). It is important to note that Malaysia had their election for prime minister in May 2018. This thesis will acknowledge the result but will focus on existing policies both past and present.

The sub-questions that this thesis will specifically target are the following:

- What energy challenges exist for Malaysia?

Malaysia has a growing population within its borders. With a growing population comes the need to generate more electricity to accommodate growth. While the federal

government looks to importing resources from other countries, whether this plan is sustainable over a longer period is yet to be determined. The answer to this question measures the severity of challenges that exist to provide the proper scope of work needed to help Malaysia.

- Could palm oil be a viable option to substitute fossil fuels for electricity production?

One of the abundant resources that Malaysia has within its borders is palm oil. While palm oil is not primarily used as a biofuel, the federal government has considered using the product as a potential solution. This thesis will dive into whether palm oil is worth being considered as a potential solution and why it may be considered. The viability of this question will be dependent on how much land space will be needed to generate the same level of energy that the fossil fuel consists of for electricity production.

- How is Malaysia using solar energy as a renewable fuel source?

The geographic location of Malaysia enables the perfect conditions for physical growth of palm oil trees, but for the same reasons solar energy can be a lucrative option for producing clean, renewable energy. This thesis will lay out what is currently being done with solar energy in Malaysia by comparing scientific literature with current events and original analysis. The metric by which this question will be answered is identifying the current and use potential for solar energy soon, specifically within the context of energy policy.

- What is the optimal fuel energy mix for Malaysia going forward?

After analyzing the past and current energy situation in Malaysia, this thesis will propose a solution for Malaysia going forward to resolve near-future energy demand

concerns while maintaining the international goals set by the United Nations. Comparing the cost of implementation and the reduction of carbon emissions are considered against the amount of electricity generated to accommodate the growing population. This is discussed for future research considerations.

The main hypothesis for this thesis is that Malaysia is focused primarily on their domestic energy concerns and will overlap with the United Nations' goals in a passive nature. The definition of "passive" for the sake of the hypothesis is that the Malaysian government does not allow the United Nations' SDGs to influence their domestic policy and solely focuses on their domestic needs. The sub-questions listed above help quantify the domestic energy concerns that Malaysia has but also what resources are already available for addressing these concerns. After answering the questions listed above, coupled with the semi-structured interviews conducted over the course of research, a complete picture can be seen to show to what extent Malaysia aligns with international goals, specifically the United Nations' SDG #7.

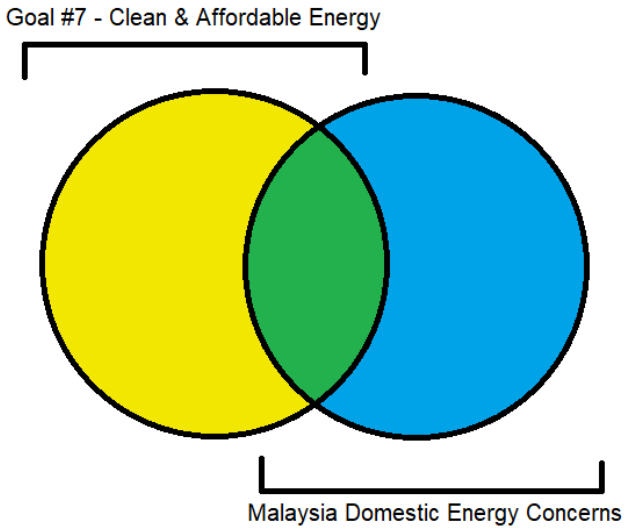

Figure 6 - Goal of Combining SDG #7 with Domestic Energy Concerns

METHODOLOGY

The thesis focuses on energy policy and energy data research from Malaysia's founding in 1960 leading up to 2017. A combination of scientific literature, semi-structured interviews, and original data analysis helps display what currently exists for Malaysia as well as potential solutions that can combine the goals of the federal government with those of the United Nations. Dimensional analysis and policy analysis are key components for the thesis. Interviews with various experts have been conducted to supplement the research information gathered to ensure that temporal research covers an appropriate amount of time and that current factors are considered. This is especially important given the outcome of the recent prime minister election in Malaysia in May 2018. Experts for these interviews stem from both the public and private sectors, and from the different areas surrounding the palm oil industry and solar energy sector. Experts for the interviews are in the United States, Malaysia, Italy, and the United Kingdom. Experts are defined for the interviews as individuals who have peer-reviewed publications, several years of work experience within the proper sectors, or have been referred to by members of the academic community.

The first section focuses on analyzing past energy policies, looking at what policies were successful and how these policies influenced the policies currently in place in present-day Malaysia. This analysis consists of data from policy research and semi-structured interviews. The second section establishes a baseline of information regarding what is available for Malaysia for their energy resources and the current demand for

energy consumption. Baseline information is accomplished from the previous literature review that detailed different areas that have been addressed and identified areas that have not previously been addressed. Electricity generation and efficiency is showcased, and the thesis considers how much renewable generation is produced in recent years. Data sets from the World Bank, Malaysian Government, the United Nations, and other international organizations that focus on population growth, imports, and exports establish the energy landscape for Malaysia.

The thesis analyzes these data sets to identify economic development and energy security concerns from recent history. The data sets are a large component as the data sets corroborate any claims or findings discovered in the scholarly literature. The combination of the research and literature review help establish the baseline for answering the main question, and four sub-questions mentioned in the hypothesis. Taking this information and applying some new analysis help frame a clearer picture for energy consumption and production of Malaysia. This will showcase for the international community what energy, economic, and environmental concerns scientists have based on the current actions of the Malaysian government.

The third section looks exclusively into Malaysian palm oil from the basic properties, to the different plantation environments that can grow the product, and to the environmental degradation features. Dimensional analysis is conducted to show the amount of land area required to offset the consumption of various fossil fuels and the implications from an economic perspective in terms of how much investment will be required to achieve the level of infrastructure. The purpose of this analysis is to provide a

methodology for international organizations that wish to help incentivize developing countries such as Malaysia to transition to renewable energy solutions instead of relying on fossil fuels or other energy sources.

The fourth section observes the potential of solar energy to substitute the use of fossil fuels in electricity generation. Observing the expansion of solar energy capacity and the Feed-In Tariff (FiT) program provides a context to where Malaysia stands with their renewable energy capability. This shows how Malaysia can offset the future energy demand from a growing population soon. Input specifically from a national Malaysian energy company representative gives context on how the Malaysian government plans to establish itself as responsible stewards on an international stage while meeting domestic energy concerns. An explanation of the FiT is provided to educate those who are unaware of the terminology or the mechanics of the program as similar programs such as 'Net Metering' are used in other countries to incentivize the use of renewable energy.

The final section looks at the social and political landscape of Malaysia while acknowledging the climate before and after the prime minister election. The information gathered from the interviews plays an important role in this section particularly since first-hand experiences are more relevant than academic literature as current events are constantly in flux. Background information on each interviewee is provided below showcasing their qualifications for contributing to this thesis.

Interview Profiles

Kate Clemans

Kate Clemans is a member of the Board of Managers of Crowell & Moring International and a strategic advisor particularly with matters concerning the Eastern Asian region. Ms. Clemans has extensive knowledge of the Asia Pacific region and is seen as the leading private sector advisor in the Asia Pacific Economic Cooperation (APEC) forum (C&M, 2018). The insights Ms. Clemans provided focus on the political and social aspects of Malaysian energy.

Malaysian Energy Company

An executive from a Malaysian energy company that focuses on oil and natural gas nationwide offers insight on how the country approaches energy concerns both in the short and long term. The type of insights this company provides comes from a domestic perspective on how policies have worked in the past and which policies to keep an eye on for the future. Their input on how the United Nations' policies overlap with the domestic energy policies is crucial in answering the primary research question.

World Bank Analyst

A World Bank Analyst who has worked with the World Bank from 1988 to 2011 has presented on behalf of the Sustainable Development Goals. The analyst also was commissioned by the Economic Planning Unit for the Malaysian government to create a report called *Moving Up the Value Chain* that observed Malaysia's potential role in the solar energy industry. As Malaysia's pivot into renewable energy stemmed from the Tenth Malaysia Plan, the analyst's insight onto what Malaysia should or should not do

within solar energy is invaluable from an economic perspective that can drive energy policy going forward.

Rina Haiges

Ms. Haiges is from Malaysia and is currently a PhD student at Newcastle University in the United Kingdom. She is within the Sir Joseph Swan Center for Energy Research and is researching "Integration of Renewable Technology for Sustainable Power Generation." Her recent publication "Optimization of Malaysia's power generation mix to meet the electricity demand by 2050" aligns extremely well with the purpose and research questions of this thesis. Her input is useful from an academic and local perspective.

Dr. Bridget Welsh

Dr. Welsh is an Associate Professor of Political Science and Director of Asian Outreach at John Cabot University in Rome, Italy. She is also a Senior Research Associate at the Center for East Asia Democratic Studies of the National Taiwan University. She analyzes politics in Southeast Asia including Malaysia, Singapore, and Indonesia. She has written several books on Malaysian politics and has lived in Malaysia for 30-35 years both from growing up in the country to working there for research. Her input focuses on the social and political aspects of the thesis and a perspective of someone with a political focus who has grown up in Malaysia.

Limitations and Bias

The main source of bias for this project is the author's belief that a viable solution exists to resolve all energy concerns for Malaysia, just that the answer needs to be

discovered. This can potentially sway the interview questions and the specific data sets selected for analysis. A limitation for this project is the inability to travel to Malaysia to discuss with the local population about the energy concerns that may or may not be prevalent in the local culture. Another limitation is the number of interviews as more interviews would be able to broaden the scope of information and provide more data to mitigate bias. Biases in data sets can influence the analysis, while obtaining data from multiple sources improve the accuracy of any analysis while reducing the presence of bias. This same mentality applies as multiple interviews acknowledges the same question to address the interviewee's potential to bias the results. The use of multiple sources of information mitigates potential bias of the results.

MALAYSIAN ENERGY POLICY ANALYSIS

Throughout Malaysia's history, energy policy has focused primarily on maintaining economic growth but has shifted priorities as sustainable development became an international topic among countries (First Plan, 1966; Eighth Plan, 2001). By breaking down domestic energy policies over time, influences on recent energy policy help provide a resilient solution for future energy needs. Policies chosen for this section will focus on what has led to current renewable energy policy and helped shape Malaysia's energy initiatives and goals.

Malaysia Plans

When Malaysia first became an independent nation, the first few Malaysia Plans pointed to efforts to increase oil and natural gas reserves so that Malaysia would have a sustainable amount of resources to help promote the economy (Third Plan, 1976). As time passed, and international priorities had shifted to be more sustainable, the Malaysian government began focusing on preserving their current level of resources while looking for technological advancements from within the country to help maintain a constant level of economic growth (Seventh Plan, 1996). It is the combination of constant economic growth while gradually shifting away from fossil fuel energy resources that happens to align with several international agreements and helps embolden Malaysia's presence on the international level for being a developed nation.

The first time 'the environment' or 'energy' is mentioned within the Malaysia Plans is with the 6th Plan which dates between 1991 to 1995 (Sixth Plan, 1991). This

aligned with the emergence of international discourse from the Brundtland Commission and "Our Common Future" as the discussion of sustainable development began to globally emerge. The discourse within the different Malaysia Plans since 1991 show a paradigm shift away from solely looking to improve Malaysia's gross domestic product (GDP) to looking at sustainable growth for different periods of time. Listed in the 7th Plan were points of sustainable development, reducing the dependence on energy imports, and to create a balance between medium and long-term growth (Seventh Plan, 1996). Policies such as the Electricity Supply Act emerged because of the 7th Plan to also encourage advances in energy technology and to move Malaysia away from "instrument driven economy to productivity driven" (*IBID*). The 9th Plan was a step forward for biofuels which prompted policies to use palm oil within gasoline for vehicles, like how ethanol is used in the United States (Ninth Plan, 2006). There were some steps forward, but the research and technology did not indicate potential solutions that we see today. The 10th Plan was truly the first plan that addressed solar energy within Malaysia and was the first plan to take market steps to make solar energy a viable option instead of a higher end commodity for the upper class (Tenth Plan, 2011). The downside of the 10th plan was that later on the Feed-In Tariff would be taken away and social acceptance of solar panels became more of an informational concern rather than an economic concern.

The most recent Malaysia Plan, the 11th Plan, has six main focal points where the fourth point states, "pursuing green growth for sustainability and resilience" (Eleventh Plan, 2016). The 11th Plan echoes Plans 7 through 10 by focusing on green technology that will enable Malaysia to grow economically by not being as vulnerable to

international energy markets or to growing electricity demand (*IBID*). Also, point four of the plan states "Green growth refers to growth that is resource-efficient, clean, and resilient. It is a commitment to pursue development in a more sustainable manner from the start, rather than a more conventional and costlier model of 'grow first, clean up later'" (*IBID*).

Palm Oil Regulations (1960-2007)

Policies related to Palm Oil regulations first begin with the emergence of the local market for palm oil, but closer to the turn of the century the regulations were focused region by region. Regions like Sabah and Sarawak had biodiversity laws put into place in 2000 and 1997 respectively which were necessary as Borneo was primarily rural jungle with many different species of plant and animal (Palm Oil, 2018). There have not been any new laws put into place for palm oil regulations since 2007 when pesticide use was modified for sales and storage (*IBID*). As the discussion of energy usage shifts toward renewable sources, palm oil needs to be reevaluated for further regulations to meet international trade standards and environmental concerns.

Petroleum Development Act (1974)

What was the policy?

The Petroleum Development Act was created "to provide for exploration and exploitation of petroleum by (PETRONAS) which will be vested the entire ownership and rights in respect of petroleum." The company known as PETRONAS was created with the initial intention of having a singular entity handling all matters related to

petroleum and related products. Created in 1974, this policy was designed to mainstream the development of the energy sector for a young nation such as Malaysia.

Was it successful?

During the Second Malaysia Plan, the focus was on economic development which includes the development of energy resources. The policy was successful in enabling a singular corporation to have vertical implementation for oil and the similar products. In economics, it is seen as an advantage to have one company oversee each phase of production for a product. This policy enables PETRONAS to have those rights. The efficiency of petroleum processing has given Malaysia consistent economic growth over the past few decades.

What is the main takeaway?

For the Petroleum Development Act, this shows that the oil and natural gas industry has been in the hands of PETRONAS since 1974 and therefore any conflicting energy interests would overlap with goals set forth by PETRONAS. The growing energy concern of diminishing oil and natural gas supplies also falls upon the shoulders of PETRONAS which leaves the company in an interesting position. Caught between the emergence of renewable energy technology and the consumption of non-renewable materials, PETRONAS seems to be a key for Malaysia to move forward in the energy industry.

National Depletion Policy (1980)

What was the policy?

The National Depletion Policy of 1980 was introduced to protect the oil resources found in Malaysia by curbing the amount of production that was allowed daily. The amount of production allowed from the oil fields for oil initially in place (OIIP) was 1.75% but was later revised to 3% due to the conservative estimates from survey data and economic need in 1985 (Jalal and Bodger, 2009). The policy was put into place due to several energy forecasts that estimated the depletion of resources in 20-25 years based on 1980 production levels (*IBID*).

Was it successful?

The National Depletion Policy was enacted on the tail end of the Third Malaysia Plan which focused on cultivating the agricultural industry but continued to focus on economic growth. Oil is still used in production in 2017 and is forecasted to be a national trade good. The fact that oil will still be used in the future means that this policy was successful. Discovery of new pockets of oil and improvements in technology are variables when calculating the life expectancy of an energy fuel supply.

What is the main takeaway?

Had this policy not been successful, Malaysia would need to import larger amounts of oil since the resources are not only used in energy production but in other products such as glass and plastics that are used in several different industries. This policy extends the life expectancy of the domestic oil supply which is important as the global market remains volatile depending on the supply and demand. By becoming

insular to the global forces of oil production and consumption, Malaysia is not subject to market volatility and can therefore predict economic growth on a more consistent level and address other issues that may prevent the country from becoming a developed nation. The emergence of natural gas and renewable energy technology also aided in this policy's success.

Five-Fuel Diversification Policy (2001)

What was the policy?

Initially in 1981 there was a Four-Fuel Diversification Policy that spread the production of electricity to coal, natural gas, oil, and hydroelectric but the fifth fuel was renewable energy sources such as wind, biogas, and solar energy. The policy's aim was to gradually shift from non-renewable energy resources to renewable sources to help curb the consumption of domestic energy supplies while also accommodating the growing population within Malaysia. The policy aimed to have renewable energy contribute to 5% of the country's energy consumption while gradually increasing that number over time afterwards.

Was it successful?

With the Malaysian Government concerned about energy resource supplies, the diversification policy was created to help curb the consumption of resources. Based on the information shown in a later section, this policy was successful in slowly integrating renewable energy resources into the energy mix but failed to meet the goal of 5% by 2005. Other policies would come later to improve the presence of renewable energy as economic and technological barriers exist to prevent further implementation. The biggest

reason why renewable energy was not a larger component of the nation's energy mix was due to the short turnaround time (4 years) for infrastructure and economic incentives, but also informational barriers since residents were most likely unaware of what options were available or how to properly implement them for optimal use. The interviewees within this thesis identified different types of barriers for renewable energy including technological for energy storage, social acceptance of solar panels by Malaysian citizens, and infrastructure challenges for the expansion of a centralized electric grid.

What is the main takeaway?

Renewable energy, while a promising directive for the future, takes time and careful planning to properly implement on a macro scale. Smaller projects such as community solar tend to be easier because of the smaller sample size and far more control over a smaller area. Trying to incorporate a new type of energy into a mix that was engrained with oil, natural gas, coal, and hydroelectric is not something that can be done in a four-year period without massive investment and careful execution for implementation.

National Renewable Energy Policy and Action Plan (2009)

What was the policy?

In response to the Five-Fuel Diversification Policy's shortcomings, the National Renewable Energy Policy and Action Plan was designed to better incorporate renewable energy into the policy and infrastructure for future energy development. The document specifically has five policy objectives: (1) to increase renewable energy contribution to the national power mix, (2) facilitate growth in the renewable energy industry, (3) ensure

reasonable renewable energy generation costs, (4) conserve the environment for future generations, (5) enhance awareness on the role and importance of renewable energy (KeTTHA 2009). The policy would have several benchmarks for 2011, 2015, 2020, 2030, and 2050 to learn from previous mistakes in the Five-Fuel Policy but also to strive for goals to align Malaysia with international objectives of transitioning to renewable energy resources for cleaner and more affordable energy.

Was it successful?

The policy is still in progress as several benchmarks take place in 2020, 2030, and 2050, but as of the end of 2017 the progress of the five policy objectives looks promising. In increasing RE contribution, there has been an increase in solar energy, biogas, and biomass for the national energy grid since the policy's enactment. The increase in these areas shows that the targets are achievable depending on the country's progression going forward. From programs such as the Feed-In Tariff and the emphasis in Malaysia Plans 9, 10, and 11 for renewable energy, growth is far easier for solar energy specifically while attaching to the electric grid for biogas is also easier, making the process more of a "low-hanging fruit". Regarding energy costs, the price is still high due to the high entrance cost of the technology and the slower rate of return for investment, causing companies to take a slower approach in implementing the technology on a larger scale. Conserving the environment is a constant goal for the Malaysian government as more information becomes available regarding the role of humans on the environment from both a micro and macro scale when comparing local human health to global air temperatures over time. Information is still a challenge for the Malay as fewer citizens

are aware of all their options and therefore do not take advantage of government programs or incentives that are available because of this policy.

What is the main takeaway?

The Malaysian government is trying to implement more renewable energy into their mix, to put the main takeaway simply. This policy has a much longer forecast than other energy policies that looked at timelines within the duration of one or two Malaysia Plans. This policy is forecasted all the way to 2050, after the period when the federal government plans to have Malaysia join the ranks of developed countries and become more of a presence on the international stage. The timeline for these goals also aligns to some extent with international initiatives for sustainable development by curbing the use of fossil fuels for energy. These initiatives also allow countries to investigate possible alternatives depending on the topography and availability for each nation. Malaysia's proximity for solar radiation enables solar energy and biogas/biomass to be the two most likely candidates, but the implementation will take time.

Renewable Energy Act (2011)

What was the policy?

The Renewable Energy Act, or New Energy Act, was designed to establish the Feed-in Tariff system with an annual installed capacity cap (IEA, 2016). The costs for the system are placed on the consumers by having a 1% increase in their electricity bills, but about 75% of domestic consumers who consume less than 300 kWh/month will be exempted from this surcharge for the fund (*IBID*). To benefit from the tariffs, approval from the Sustainable Energy Development Authority (SEDA) will need to be granted like

obtaining a permit (*IBID*). The FiT program will apply for 21 years for solar and hydro power, while biomass and biogas will have a 16-year period for the program (*IBID*). In May 2015, geothermal plants were deemed eligible for this program (IEA, 2016).

Was it successful?

The policy was successful in that it promoted the discussion for renewable energy within Malaysia. The Tenth and Eleventh Malaysia Plans both discuss renewable energy in a larger capacity to satisfy green economic growth and this policy was a step towards that direction (Tenth Plan, 2011; Eleventh Plan, 2016). Where the policy shifted was in 2015, the FiT program was no longer bringing on new customers and the net metering program was implemented in its place (Tenaga, 2017). Despite the shift towards net metering, this policy presented the federal government with a method in which to gather funds for renewable energy initiatives across the country without penalizing citizens that are on the lower end of the economic spectrum. Specifically, by having exemptions for people that consumed less than 300 kWh/month helped the lower class save money, but in a social capacity could have encouraged those near that mark to conserve energy to avoid the surcharge.

What is the main takeaway?

The main takeaway from this policy is that help will need to come from the public sector to encourage the use of renewable energy since the higher cost of purchase and maintenance is a barrier that affects companies and citizens alike. The Feed-in Tariff program lowered those barriers to allow the technology to be more accessible for entities

which in turn showed the success that these technologies can provide if the initial cost can be overcome.

Sustainable Energy Development Authorities Act (2011)

As the Malaysian government began to pivot their priorities for renewable energy compared to fossil fuel energy resources, the SEDA was created. The purpose of this policy was the creation of SEDA, the Sustainable Energy Development Authority, as a government entity that could handle matters relating to sustainable energy practices (SEDA, 2011). While the policy was brief in terms of length, the impact from the policy enabled a focused entity to address the national energy concerns was paramount. As international narratives began to focus more on the preservation of the Earth's climate, and the reduction of fossil fuel usage, SEDA was tasked with propelling Malaysia towards accommodating with those international initiatives. These initiatives include the Sustainable Development Goals set by the United Nations which are the primary focus of this thesis.

Green Technology Master Plan (2017)

To align with the Eleventh Malaysia Plan, the Green Technology Master Plan (GTMP) creates a framework with four main pillars: energy, environment, economy, and social (Kettha, 2017). With the help of several UN officials guiding the EPU, the GTMP aligns well with the SDG goal #7. "This first edition of the GTMP focuses on six key sectors: Energy, Manufacturing, Transportation, Building, Waste, and Water. The GTMP attempts to harmonize the policy directions of each sector towards a common goal of sustainable utilization of natural resources" (*IBID*). The GTMP will rely on several

entities to achieve a sustainable energy model, mainly from the federal government, the national energy market, and through research and development. There is a knowledge gap is noted in the GTMP that intends to be addressed by "promoting human capital development" presumably to accommodate the rise of these technologies born from R&D.

Regarding energy, the GTMP has laid out targets for the energy sector which is presented in table 3 below, forecasting until the year 2030. The table looks at how much renewable energy contributes to the national grid and the energy efficiency associated with those technologies, specifically PV solar efficiency (Kettha, 2017). While the GTMP does continue to discuss the other key areas, this thesis will highlight the energy sector and the goals associated. This policy is an ambitious policy due to the number of moving parts associated with having a sustainable lifestyle. In the United States, there were movements to conserve electricity by turning off the lights as you leave a room or adjusting the thermostat in your home, but in Malaysia the narrative is different. In the interview with a Malaysian energy company executive, "The GTMP involves lots of education for energy usage and managing energy efficiency" (Malaysian energy company executive, personal communication, June 11, 2018). The Malaysian energy executive indicated that there was direct overlap between the United Nation's Sustainable Development Goal #7 and the Green Technology Master Plan, stating that there are representatives from the UN that work with the Economic Planning Unit to create the steps and goals within the Green Technology Master Plan (Malaysian energy company executive, personal communication, June 11, 2018).

Table 3 - Targets in Energy Sector for the GTMP (Kettha, 2017)

Sectors/Areas	Year		
	2020	2025	2030
Renewable Energy (RE)	• 20% • RE mix (installed capacity)	• 23% • RE mix	• 30% • RE mix
Energy Efficiency	-	• 10% • Reduction in electricity consumption	• 15% • Reduction in electricity consumption

Sam Peltzman Model

For public policies, politicians and lawmakers weigh the balance between benefits created by a policy and the number of votes they may gain or lose depending on the parties that stand to gain or lose from a policy. In 1976, Dr. Sam Peltzman created a model that investigated this balance for policymakers to help explain why certain policies would gain traction (Peltzman, 1976). To simplify the model, the model observes the party that gains from a policy and the opposition to that policy. Then the odds that each member of that party votes to support that policy is compared to the opposition and the odds that each member of the opposition votes. If there are more votes likely to come from the opposition, the policymaker is less likely to put forward the policy.

In equation 1, 'M' stands for majority, 'n' represents the number of people who benefit from a policy, 'N' represents the number of people in the opposition, and 'f' and 'h' represent the probability of people in those respective groups voting for or against a policy. If 'M' is positive, the policymaker moves forward because there is a net benefit for their political standing, if 'M' is negative they become resistant to moving the policy forward because they could lose votes and potentially voted out of office. The model goes into greater depth by going into the net benefit capital created, lobbying, education, and other factors, but for the sake of this analysis the basic model is used to illustrate trends found within Malaysia. In some instances, which are noted in Dr. Peltzman's model, the perception of the benefits/losses is misinterpreted which clouds the result from equation 1 and results in surprise events for political races. The benefits can be

misinformed since energy benefits emerge generally in the future compared to immediate costs that are placed on the opposition.

Equation 1 – Sam Peltzman Model Example

$$M = (n * f) - (N * \not{n})$$

This model can be used for the energy policies discussed in this thesis by looking at which party benefits, and which parties would be opposed to the different policies. For example, in looking at the Petroleum Development Act the party that directly benefits would be the members of PETRONAS and the opposition would be other potential companies hoping to establish a foothold in Malaysia for commerce. Most of the energy policies discussed in this section benefit Malaysian citizens by increasing the energy security and lowering potential future costs that could occur from depleted domestic resources. In those policies, the opposition would be the energy companies that rely on fossil fuel energy resources to generate revenue since the cost, or dead weight loss, would be placed upon them for the success of the energy policies. Due to the companies employing Malaysian citizens, these energy companies have influence that can affect the political power for each type of policy.

The Peltzman model points out that citizens need to become aware of the benefits when they occur and in what capacity, but this plays into the issue of education within Malaysia and how the education system needs to be improved. This is discussed later in greater depth as the education issue comes up for the acceptance of renewable energy technology and the capacity to install and repair these technologies for residential consumers. The Peltzman model also points out that citizens need to become aware of

the costs or dead weight that is generated from policies, so they become informed of which politicians are responsible. Using the Peltzman model, it can be inferred based on the policies that have been passed that the Malaysian government looks to keep energy companies happy with their involvement in each policy. Despite that, the Malaysian government has these companies shoulder some, if not most, of the costs to benefit Malaysian citizens due to international recognition and longer term benefits. When looking at the model in a micro sense, meaning just in Malaysia, there may not be a lot of opposition, but when looking in a macro sense for the whole world, where commerce takes place between countries, the opposition can have a heavier weight and thus international policies tend to reflect avoiding those types of conflicts.

Research Questions Revisited

Visiting these national policies over the different Malaysia Plans has offered insight as to what energy challenges existed before and how they were addressed based on where each policy was focused. There is a clear shift in priorities within energy policies to first stabilize the fossil fuel supplies within Malaysia but then begin to branch out to other energy sources to help diversify resources and accommodate population growth and energy demand. It is clear from the renewable energy goals set forth by the more recent energy plans that future energy demand is aimed to be accomplished by a blend of renewable resources and not from one singular resource such as solar. This shift also aligns with the SDG Goal #7 as renewable energy is a priority set forth by the United Nations. The struggles with earlier renewable energy policies show that more than financial government incentives will be required for the widespread use of these

resources. While this section does not address the viability of palm oil, it does address the final two research questions as solar energy is encouraged by the government, but the optimal fuel mix is starting to take shape in the form of the Green Technology Master Plan.

ENERGY PROFILE ANALYSIS

In looking at Malaysia, it is important to observe what has transpired in the past and what is forecasted in the future to better understand the needs of the country and to provide targeted solutions. This section will home in on the electricity demand that is forecasted for Malaysia, the types of energy resources used over time, exports and imports over time, and observing current renewable energy practices. Points of emphasis are made with reference to the National Depletion Policy of 1980 which looked to reduce the amount of oil consumption, and the Fifth Fuel Policy of 2000 which looked to spread the energy use among five types of energy resources.

Electricity in Malaysia

To measure electricity consumption per capita, Figure 7 shows information from both the Energy Information Administration (EIA) and the World Bank about Malaysia's growing population from 1980 until 2016. The trendlines have been added into the graph to help extrapolate into the future on what can be anticipated for population, energy consumption, and that consumption per capita. The population data follows a linear trend while both electricity consumption and electricity per capita follow a quadratic trend. The R^2 value for both electricity graphs will increase as the higher degree function is used, but the difference in value is minimal. Figure 7 shows a comparison of population with electricity consumption per capita. Unlike some of the other figures that are shown, there is not emphasis on the two government policies as mentioned earlier because electricity is consumed by the citizens and is not focused on how the electricity was

generated. The takeaway from figures 7 and 8 is that electricity consumption is a larger concern as population continues to grow and energy resources will need to be used to meet this demand.

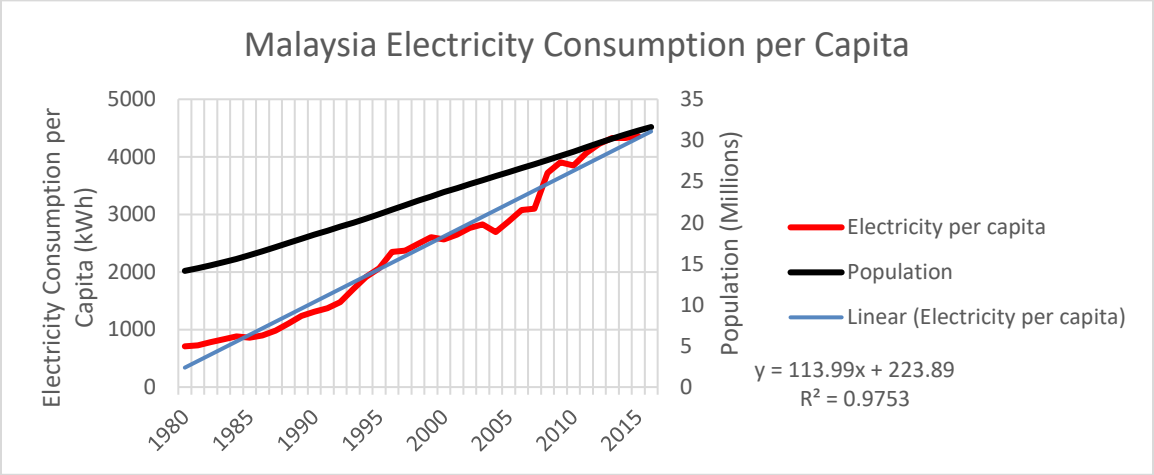

Figure 7 - Malaysia Electricity Consumption (World Bank, 2016; EIA, 2015)

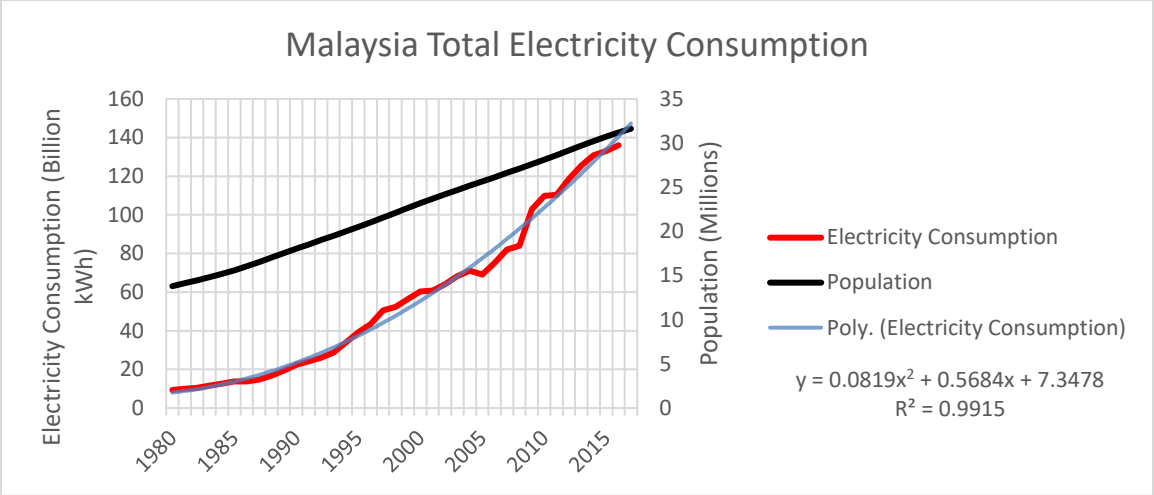

Figure 8 - Malaysia Electricity Consumption per Capita (World Bank, 2016; EIA, 2015)

Oil in Malaysia

Oil was first used to generate revenue for Malaysia in the early 1960's through the 1970's as the country was first working on being its own sovereign nation. In 1980, the National Depletion Policy sought to extend the lifespan of Malaysia's oil reserves by setting a cap on the amount of oil that could be produced in a given year (Jalal and Bodger, 2009). This cap was increased a few years later due to the amount of oil held in reserve and to help keep pace with the federal government's desire to maintain at least a 6% growth of GDP annually (*IBID*). As shown in the literature review, in 1981 the Malaysian government also instituted the Four Fuel Diversification Policy which sought to transition the electricity generation away from solely oil to a combination of oil, natural gas, coal, and hydro power (*IBID*). In 2000, the Malaysian Energy Department expanded the diversification policy by including biomass into the mix and Figure 9 showcases the effects of these policies by the decrease in oil usage for electricity

generation (Jalal and Bodger, 2009). Figure 9 also includes data obtained from the World Bank to account for the energy mix in 2010 and in 2015.

By contrast, oil consumption has not leveled off. Figure 10 shows the BP annual report that compares the amount of oil that Malaysia produces, consumes, imports, and exports (BP, 2017). As indicated from Figure 10, Malaysia has recently begun importing more oil, which puts a strain on the national economy. From the analysis in the previous section, this increase in oil consumption is not attributed to electricity generation due to the type of energy mix that exists within Malaysia for electricity. It is common knowledge in the energy industry that the price of oil barrels fluctuates tremendously over time due to supply and demand expectations as well as world events that can trigger a spike or fall. Figure 11 gives a logarithmic scale into oil prices over the past 70 years, and while Malaysia has only been a country for 55 years, the Malaysian government must closely observe the pricing of oil to determine how much it should import or export. An economic solution to dealing with volatility in the oil market is to explore potential substitutes that provide more options in hopes of lowering prices, but also increasing the elasticity of oil for the future.

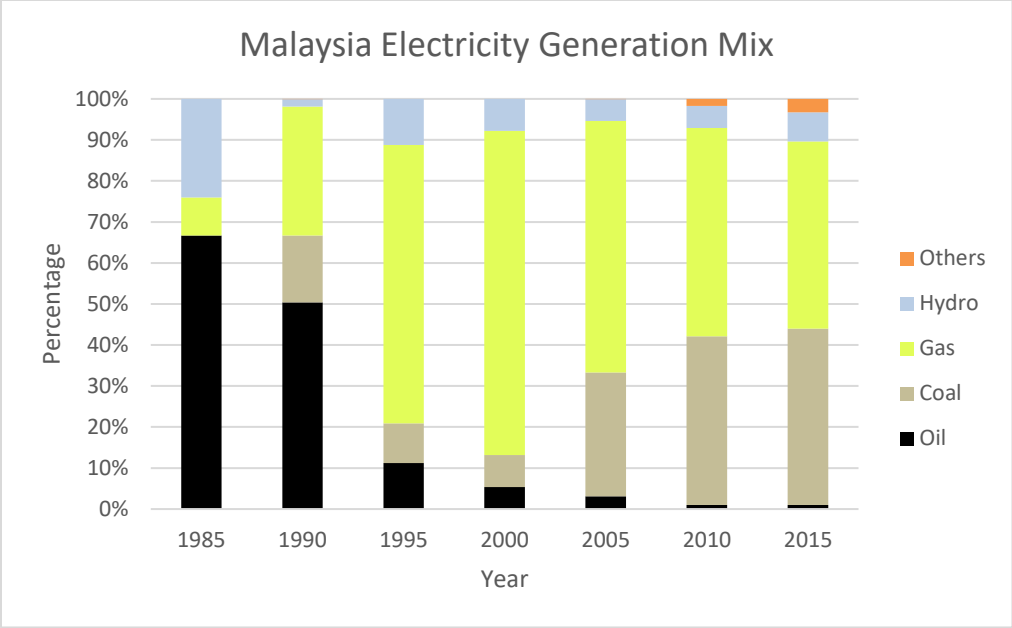

Figure 9 - Malaysian Energy Mix (Jalal and Bodger, 2009; World Bank, 2015)

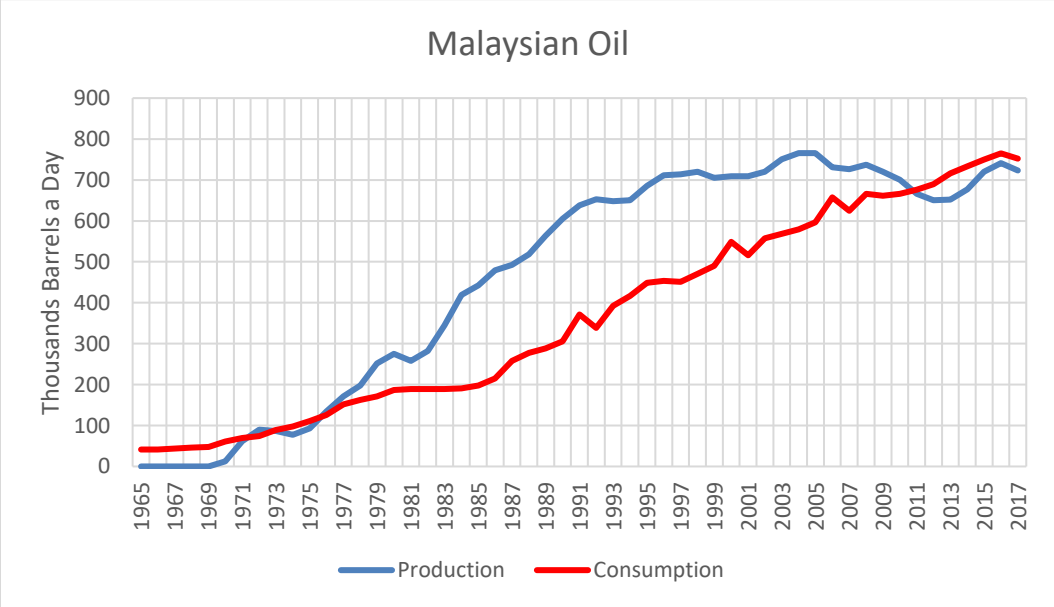

Figure 10 - Malaysian Oil from 1965 - 2017 (BP, 2017; EIA, 2017)

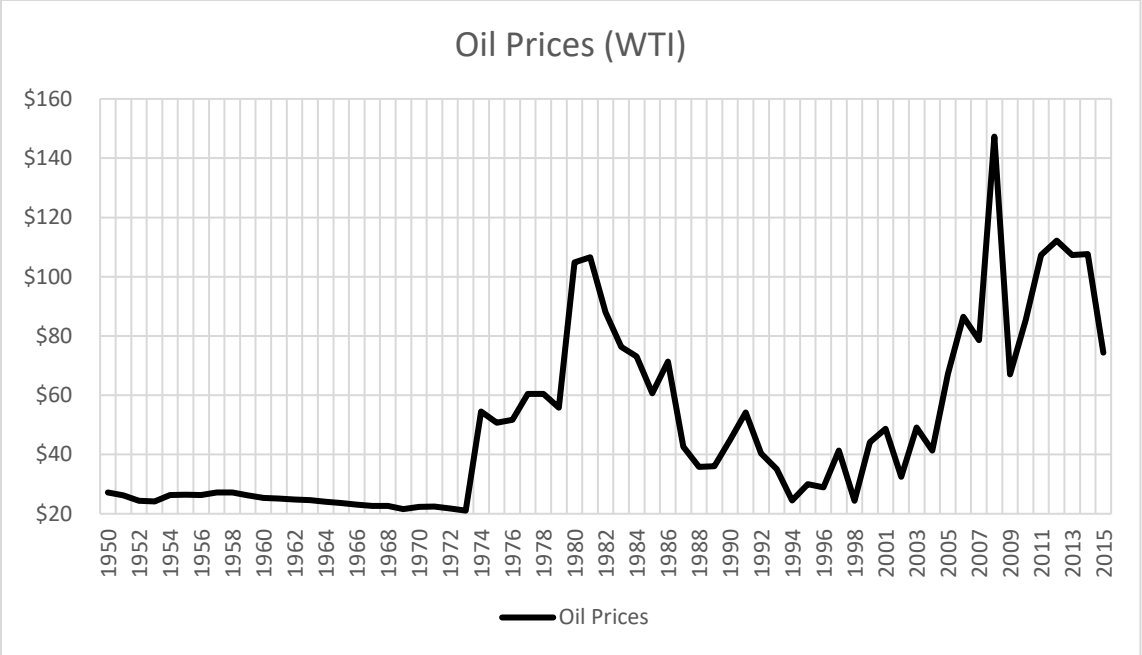

Figure 11 - Price of Oil using WTI measurement (Macrotrends, 2017)

Natural Gas in Malaysia

The information from the EIA shows that Malaysia is producing natural gas at a greater rate than consuming in which the surplus more than likely is going into international trade with surrounding nations (EIA, 2017). Figure 12 shows this comparison between the production and consumption for natural gas. The Malaysian energy company executive stated that since "Malaysia aims to use natural gas as a bridge fuel to help become more sustainable in the coming future" (Malaysian energy company executive, personal communication, June 11, 2018). The data was in part shown in cubic meters, so a small conversion was done to make sure that the data set was entirely in cubic feet.

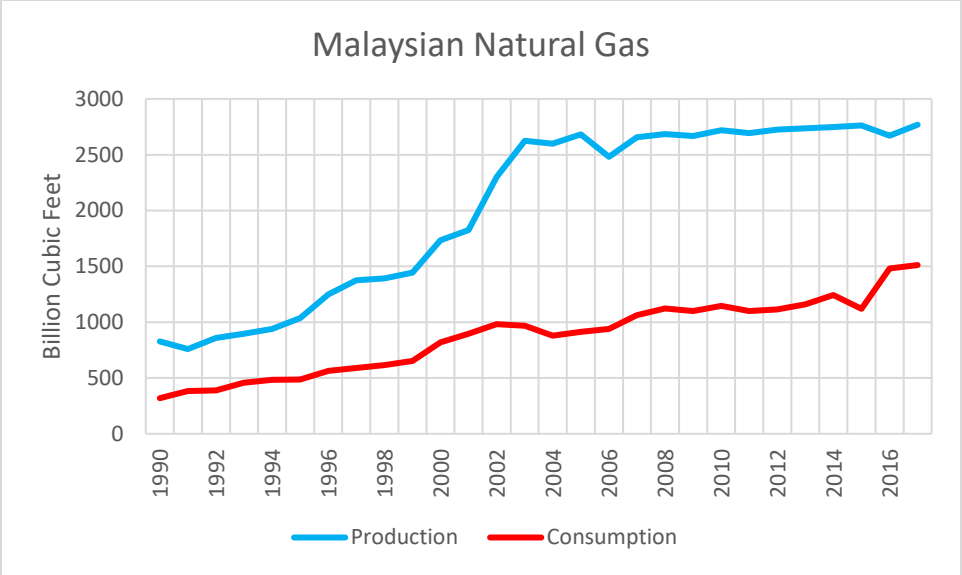

Figure 12 - Malaysian Natural Gas from 1990 - 2017 (EIA, 2015; BP, 2017)

In terms of supply for natural gas, there have been conflicting perspectives on the lifespan of Malaysia's natural gas supply since the scientific literature predicts the natural gas supply to expire around 2030 (Ahmad, 2011). Compare that information to the information gathered from the Malaysian national energy executive, stating "Malaysia has a healthy supply of natural gas, such that natural gas will be the bridge fuel towards a sustainable energy initiative" (Malaysian energy company executive, personal communication, June 11, 2018). With these conflicting reports, it is possible that variables such as energy extraction technology, smarter use of energy resources, and updated data play a role in the change in prognosis when comparing the two sources and the time the information was received.

Coal in Malaysia

Per the EIA, Malaysia has consumed coal at a much higher rate than it produces which leads to Malaysia having to import coal from neighboring countries such as Indonesia and Australia (EIA, 2015). In 2011-2012, Malaysia imported $356 million, or 184,600 short tons, of coal from Australia for the sake of electricity generation and for heating purposes (Australian Government, 2012). In looking at figure 13, the difference between production and consumption illustrates a constant problem of affordable energy generation for the Malaysian government. A practical alternative solution to using coal would be a step in the right direction for not only economic reasons, but environmental reasons as well as stated within the Eleventh Malaysia Plan (Eleventh Plan, 2016).

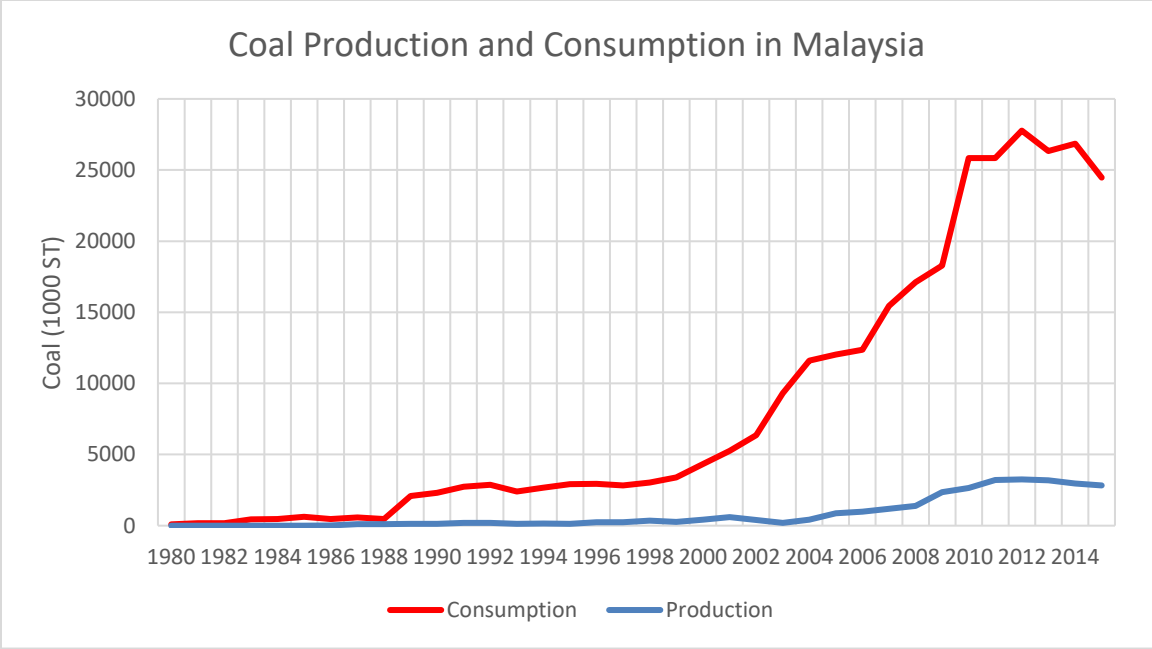

Figure 13 - Comparison of coal consumption to production 1980 - 2015 (EIA, 2015)

Existing Renewables in Malaysia

Per Muhammad-Sukki *et al.*, "In the last decade, both the government and private sectors [of the world] are trying to cut the dependency of fossil fuels by optimizing existing technologies as well as venturing into renewable technologies" (Muhammad-Sukki 2012). While the potential for renewable energy can seem to solve a lot of problems that fossil fuels bring in terms of the environment, economics, as well as political and social benefits, the actual implementation generally comes at a higher price due to the new technology and the slower rate of returns. By looking at what already exists within Malaysia, one can see what has and has not worked in the public and private domain to make solutions going forward.

The potential for hydropower is significant since "total gross hydro potential is 414,000 GWh/year of which about 85,000 GWh/year is available in the Malay Peninsula" (Abidin and Othman, 2005). Since 1939, when the Chenderoh Dam was created, there have been a total of eight major hydro dams with the Bakun Hydro Dam in Sarawak being the only major project under construction (Abidin and Othman, 2005). There is a high initial cost to implementing a hydroelectric dam, but the long-term benefits outweigh the economic cost (*IBID*). The environmental impact a dam could have on local ecosystems has to be accounted for to avoid damage to biodiversity. Depending on the type of dam that is created, minimal environmental damage and displacement could occur, maximizing the cost-benefit ratio after internalizing environmental costs. While hydro power has been carefully considered and used for a long time in Malaysia, it does not have the capacity to generate enough electricity to properly substitute for fossil fuels (Eighth Plan, 2001). Hydro power also does not address concerns of sending electricity a long way to citizens that do not live near the coastline (Tenth Plan, 2011; Eleventh Plan, 2016).

Per Chua, "Although there is potential in biomass, biogas, municipal waste and mini hydro, solar PV has been identified as the energy source with the highest potential in satisfying the energy needs of Malaysia" (Chua 2012). Solar energy is considered in-depth later, but energy solutions do not have to rest with one type of source and can be spread amongst multiple possibilities for greater flexibility and less volatility. Options such as palm oil for biofuel are considered especially since the waste from palm oil plantations is already used for biofuel.

Research Questions Revisited

Like the energy policy analysis section addressed specific research questions, the energy profile for Malaysia addresses the same type of concerns. By looking at each energy resource, the problems arose for each resource type for the pros and cons and the potential outlook going forward and compared to the SDG Goal #7. The electricity consumption per capita graph showing an increase over time like a quadratic function indicates the growing need for efficient energy infrastructure and the need for more energy production. Palm oil is not addressed within this section, but information is presented to aid in selecting a viable fuel energy mix for electricity concerns going forward. A careful balance will need to be considered for what is economically feasible for Malaysia to the environmental concerns that each energy resource brings.

PALM OIL ANALYSIS

Palm Oil Outlook

To answer the second sub question, palm oil analysis is conducted to lay out if it is possible to have palm oil substitute fossil fuels to generate electricity. A lot of research related to palm oil seems to focus on deforestation versus the expansion of palm oil fields (E.g. Bhagwat & Willis, 2008; Cramb & Ferraro, 2012; Danielsen, 2009; Lim & Teong, 2010). With the expansion of palm oil fields comes the depletion of usable land for citizens, as well as biodiversity loss. As mentioned before, the Malaysian government also should worry about not having a trade partner for the biodiesel industry due to the number of carbon emissions released from the lands that they develop. Dr. Welsh discussed the issue of palm oil trade with respect to trade partners, stating "It's pretty clear that the government needs to diversify the sources where it distributes its palm oil to. Most of the trade is going to China and as the demand for palm oil decreases, the palm oil market becomes more vulnerable" (Dr. Bridget Welsh, personal communication, October 24, 2018). On the other hand, there is concern that the country will run out of oil and natural gas. To help offset this concern, palm oil can be used to generate electricity in the form of biofuel. The following analysis will go into the mathematics of how much land is required to substitute crude oil, coal, and natural gas with palm oil for electricity generation to help preserve domestic supplies.

Energy Dimensional Analysis

In comparing palm oil versus crude oil, information regarding the energy content of the two different fuels are considered as well as a direct comparison for how many acres of palm oil trees need to be planted to yield the equivalent level of production. Necessary information for the dimensional analysis includes energy from a gallon of crude oil, a gallon of biodiesel as well as basic conversions such as how many gallons are in a barrel and days in a year. For this analysis, 365.25 days are used to account for leap years. Time, area, and energy conversion rates are noted in the explanation below along with some mathematical calculations so that if this equation is considered in the future, alterations can be easily made to meet future standards. The information was gathered across different years for standards, such as the number of barrels consumed by Malaysia per day, but this analysis provides an outline of how large of an area would need to be devoted to Malaysian palm oil plantations to completely replace the consumption of various fossil fuels.

The methodology for the following equations establish how much energy, in BTUs, each type of energy source creates and then determine how much palm oil biodiesel would be needed to match that amount of energy. From there the amount of land space is calculated to determine how large a space is needed for palm oil plantations solely to create enough biofuel. The comparisons are against the size of several states within the United States for visual purposes.

A gallon of crude oil produces 136,405 Btu of energy compared to biodiesel which produces 121,000 Btu per gallon (EIA 2016; Rapier 2006). The consumption of

crude oil for Malaysia in 2014 was 745,000 barrels/day which translates to 271.925 million barrels of oil or 11.4 billion gallons of oil per year (EIA 2014). Each tree of palm oil produces 42.5 kilograms per year, or 13.2 gallons of fuel, which means that to match the amount of energy production from crude oil in 2014, Malaysia would have to devote 6.59 million hectares (Malaysian Palm Oil Board 2011). This results in the size of West Virginia when compared to the United States.

Equation 2 - Energy created from crude oil consumption per year

$$\frac{745000\ barrels}{day} * \frac{42\ gallons}{barrel} * \frac{365.25\ days}{year} * \frac{136405\ BTU}{gallon} = \frac{1.559\ quad\ BTU}{year}$$

Equation 3 - Land required to offset energy production from crude oil

$$\frac{1.559\ quad\ BTU}{year} * \frac{1\ gallon\ (bio)}{121000\ BTU} * \frac{1\ tree}{13.2\ gallons} * \frac{Hectare}{148\ trees}$$

$$= \frac{6.59\ million\ hectares}{year}$$

For natural gas, Malaysia consumed 1.1 trillion cubic feet of natural gas with each cubic foot producing 1032 BTU of energy (EIA 2014; EIA 2016). This leads to needing 1.1352 quads of BTU, or 1.1352 x 10^{15} BTU. The necessary space to completely offset from natural gas is 4.80 million hectares which is roughly one-and-a-half times the size of Maryland.

Equation 4 - Total energy produced from natural gas

$$\frac{1.1\ Tcf}{year} * \frac{1032\ BTU}{1\ cubic\ foot} = \frac{1.1352\ quad\ BTU}{year}$$

Equation 5 - Land required to offset energy from natural gas

$$\frac{1.1352\ quad\ BTU}{year} * \frac{1\ gallon\ (bio)}{121000\ BTU} * \frac{1\ tree}{13.2\ gallons} * \frac{Hectare}{148\ trees}$$

$$= \frac{4.80\ million\ hectares}{year}$$

Overall from this analysis, the Malaysian government would have to devote 11.39 million hectares to palm oil to replace the energy consumption from both crude oil and natural gas. This size is roughly the size of the state of Ohio. With Malaysia having 32.985 million hectares in total, 34.53% of the total land would need to be dedicated to palm oil to fully substitute natural gas and crude oil.

Equation 6 - Total energy produced by coal per year

$$\frac{28.3\ million\ short\ tons}{year} * \frac{19882000\ BTU}{short\ ton} = \frac{0.563\ quad\ BTU}{year}$$

Equation 7 - Land required to offset energy produced from coal

$$\frac{0.563\ quad\ BTU}{year} * \frac{1\ gallon\ (bio)}{121000\ BTU} * \frac{1\ tree}{13.2\ gallons} * \frac{Hectare}{148\ trees}$$

$$= \frac{2.38\ million\ hectares}{year}$$

This increases the land necessary to 13.77 million hectares or 41.75% of Malaysia which is larger than the size of Pennsylvania. The good news regarding the sizable land required is that palm oil trees can produce oil for 25 to 30 years (Sime Darby 2014). No additional land will be required. Looking at the versatility of palm oil means that even more land will need to be dedicated since palm oil is currently used for more than just

electricity generation. This makes the idea of completely substituting fossil fuels with palm oil a possibility but not a reasonable one.

Table 4 - Comparisons of energy produced, palm oil space needed, and percentage land space of Malaysia (EIA, 2014; EIA, 2016)

Energy Source	Quad BTU/Year	Land Space Needed (Million hectares/year)	% land of Malaysia
Crude Oil	1.559	6.59	19.98%
Natural Gas	1.1352	4.80	14.55%
Coal	0.563	2.38	7.22%
Total	**3.2572**	**13.77**	**41.75%**

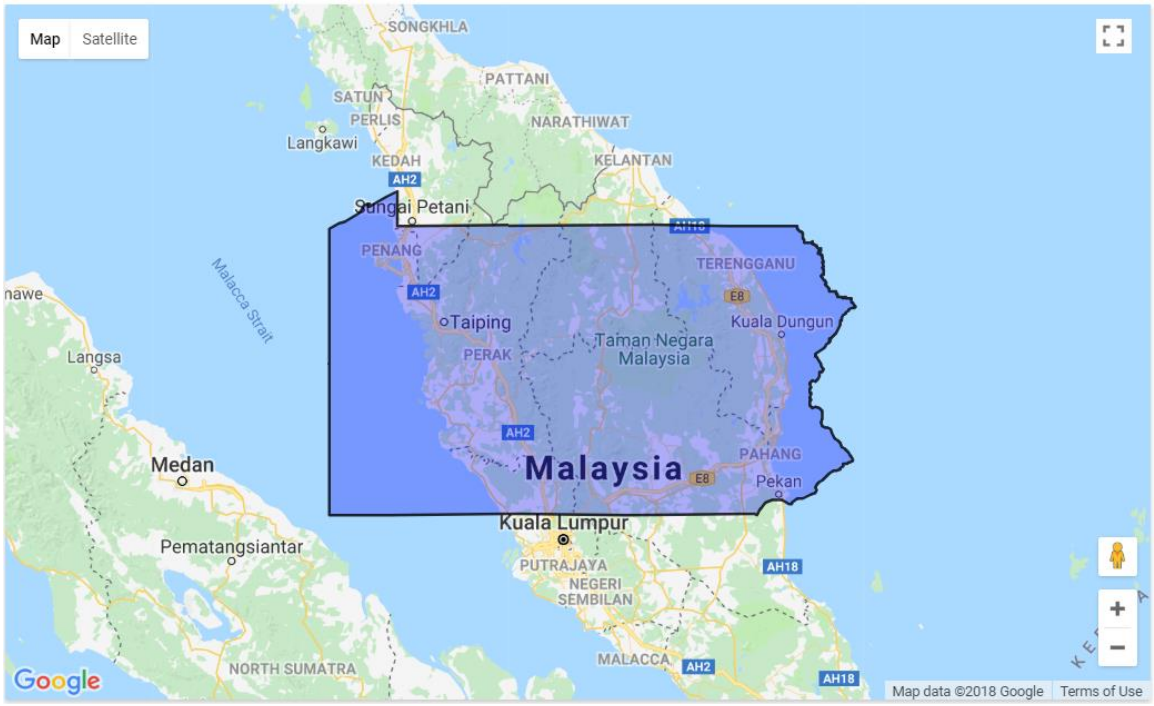

Figure 14 - Visual comparison of Malaysia to Pennsylvania, USA (Google Maps)

Ramifications from Analysis

Looking at the daunting statistics for the land area necessary to offset usage of fossil fuels brings pause as far as how much the Malaysian government wants to try to offset their energy consumption overall versus how the split should be between biodiesel and traditional energy sources. The Malaysian energy company executive stated that this sort of shift will require more land to accommodate the growing demand of palm oil for the sake of the transportation industry, but there is also the addition of biogas made from palm oil companies that will eventually connect to the national grid and provide more renewable energy over time (Malaysian energy company executive, personal communication, June 11, 2018). There is also the challenge that there are not many financial incentives to improve the palm oil industry. Both Kate Clemans and Dr. Bridget Welsh discussed that while there are technological improvements that can be made in the production process to save on emissions and energy, the palm oil plantation owners are content with their current profit margin and do not want to change any process without significant incentives (Dr. Bridget Welsh, personal communication, October 24, 2018; Clemans, personal communication, April 12, 2018).

The environmental concerns for biodiversity and the global environment make palm oil as an energy substitute less attractive economically for plantation owners when looking at other options such as the continued use of fossil fuels and the potential of renewable energy. As regulations occur for sustainable practices of palm oil to preserve biodiversity, the added costs are placed upon the plantation owners. The costs could be transferred to the consumer, but then the plantation owners run the risk of losing potential

customers due to the higher costs. Per Rina Haiges, biofuel is already being used from "the National Biofuel Policy, which gives emphasis on the blending of 5% palm oil with 95% petroleum diesel to produce biofuel/biodiesel" (Haiges, personal communication, July 13, 2018). Also, according to Rina Haiges, "Using palm oil as biofuel for electricity generation may still be in the research stage but not as much information has been published; however, using palm oil waste (biomass or biogas) to generate electricity has greater potential" (*IBID*). According to the Malaysian energy executive, the national biofuel program, run by the Malaysian government, is looking to change the amount of palm oil found in gasoline at the pump, like ethanol found in the United States' gasoline, from 5% to 10% soon (Malaysian energy company executive, personal communication, June 11, 2018).

For the palm oil analysis, this addresses the viability of whether palm oil could be a substitute for fossil fuels on a larger scale. The policies surrounding palm oil and other types of energy resources are steps towards having cleaner energy, but the challenge is straddling between economic viability and the environmental goals set forth by the SDGs. This information, much like some of the other sections, ties into determining the proper energy fuel mix needed to satisfy growing electricity demand. In the next section, solar energy is observed to see how viable the resource is and how effective solar panels are in solving the growing electricity concerns.

SOLAR ENERGY IN MALAYSIA

For this section, an analysis is conducted for the potential benefits for Malaysian solar energy, but also a look into what is currently happening with regards to solar energy to see what infrastructure is already in place and whether it is feasible to incorporate solar energy on a larger scale to help offset the use of fossil fuels. Dimensional analysis is conducted based from scientific literature found over the course of the literature review and combined with the insight of interviews from professionals. Input specifically from a Malaysian national energy company is critical in showcasing the current energy landscape for solar energy for both the present and the future. Input from other interviewees will contribute to the discussion about solar energy capability in Malaysia and the potential challenges that the country faces.

Per Sabo *et al*, "Malaysia has good solar insolation with about 4-5 $kWh/m^2/day$" which translates to 1460 - 1825 $kWh/m^2/year$ (Sabo, 2016). This number has been calculated already with the efficiency of photovoltaic (PV) panels taken into consideration as of 2011 and does not account for technological advancements of PV panels since 2011. Also, to note is that the number provided in Sabo accounts for several hours of sunshine per day. That number has been extrapolated over a year to account for weather related detriments during the Northeast monsoon season which takes place from October to March. While the efficiency for solar panels has increased over recent years, the efficiency for solar panels is still within the range of 20-40% where an expensive option has a 43% efficiency but is not practical for the average consumer (Malaysian

energy company executive, personal communication, June 11, 2018). Dr. Welsh points out an issue regarding efficiency in that "there is a lack of consistent sun over the course of a year due to haze and the monsoon season" (Dr. Bridget Welsh, personal communication, October 24, 2018). Energy storage is also a challenge because users may not use all the energy created from the PV panels at the time of generation, but the current storage technology is not sufficient (*IBID*). Figure 15 is a map of solar radiation for southeast Asia, including Malaysia, that shows the potential in terms of kWh/m^2/year. The figure shows the range of annual solar radiation to be great for solar energy throughout the entire country since there appears to be a uniform distribution of energy compared to a country like Taiwan in the figure that indicates only a specific area be viable for solar energy. Based on the annual irradiation map, the quantity of solar potential has not changed substantially since Sabo in 2016. The potential for solar PV energy replacing fossil fuels is examined later on, but it is important to note that a domestic energy supply such as solar energy would help stabilize Malaysia from an energy security perspective and would enable Malaysia to be shielded from market volatility for energy commodities.

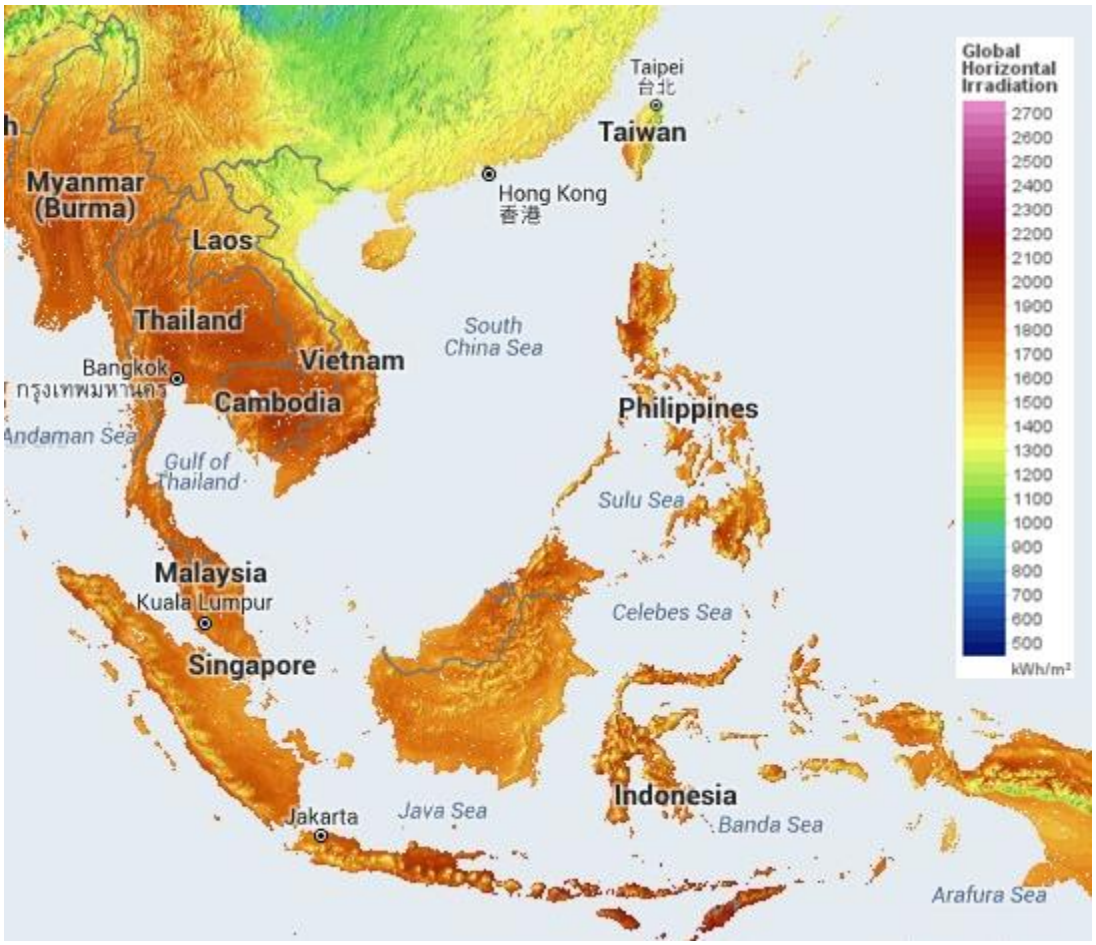

Figure 15 - Overview of solar irradiation conditions in Southeast Asia (Solar PV Trade, 2018)

One method that the Malaysian government has sought to promote the use of solar panel technology within the country is by using the FiT program. The FiT program is like a term called "net metering" in that both programs aim to reimburse the user of the technology with economic incentives for using renewable energy. "Net metering" is when the credit received for contributing a certain quantity of electricity matches the cost of consuming that same quantity from the electric grid, while the FiT program looks to have the credit outweigh the cost. Other developed countries look to use both "net

metering" and programs like the FiT program to lessen the amount of electricity needed to be created by electric companies on the national or regional grid. A raised FiT rate will degrade over time to project the cost and affordability of the technology. On November 1st, 2016 the Ministry of Energy, Green Technology and Water (KeTTHA) replaced the FiT system with a net metering system that is scheduled to go from 2017 through 2020 (Tenaga, 2017). The reason for the change is to give everyone access to potential benefits of solar PV energy rather than bid on a quota as determined by the FiT system (*IBID*). The interviews conducted did not directly address the change from the FiT system to a net metering system, but part of the change was shared by the Malaysian energy executive when talking about the Green Technology Master Plan and how information was important for Malaysian citizens to ingest to help increase the use of solar panels.

Capacity is the maximum amount of energy that can be created from solar energy generation while taking into consideration the efficiency of the solar panels. From the Suruhanjaya Tenaga Energy Commission, solar energy capacity has expanded from 189 megawatts (MW) to 235MW from 2015 to 2016 with the intention of introducing 800MW through competitive bidding of private companies to then install over the course of 2017 through 2020 (Tenaga, 2017). In speaking with the Malaysian energy company executive, the goal for renewable energy is to have a capacity of 2080 MW by the year 2020 (Malaysian energy company executive, personal communication, June 11, 2018). This capacity would include solar, biogas, and biomass. The added solar capacity of 800MW with the new contract will set to increase the total solar capacity to 1035MW by

the year 2020, but what impact will this mean for offsetting fossil fuels for electricity generation?

Using the information from the palm oil analysis, equation 7 converts the MW generated by the solar panels over the course of a year to the different fossil fuel energy resources that were compared when looking at palm oil as a potential substitute. Table 4 shows the calculations of how much of each resource is saved by utilizing the solar capacity by 2020. While the results shown in Table 4 are promising for reducing the consumption of fossil fuels, more will need to be done to meet international goals and to help preserve the reserves for a longer period.

Equation 8 - Converting MW generated from solar PVs to Btu for comparison

$$1035\ MW * \frac{947.82 \frac{Btu}{s}}{1\ MW} * \frac{60\ secs}{min} * \frac{525{,}600\ min}{year} \approx 30.937\ trillion\ Btu/year$$

Table 5 - How much 1035 MW of solar energy saves

Fuel Source	Btu/Unit	Units saved/year
Crude Oil	5,729,010	5.4 million barrels
Natural Gas	1032	29.977 Bcf
Coal	19882000	1.556 million short tons

Cost Comparison for Solar Panels

While the environmental factors can be an appealing reason to utilize more solar energy, the cost for consumers plays a big role because it presents a pay wall that

consumers may not be able to meet and therefore be priced out of solar energy. In Table 6, the price for solar panel systems for the United States is compared to Malaysian solar panel systems by using numbers from a company in Malaysia and from a solar group that researches solar energy costs in the United States (FitSolarPlan, 2018; Energysage, 2018). Information for different sizes of solar panel systems are provided. In cases where one currency is provided, the conversion is made to provide context.

Table 6 - Cost Comparison of Solar Panel Systems between Malaysia and the US

System Size (kW)	Cost (RM) ^conversion from USD	Cost (USD) *after tax credit ^conversion from RM	Unit Cost (USD/kW)
5 (Malaysia only)	52,500	12,599^	$2519.80
6 (US only)	54,974^	13,188*	$2198.00
8	76,000	17,584* 18,240^	$2198.00 / $3040.00
10 (US only)	91,624^	21,980*	$2198.00
12 (Malaysia only)	105,000	25,198^	$2099.83

Based on the table, the US prices are constant with the unit cost of kW for each system, but there is a fluctuation in pricing per kW in Malaysia with the best value being a 12kW system. The problem with the Malaysia pricing system is that each home will require a different sized system so if a home only needs 8kW for their needs, they will be in the most expensive bracket. The cost shown in United States dollars shows the price wall that families must overcome to install these systems. One concept that is also used for solar panel systems is the 'break-even period' or the period in which the savings on energy costs equal to the cost of the system itself. According to the company

'FitSolarPlan' in Malaysia, the 'break-even period' range is 6.2/5.6/5.2 years for a 5/8/12 kW system based on the savings of from electricity consumption and from net metering offered in Malaysia (FitSolarPlan, 2018).

One of the bigger reasons why PV panels are not used in a more widespread fashion is due to the high material and installation costs associated with mining the raw materials and the creation of solar panels (World Bank, 2011). From earlier sections, other reasons why PV panels are not in wide use is lack of proper information for consumers, and the struggle with social acceptance for solar panels (Jing 2015). Per the World Bank analyst, "In our discussion with the Economic Planning Unit in our 2011 report, (the World Bank) felt that producing solar panels would be like the electronics industry where the market would not be as productive. The cost of solar panels is going down exponentially and looking downstream of the market of solar panels will have a higher net profit. Part of looking downstream is building up knowledge capacity but Malaysia is lacking in that knowledge for their workforce" (World Bank, personal communication, July 9th, 2018).

Malaysia, in 2014, was number six in the world in manufacturing solar panels, but that is largely due to Chinese corporations establishing businesses within Malaysia both due to the rich supply of raw minerals needed for solar panels, but also due to favorable trade policies intended to promote Malaysia's economy through international commerce (World Bank, 2014). According to the Malaysian energy executive, in 2018 Malaysia is third in the world for manufacturing solar panels, behind China and Taiwan, and aims to utilize the technology for meeting international goals as well as domestic goals

(Malaysian energy company executive, personal communication, June 11, 2018). The surge in solar panel production is due to the global demand from developed countries looking to move their renewable energy agenda but also because Malaysia aims to take a firm foothold in the global market for solar panels. This foothold looks to provide cleaner energy for both Malaysia and for the developed countries that look towards SDG #7 for cleaner energy. The cost for solar panels has been slowly going down as the technology has improved, making it more affordable for businesses and in turn affordable to residents that hope to take advantage (Ahmad, 2011). Per the Malaysian energy executive, while the cost is slowly going down, the price is still too high for the average consumer, so the technology is still not widespread enough to fully meet the energy concerns (Malaysian energy company executive, personal communication, June 11, 2018). In the next section, the political and social dynamics of Malaysian energy is addressed because they are just as important as for the economics to work.

Research Questions Revisited

Regarding this section, the question of how Malaysia is using solar energy as a renewable fuel source is addressed from looking at the motivation of producing solar panels and how the production is tied with SDG #7. This section also showed the viability of solar energy across the entire country to show that solar panels could help offset the energy concerns for the future. This section also detailed the concerns for solar panels which ties into optimal fuel mixing to combat the growing energy demand for electricity. While solar panels seem to be a good idea in terms of energy, their

implementation and acceptance is a different challenge compared to technological issues like energy efficiency.

SOCIAL AND POLITICAL ISSUES WITHIN MALAYSIAN ENERGY

Part of the challenge of incorporating an agenda focused more on renewable energy sources is the political and social barriers that exist within Malaysia. To gain a better perspective on what goes on within Malaysia, interviews have been conducted with specific professionals that have a wealth of experience in the region but also with the energy landscape from political and social perspectives.

Sometimes a country's political focus shows which direction energy policies will trend towards for energy resources and plans for technology as it pertains to energy efficiency. The prime minister election ended with the incumbent candidate, Najib Razak, losing to his opponent, Mahathir Mohamad, showing the first time in the country's history that the political party controlling the federal government is not part of the Barisian National Party. Per a Malaysian energy executive, while this shows a political swing in the country's ideology going forward, this change does not affect energy policy due to the positive effects the policies aim to bring about (Malaysian energy company executive, personal communication, June 11, 2018). In speaking with the Malaysian energy company executive, policies such as the Green Technology Master Plan align perfectly with the United Nations' SDGs and therefore showcase the country's ambition to work alongside other developed nations to one day join their ranks, with the goal of achieving that status by 2020 (Malaysian energy company executive, personal communication, June 11, 2018).

Petronas, a company placed in charge of oil and natural gas production within Malaysia since 1974, is seen as "the cash cow of Malaysia and should not be disturbed if at all possible" (Clemans, personal communication, April 12, 2018). After hearing differing views on the role of Petronas, the interview data points to Petronas holding a lot of sway in the energy industry for Malaysia that has the capability to hold back or encourage the progression of renewable energy usage. The Malaysian government has conflicting motives from conserving fossil fuel supplies to constant GDP growth. By using those resources, Petronas is the nucleus for how the energy landscape will progress further. While the National Depletion Policy of 1980 did cause Petronas to curb the production levels, the amount of revenue the company has feeds into the Malaysian government and provides some political sway. The Peltzman model ties into this influence especially when it comes to any energy policies that try to remove control of Petronas for energy resources. Per a Malaysian energy executive, Petronas has encouraged the promotion of alternative fuel sources to help extend the lifespan of Malaysia's domestic energy reserves and to align more with international energy initiatives (Malaysian energy company executive, personal communication, June 11, 2018).

Per Kate Clemans, the potential of palm oil as a biofuel for Malaysia's energy concerns will stem from the plantation owners that look to have incentives from the Malaysian government like how the United States government subsidizes corn for ethanol production (Clemans, personal communication, April 12, 2018). Petronas supports the use of palm oil, but not as a biofuel beyond the fuel mix standards set for

gasoline (Malaysian energy company executive, personal communication, June 11, 2018). "Linking the plantations to use biogas and biomass for energy production will contribute to the national energy mix compared to palm oil as a biodiesel" (Malaysian energy company executive, personal communication, June 11, 2018). The plantation owners are linked to energy companies because the cooperation from the plantations makes the overall cost of biogas and biofuel cheaper. In turn, if the government incentives can be put into place to subsidize palm oil for the purposes of generating more biofuel, they reduce the need to use fossil fuel resources.

As to how solar energy can play a role in resolving some of the social and political issues pertaining to Malaysia, Ms. Clemans states "I don't think social acceptance is an issue for solar energy. The issue will be cost related for residential solar" (Clemans, personal communication, April 12, 2018). "Absent an election, you would find this whole area governed by the following: Petronas being the cash cow and contributing most of the sovereign wealth of Malaysia, rural areas the government wants to keep happy because there is a lot of insurgency there and radicalization especially in the outlying areas and being innovative and leading in energy policy/practice to join the big boys of developed nations" (Clemans, personal communication, April 12, 2018). The Peltzman model could be used with regards to the influence on the election from Petronas or other energy entities that could benefit from policies. This ties into the energy challenges that exist within Malaysia since there exists a social divide between the middle and lower classes. According to Ms. Clemans, it seems that the potential for solar energy improving the quality of life for those in rural communities addresses two of the

main points while leaving Petronas focused on conserving oil and natural gas supplies for a longer period. Contradictory to that, the World Bank analyst pointed to the corruption found within the Najib administration stating, "kickbacks were found all over the place under Najib" and "Petronas didn't want competition (in 2010) in the energy industry" (World Bank, personal communication, July 9, 2018). Dr. Welsh concurs with both Kate Clemans and the World Bank analyst regarding the social and political challenges pertaining to the integration of solar energy but remains optimistic. "There is tremendous potential for solar energy which was underutilized. The new government is pushing for more solar usage compared to the previous government which was only interested in making money from solar energy" (Dr. Bridget Welsh, personal communication, October 24, 2018).

Another issue tied with solar energy is the information gap that exists within Malaysia. In the Eighth Malaysia Plan, the discussion of the knowledge gap stemmed from the notion that universities within Malaysia were not producing quality workers and were not leaving an impression in international discourse (Eighth Plan, 2001). Ms. Clemans spoke about the knowledge gap, stating "(The Malaysian government) has been trying to work on this for years. (The government) tried eLearning to help leap frog forward, but that didn't work as students would go abroad for universities in the UK or Singapore. (The government) also increased the number of Malays in their universities but everything seems to backfire for them" (Clemans, personal communication, April 12, 2018). The Malaysian energy company executive concurs with Ms. Clemans that "education for energy usage and managing energy efficiency is a challenge within

Malaysia" (Malaysian energy company executive, personal communication, June 11, 2018). While the knowledge gap exists within Malaysia, it is likely that using solar panels for rural communities would be a challenge for repairs and maintenance purposes. Per Haiges, "Awareness of solar energy potential is still rather low amongst the people in Malaysia. Malaysia also lacks electricians who are familiar with the correct installation of PV systems. Wrong installation without complying to safety regulations can lead to fire hazards of those systems" (Haiges, personal communication, July 13, 2018). If this gap is closed, domestic workers should be skilled enough to complete repairs themselves and not rely on outside professionals to complete the work, thus saving money for local businesses and the federal government. "Building up the knowledge capacity for installing and repairing solar panels is paramount since the engineering will only yield roughly $1/watt generated (in 2010)" (World Bank, personal communication, July 9, 2018). Even with the installation of these panels for residents, understanding that energy is not an infinite resource will also present a challenge because it presents a macro way of thinking for citizens who may be focused on their day-to-day lives instead of the broader impact (Malaysian energy company executive, personal communication, June 11, 2018). This methodology of thinking is akin to when the United States would issue campaigns encouraging its citizens to turn the lights off when they left the room or adjusting their thermostats accordingly to save energy.

Finally, an international issue stemming from solar panels comes from the companies that have investments in Malaysian solar and how those investments impacts domestic influence and international trade. As Malaysian solar began to emerge in the

global market, China began investing more into Malaysian infrastructure in the form of various projects (SCMP, 2017). Per Kate Clemans, if China were to begin to invest in Malaysian solar, the rural populations would not be as welcoming to the idea of implementing local solar panels because of the potential influence that China would be able to bring (Clemans, personal communication, April 12, 2018). There exists tension between the Malays and the Chinese within Malaysia, and the extra influence may cause the rural populations to impede the progress of solar since the clear majority of those that live in Sabah and Sarawak are Malay (SCMP, 2017). The 2018 tariffs imposed by President Trump of the United States impact Malaysia because of the fear of China using Malaysia as an intermediary for exporting solar panels to other developed countries (*IBID*). While these renewable energy sources could be the potential solution for resolving electricity production concerns as well as help bridge social inequality within Malaysia, social and political interests may keep these solutions at bay.

When asked about whether an international organization like the United Nations should step in to try and help Malaysia with their energy concerns, Dr. Welsh pointed to the new administration with optimism. "The leadership has to come from within with the new prime minister focused more on renewable energy. Malaysia cannot do it alone and having an organization like ASEAN where multiple countries working together will help tremendously. The United Nations can provide guidance and a framework for technical expertise to learn the best practices, but the leadership within Malaysia must initiate the movements. It will be important to work with environmental actors to help create a new framework. One example is the recycling law that has started to change the behavior of

Malaysian citizens. Similar efforts will need to be done from multiple points to change people's behavior for electricity consumption, in part because electricity is so cheap from being heavily subsidized" (Dr. Bridget Welsh, personal communication, October 24, 2018).

The Malaysian energy executive indicated that there was direct overlap between the United Nation's Sustainable Development Goal #7 and the Green Technology Master Plan, stating that there are representatives from the UN that work with the Economic Planning Unit to create the steps and goals within the Green Technology Master Plan (Malaysian energy company executive, personal communication, June 11, 2018). Petronas has encouraged the promotion of other fuels to extend the lifespan of domestic supply of fossil fuels. Kate Clemans calls upon the plantation owners if palm oil biofuel were to play a bigger role and the Malaysian energy executive concurs with Kate Clemans. Cost seems to play the bigger role for solar energy challenges. This challenge ties directly with social issues especially related to income inequality. The information gap and education gap also play a role in the barriers for more widespread use of solar panel systems in the residential sector, all while avoiding Chinese influence in the marketplace.

CONCLUSION

Over the course of the past 55 years, Malaysia has climbed up the ranks of developing nations economically by utilizing the domestic supply of fossil fuels and slowly improving the living conditions for all its citizens in each province. As Malaysia entered the new millennium, the attention began to shift towards renewable energy practices primarily from domestic interests to maintain energy security. The shift to renewable energy was also international as potential trade partners began to establish environmental emission standards for imports relating to palm oil products and other business practices found common in Malaysia. While the energy concerns for the Malaysian government focus on the economics of energy products, as supplies begin to diminish and the demand for energy and electricity begin to rise, the emergence of renewable energy technology in other parts of the world began moving Malaysia to incorporate alternatives.

The primary question for this thesis was how much Malaysian domestic energy policy overlapped with the UN's SDG #7. Based on the interview data gathered from the Malaysian energy executive, there is a direct overlap between the two sets of goals as the UN has helped the Economic Planning Unit create the Green Technology Master Plan (Malaysian energy company executive, personal communication, June 11, 2018). Other interview data shows a willingness of the Malaysian government to work with the SDGs which supports the information gathered from the interview with the Malaysian energy executive.

The first sub-question was what energy challenges exist for Malaysia. Energy challenges exist in Malaysia where the federal government is trying to meet energy consumption needs to match population growth and growth of energy consumption per capita. The first table in this document that shows the different Malaysia Plans shows that energy consumption per capita is on the rise so more energy will need to be created in both peninsular Malaysia and Borneo. Efforts to incorporate more biofuel in gasoline, renewable energy for heat and electricity, and education campaigns to promote efficient energy usage will all help contribute to resolving energy concerns, but the markers within the GTMP will showcase just how successful those efforts are by the years 2020, 2025, and 2030 respectively. The research conducted on energy policy, and how the presence of energy resources increased, showcases that Malaysia does have a series of energy challenges with regards to electricity production and incorporating more renewable energy into the national grid mixture. The interview data does indicate that the Malaysian government wants to focus more on renewable energy for sustainability purposes but also to prolong the lifespan of the domestic fossil fuel supply.

The second sub-question was whether palm oil could be a viable option for replacing fossil fuel usage in electricity generation. Utilizing palm oil, Malaysia established itself as a world leader for the specific niche of goods until 2008 when Indonesia surpassed Malaysia in palm oil production and exports. As Indonesia begins to solidify the palm oil plantation holdings over time, it may be wise for Malaysia to innovate the use of existing palm oil fields to accommodate growing energy concerns. As stated earlier, the Malaysian government already uses palm oil by-products as part of

the Fifth Fuel Diversification Policy so the transition to using palm oil as a biofuel would require minor adjustments from an engineering perspective. Vested interests not connected with the federal government would prefer to see the government keep the status quo by not putting restrictions on oil and natural gas, and instead import more energy products from neighboring countries as energy demand continues to rise. For palm oil to be a success, government policy would need to be established in a future Malaysia Plan to ensure the execution and success of using palm oil directly as a biofuel. Environmental regulations need to be established due to economic pressure from global trade partners and to protect environmental resources within Malaysia. Economic incentives and the construction of an energy infrastructure would overcome some of the barriers that make the plantations hesitant to contribute to the energy mix, but policies have already come underway. As this thesis has laid out, it is impractical to create new fields of palm oil plantations for the sake of substituting fossil fuels with palm oil biofuel so existing plantations would need to be utilized to make this solution a reality.

The third sub-question focused on solar energy as a renewable fuel source in hopes to resolve energy demand concerns and improve sustainability. Solar as a solution is the more viable solution as evidenced by the analysis presented in this document. Another reason is the recent contract establishing 200MW of capacity each year from 2017 to 2020 being added. A contract between the federal government and a private company shows the commitment for solar energy, but the amount of interest from the private sector to get said contract also shows that the private market wants to press forward. The energy savings will begin to help alleviate some of the energy demand

concerns correlated by rising population, but the rate of deployment for solar panel capacity may need to exceed 200 MW per year to accommodate the energy concerns. The law of transmission for electric circuits states that the farther electricity must travel to its destination, the lower yield that electricity will have which points out the difficulty if the electricity generated by solar PVs is sent a great distance. By having multiple locations for solar energy, or by promoting the use of residential solar PVs, the transmission issue would be addressed and rely less on the national grid to provide energy. The use of solar energy would also provide an opportunity for the Malaysian government to appease the people of rural communities by showcasing the investment towards their well-being and by improving the quality of life by transitioning the rural populations from burning biomass for heat to using solar energy. Efficiency and cost are also the greatest barriers for implementing this technology on a more macro scale and would need to be adjusted to tap into the potential that exists across the entire country. I would recommend that the Malaysian government do local-level incentives to encourage group solar projects.

Regarding the optimal fuel mix, the fuel diversification programs that the Malaysian government has already implemented were attempts to achieve a successful fuel mix but have been slowed down by technological, social, and political barriers. While cost-benefit analysis might provide proper context, it is this author's opinion that using natural gas as a bridge fuel would buy enough time for renewable technology to advance to a point where the price would allow citizens to take advantage of renewable energy on a macro scale. Education needs to be considered since technical jobs will

require a certain level of education both at the high school and university level. By keeping the education at a high level, local talents would let the costs go down and keep the employment within the country. Palm oil as a fuel source for electricity does not seem practical due to the amount of land space that would be necessary to accommodate the energy demand. Currently palm oil accounts for 7% of gasoline in the same way that ethanol is partially used in the United States for gasoline (Malaysian energy company executive, personal communication, June 11, 2018). Solar energy will ultimately be a primary component of an optimal energy mix because the efficiency will improve. As this efficiency increases, the infrastructure already in place for these PV panels will require little to no additional economic cost while reaping the benefits of what the sun has to offer. Ultimately the optimal energy mix will not be achieved until the year 2030 or later as technology improves.

For further research that this thesis does not address involve more of an economic perspective such as cost-benefit analysis instead of a cost assessment of solar energy and diving deeper into the optimal fuel energy mix. Regarding the economic analysis, comparing the costs to benefits for using the different fuel sources would be preferable when looking over a timeframe of 2010 to the present. Incorporating the Feed-In Tariff and other similar policies should be considered when making comparisons of which fuel source(s) would be the most profitable from an economic perspective. Factoring in environmental, social, and political components would address the optimal fuel mix based on a scoring system or an equation that has different weights associated with each

component. The primary challenge to assess an optimal fuel mix is how analysis is framed and what is the objective of creating an optimal fuel mix.

Overall Malaysia is in a transitional state between being a developing country and a developed nation. By aligning their domestic goals with those of international organizations such as the United Nations, Malaysia establishes itself on firmer footing when standing next to other developed nations that have already made strides with reference to energy and the environment. Upon hearing from the representative of a national energy company that the Economic Planning Unit coordinates directly with representatives from the United Nations, the domestic energy policies created within Malaysia align with the SDGs in mind to the extent that they have direct input during each phase of policy production from the UN (Malaysian energy company executive, personal communication, June 11, 2018). The seventh goal established by the United Nations SDGs provides an opportunity as the agenda for the seventh goal fits within the Venn Diagram of Malaysia's goals as a country with the goals laid out by the United Nations.

APPENDIX A – INTERVIEW QUESTIONS

Below is the set of interview questions asked to everyone who agreed to take part. The interviews were set in a semi-structured way to allow everyone to incorporate their expertise in a way they saw fit towards the topic of this thesis.

Introduction Consent: *"This interview is to discuss various topics related to the energy landscape of Malaysia from the policy trends associated with Malaysian energy to the potential social and political aspects. I would like to confirm that you, the interviewee, are consenting to being recorded for the purposes of supplementing the academic research that has been collected beforehand. Know that at any time you may stop the interview for any reason."*

Q1: *"Are you okay with being recorded for the purposes of this interview?"*

Q2: *"Are you okay with your name and professional title being used for the purposes of my thesis research?"*

[If consent is stated with Q1, continue with the interview. If consent is not given with Q2, then the name and title will not be stated within the thesis and the data gathered will not be used.]

Q3: *"How familiar are you with the country of Malaysia?"*

Q4: *"Are you aware of any public policy related to Malaysia's energy?"*

Q5: *"Do you have any thoughts on palm oil being potentially used as a biofuel in Malaysia to generate electricity?"*

Q6: *"What are your thoughts about solar energy being utilized in Malaysia? Specifically with peninsular Malaysia? Specifically with the Borneo region?"*

Q7: *"What do you feel prevents Malaysia from using solar energy more?"*

Q8: *"Are you familiar with the Sustainable Development Goals? Specifically with Goal #7?"*

Q9: *"Do you feel the United Nations, or another international organization should step in to help Malaysia use renewable energy more to help achieve Goal #7 of the SDGs?"*

Q10: *"Is there any other comment or concern you would like to share regarding Malaysian energy?"*

"Thank you for your time to speak with me today. If you would like access to the recording and/or the information being used in my thesis, please do not hesitate to contact me."

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BIOGRAPHY

Douglas Alan Gardiner graduated from Mercersburg Academy in Mercersburg, Pennsylvania in 2007. He received his Bachelor of Arts from Worcester Polytechnic Institute (WPI) in 2013. He also received a minor in mathematics while attending WPI and took extensive coursework in economics, physics, and electrical engineering. Douglas was employed as a math instructor for two years and transitioned to be a private math and science tutor for an additional three years. Douglas has also worked in various internships with the National Park Service at Turkey Run Park, and the Executive Office of Energy and Environmental Affairs in Boston, Massachusetts. While in Boston, Douglas worked with the ChargePoint America program to implement the first wave of electric vehicle charging stations in Massachusetts in 2011. In 2017, he worked within the NASA DEVELOP program at Langley Research Center in Hampton, Virginia during the summer and at the Goddard Space Flight Center in Greenbelt, Maryland during the fall. While working at Langley, Douglas was part of the Shenandoah Health & Air Quality team researching atmospheric chemistry above Shenandoah National Park and the Chesapeake Bay airshed. While working at Goddard, Douglas was part of the first team for the Western Europe Health & Air Quality project to help predict mosquito habitat suitability. His interdisciplinary background has enabled him to work in many unique situations and projects over the course of his studies.