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Article

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Reference: Md Muhibbullah/Rafia Afroz et. al. (2021). Solar photovoltaic panels in Malaysian homes : an economic analysis and survey of public opinion. In: International Journal of Energy Economics and Policy 11 (6), S. 454 - 464.
https://www.econjournals.com/index.php/ijeep/article/download/11750/6150.
doi:10.32479/ijeep.11750.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2021, 11(6), 454-464.

Solar Photovoltaic Panels in Malaysian Homes: An Economic Analysis and Survey of Public Opinion

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Received: 18 July 2021 **Accepted:** 13 October 2021 **DOI:** https://doi.org/10.32479/ijeep.11750

ABSTRACT

The situation of solar energy in Malaysia is examined in this article, with a focus on solar photovoltaic (PV) installations in Malaysian homes. It examines Malaysia's historical solar energy initiatives in terms of R&D, deployments, and national policy during the previous two decades, all of which have affected PV installation in the country. The New Energy Metering system (NEM) policy, as well as a cost-benefit analysis of PV installations for Malaysian homes are addressed. A preliminary survey of public opinion was performed to better understand public perceptions of clean energy policies and advantages, as well as an evaluation of public willingness to join in the NEM policy by installing PV on their homes. The NEM policy will give a reasonable return on investment, according to the cost-benefit analysis. While PV solar energy has the potential to be a viable alternative, Malaysian families face a number of challenges, including high costs, a lack of physical and financial resources, a lack of expertise, and a lack of social support. According to the survey, the majority of respondents are ignorant of the government's clean energy subsidies and strategies, and are unable to participate in the NEM policy.

Keywords: New Energy Metering, Solar PV, Cost-Benefit Analysis, Clean Energy, Malaysia
JEL Classifications: O13; O33; D12; Q21; Q56

1. INTRODUCTION

Malaysia's large population (about 32.6 million people) demands a high demand for energy, with fossil fuels accounting for 90% of it (DoSM, 2020). Coal still accounts for 38% of global power generation, whereas Malaysia is more reliant on (Ali et al., 2012). Coal accounted for 50.6% of the 2017 electricity production. Inexcusably, just 20 years prior to 1997, coal accounted for just 7.4% of total power generation, owing to the popularity of natural gas, which accounted for 63.4% at the time (Raman, 2020). However, extensive use of fossil fuels has a variety of negative environmental effects, including water and air pollution, as well as direct and indirect public health expenditures, such as early death from particulates, sulphur dioxide, and nitrogen oxide, and lost workdays (Machol and Rizk, 2013; Raziani and Raziani, 2021). Malaysia imports up to 98% of its coal, which is used in thermal power plants to generate roughly 40% of the country's energy. In 2018, the country was the world's eighth largest importer of coal briquettes and the world's 12th largest importer of bituminous coal (not agglomerated) (The Star, 2020). The Malaysian government has made many attempts to grow green energy since 2001 (Mekhilef et al., 2014). Figure 1 shows how, from 1978 to 2015, Malaysia's energy balance was mostly based on fossil fuel energy sources. However, the country has just lately begun to use renewable energy sources to generate power. Since 1979, Malaysia has adopted a variety of energy policies and programmes, including the National Energy Policy (1979), the National Depletion Policy (1980), the Four-Fuel Diversification Policy (1981), the Fifth Fuel Policy (2000), and the National Renewable Energy Policy (2011). To assist implement the rules, the government has provided different forms of green financial incentives to power companies, as well as Feed-in-Tariff (FiT) and New Energy Metering (NEM).

After adopting all of these regulations, Malaysia still relies on fossil fuels to generate electricity. Malaysia's energy balance was primarily dependent on fossil fuel energy sources from 1978 to 2015, as seen in Figure 1.

In light of this, it's important to look at why Malaysia is still reliant on fossil fuels, the Malaysian government's present policies, solar energy barriers and problems, and potential solutions. The goal of this study is to look at power consumption and supply, non-renewable and renewable energy, CO_2 emissions, and hurdles and challenges to solar energy. A cost-benefit analysis of solar panel installation in Malaysian houses is done, as well as a discussion of the NEM system. A preliminary survey of Malaysian public opinion was performed to better understand public perceptions of clean energy policies and advantages, as well as an evaluation of public willingness to join in the NEM system by installing PV on their homes.

1.1. Energy Supply and Demand in Malaysia

Energy is a necessary part of most economic and social activities. Energy consumption and economic development have been shown to be inextricably linked (Roespinoedji et al., 2019). Energy has become one of the most important factors in Malaysia's growth process, especially in terms of its contribution to the country's industrial and service efficiency (Javid and Sharif, 2016; Nugraha and Osman, 2019). Crude oil and natural gas are the main energy sources. In 2001, crude oil accounted for about 47% of total energy supply. However, within ten years, this supply had decreased dramatically, accounting for just 31% of total energy supply (Gutiérrez-Arriaga et al., 2013). Natural gas has supplanted crude oil, accounting for 45% of overall energy consumption in 2011, up from 40% in 2001 (Lim and Lam, 2014). Coal and coke energy supplies increased from 6% to 19% of overall retail energy consumption in 10 years, from 2001 to 2011. In 1996, however, the overall energy used was estimated to be about 20,000 ktoe. Twenty years later, in 2016, this number had risen to over 57,000 ktoe. Malaysia's energy demand is expected to rise by 4.8% by 2030, according to projections (WEMO, 2017). Furthermore, Malaysia is mostly reliant on fossil fuels, with coal accounting for 53%, natural gas for 42%, and hydropower (along with other sources of RE) accounting for 5% (WEMO, 2017). Despite current demand levels, the country's final energy consumption will triple by 2030 (WEMO, 2017). The average annual growth rate of final energy demand is higher than the average annual growth rate of primary energy production, as seen in Figure 2.

According to Vaka et al. (2020), the energy demand is predicted to be increased at a fastest rate in Malaysia from 96.3 Terawatt-hour (TWh) to 206 TWh (Terawatt-hour) in 2009-2035 time period. In addition, the average annual growth rate of electricity demand continues to outpace that of primary energy production (Energy Commission Malaysia, 2019). Malaysia has to find an alternative source of energy in this case. The residential sector consumed 21% of all electricity produced in Malaysia in the first half of 2010, with an average annual consumption of 3300kWh per household (Taha, 2003). It should also be noted that Malaysia's electricity is mostly generated from fossil fuels, natural gas and coal, which account for approximately 90% of total production (EPU, 2006). While Malaysia has a total crude oil reserve of 4.73 billion barrels in 2017 (Energy Commission Malaysia, 2019), Malaysians must be aware that this reserve could be exhausted in the future if they do not find an alternate supply of non-renewable energy (Štreimikienė and Baležentis, 2015; Ashnani et al., 2014).

Despite the fact that Malaysia is ranked 16th in terms of natural gas reserves (Central Intelligence Agency, 2011), it is estimated that the country's current natural gas supply will only last for around 29 years (Ahmad et al., 2011). Malaysia vowed at the Copenhagen Conference of Parties to cut carbon emissions by 40% by 2025 compared to the baseline year of 2005 (Conference of the parties (COP15, 2009). This suggests that Malaysia must transfer its power production to renewable energy supplies in order to meet the electricity demand while reducing its reliance on fossil fuels. This is not a simple challenge for Malaysia, which is rich in fossil fuels and must rapidly step away from its reliance on these commodities. To make a more significant contribution of renewable energy in the energy mix, the government, as well as different stakeholders and organisations, must make more concerted efforts.

1.2. Non-Renewable Energy (NRE) in Malaysia

A non-renewable resource is one with a high economic impact that cannot be readily supplemented by natural resources to the same extent as it is used. The majority of fossil fuels are considered non-renewable commodities and their use is unsustainable due to the billions of years it takes for them to produce. Figure 3 depicts a rising trend in Malaysian use of NRE sources from 1980 to 2017.

Malaysia has long relied on NRE sources like fossil fuels in terms of fuel oil and diesel. Since the four-fuel plan was introduced in 1981, Malaysia's reliance on fossil fuels has reduced, as seen in Figure 3. By implementing this system, Malaysia has added natural gas, biomass, and hydropower to its fuel mix. As a result of the reform, natural gas utilisation increased, while diesel consumption increased.

Figure 1: Malaysian energy mix production from 1978 until 2015 (Energy Commission Malaysia, 2019)

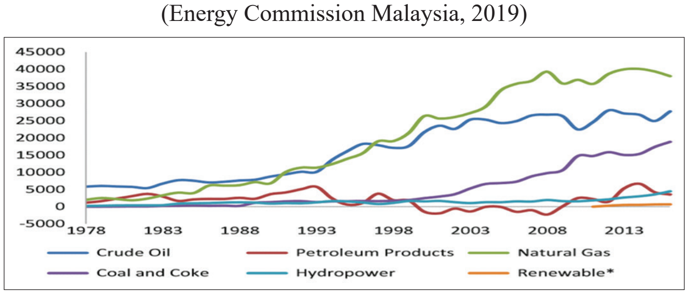
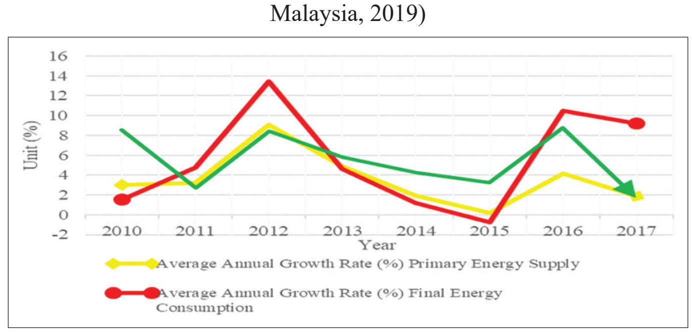


Figure 2: Average Annual Growth Rate of energy supply and consumption of Malaysia from 2010 to 2017 (Energy Commission Malaysia, 2019)

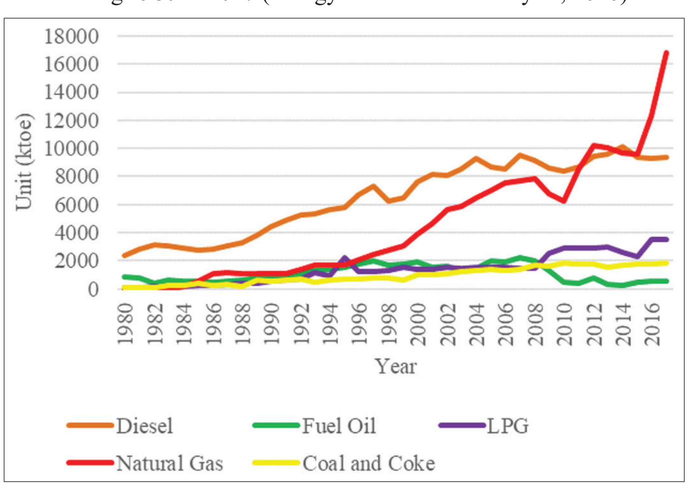


Natural gas is gradually replacing crude oil, according to Lim and Lam (2014), natural gas accounted for 45% of total energy supply in 2011, up from 40% in 2001. Energy is essential for each country's social and economic growth. According to Shahbaz et al. (2020), energy is a critical engine for economic progress. Despite technological development, Stern and Cleveland (2004) say that energy is still necessary for construction, and that technology innovation has discovered a more efficient manufacturing technique to replace an old one. It also aids in improving people's quality of life. However, society is concerned that, as a result of growing population and demand, oil prices are rising and oil production is decreasing. In this case, researchers are looking for an alternative energy source, and RE has piqued their interest (Ashnani et al., 2014; Moosavian et al., 2013; Yee et al., 2009). As the use of NRE sources grows, so does the amount of CO_2 released into the atmosphere (Figure 4). We'll look at Malaysia's CO_2 emissions in the next section.

1.3. Carbon Dioxide (CO_2) Emission in Malaysia

The carbon footprint associated with traditional fossil fuel generation, for example, has contributed to global warming, a major worldwide issue. When compared to 2005, the GHG intensity level rose by 27% in 2014, with total CO_2 emissions of 317.63 metric tonne and net emissions of 50.48 metric tonne (Farabi et al., 2019). Malaysia's CO_2 emissions grew by 4.62% each year between 1999 and 2018, rising from 113,853.4 kilo tonne to 257,840 kilo tonne (Knoema, 2019). At the United Nations Conference on Climate Change, commonly known as the Paris Climate Conference 2015 and the Conference of Parties (COP21), held in Paris, France, Malaysia agreed to a 45% reduction in CO2 emissions per unit of GDP by 2030 compared to 2005 (Khoo et al., 2019). As a result, the Malaysian Green Technologies Corporation (Genentech Malaysia), which is part of the Malaysian Ministry of Energy, Science, Technology, Environment, and Climate Change, is promoting the Low Carbon Cities Framework (LCCF). Its mission, as stated in the Green Technologies Master Plan 2017-2030, has been to push the development and expansion of green technology as a strategic accelerator for socioeconomic progress since its creation in 2010. A handbook on low-carbon city architecture, a calculation and evaluation method, and an appraisal and recognition scheme are also included in the programme. The LCCF was established to address and take action in cities that account for up to 70% of all GHG emissions.

Figure 3: Consumption of non-renewable energy sources in Malaysia during 1980 to 2017 (Energy Commission Malaysia, 2020)



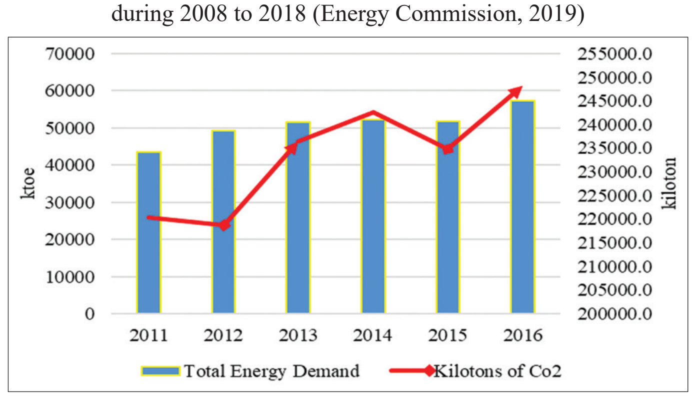
The Malaysian government's RE Transition Roadmap (RETR) for 2035 aims to find solutions to meet the government's goal of 20% renewable energy in the national energy mix by 2025 (WEMO, 2017). According to 11th Plan for Malaysia, the country aims to reduce greenhouse gas emissions by 33% (EPU, 2016). Malaysia also intends to create 2080 MW of renewable energy by 2020, accounting for 11% of total power generation, and 4000 MW by 2030, accounting for 17% (EPU, 2016). The next section addresses Malaysia's renewable energy sources.

1.4. Renewable Energy (RE) sources in Malaysia

RE is a relatively new idea in Malaysia, where it is utilised to supplement the country's domestic power generating mix. RE, which is abundant in Malaysia, is an important element of the country's present energy mix, but its acceptability and long-term sustainability have been hampered by low investment and visibility. Improved decision-making tools for analysing renewable energy technologies (RETs) in community environments are critical. A Cost-Benefit Analysis (CBA) tool, for example, may be used to analyse the potential of solar Photovoltaics (PV) technology in a community, allowing developers to make smarter investment decisions under the NEM programme. When hydroelectric power stations were established in 1939, they were Malaysia's first green energy source. Since 1978, the hydroelectric power plant has provided significant benefits to Malaysia's electrical industry. A hydraulic dam's architecture, on the other hand, is complex, encompassing not only the dam's design, construction, and maintenance, but also environmental and social considerations. Hydropower plants expanded at a 4.4% yearly rate between 1979 and 2015, as seen in Figure 5. In terms of installation capacity, the Malaysian hydroelectric power plant, on the other hand, is expected to play a greater role. It is anticipated that it will increase from 5% in 2010 to 15% by 2020 (Malaysia's Energy Commission, 2015).

The great potential of these resources in Malaysia makes biomass and biogas plants regarded to be RE resources (EPU, 2016). Furthermore, bio-energy looks to be the most frequent renewable energy source in Malaysia. Biomass has been designated as the "fifth fuel" resource in Malaysia's Fuel Diversification Policy (2001). The National Biofuel

Figure 4: CO_2 emission (kt) and total energy demand in Malaysia during 2008 to 2018 (Energy Commission, 2019)



Policy was established in 2006, with the goal of encouraging the use of ecologically benign, sustainable, and viable biomass energy supplies. However, between 2012 and 2015, the growth rate of biomass installation was just 22% (SEDA, 2016). Biomass has a long-standing heritage and potential for production of biomass for power generation and is an ecologically beneficial resource. Through burning biomass, electrical energy may be generated and the most common emissions can be created as fossil fuels.

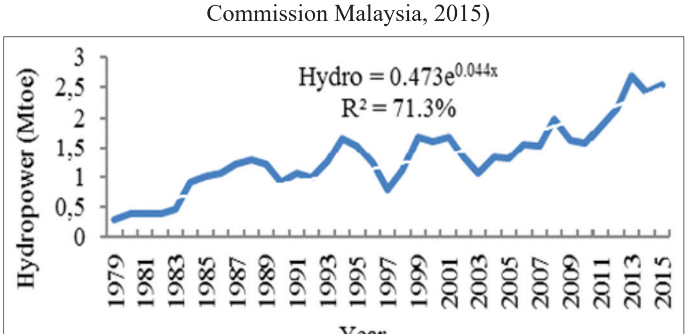
Another sustainable energy source in Malaysia is solar PV system. The phrase “solar” refers to or in conjunction with the “sun.” Thus, solar power production involves the sun’s power output. The main sources of sunlight’s energy are heat and light. Malaysia has significant solar insulation, ranging from 1400 to 1900 kWh/m^2 at a favourable location (Ahmad et al., 2011). On average, 1643 kWh/m^2 per year (Haris, 2008) with around 10 h of sun each day (Amin et al., 2009). Theoretically, a 1 kWp solar panel installed in an area of 431 km^2 in Malaysia could generate sufficient electricity to meet the country’s energy demand in 2005 (Haris, 2008).

The capacity of technology to gather sun light is unique. technology Solar PV transforms light energy into direct current power (DC). DC equipment can be supplied using DC power. DCs are also the radio and the computer. A solar electrical inverter may also convert DC power to the most often utilised alternating current (AC) power. Electric AC devices are included, to mention a few, in the laundry machine, microwave and electric kettle. On residential and industrial building roofs, small solar PV systems are commonly installed. The owner of the house can immediately utilise the electricity. Solar power may contribute up to 11% of the world’s energy supply by 2050, according to the International Energy Agency (IEA). In 2011, the global gross installation capacity of photovoltaic systems grew to 68 GW, exceeding 100 GW in 2012 (Zhi et al., 2014). Figure 6 shows that despite the 11th scheme in Malaysia sets lower targets for electricity generation from solar power systems, the solar photovoltaic system might be the most beneficial to Malaysia owing to its unique existence as well as other renewable energy sources (EPU, 2016).

1.5. Solar PV

Solar PV operates on the basis of electricity converting sunlight. The combination of PV technology with micro networks enables power manufacture and delivery worldwide. Solar PV operates on the basis of electricity converting sunlight. The combination of PV technology with micro networks enables power manufacture and delivery worldwide. As solar panels are lower, not only is their energy costs reduced, but now they are more affordable for everyone. As a consequence, Solar PV systems have soared in Malaysia, as can be shown in Table 1.

Figure 5: Hydropower Installation during 1979-2015 (Mtoe) (Energy Commission Malaysia, 2015)



Furthermore, the generation of solar power does not produce emissions of greenhouse gas that assist Malaysia to green and clean. The promotion of solar energy helps Malaysia reach its objective of reducing its carbon intensity by 35% by 2030 (Vaka et al., 2020). Following establishment of the Photovoltaics Integrated Building Project (PIC), with a focus on the speed and growth of business technology, the BIPV project in 2005 was mainly focused on policy and comprehension, technological components, market increases, financial and technology growth for the national economy. Renewable technology may therefore be used to accomplish SEDA targets with a more mature market for BIPVs (Hashim and Ho, 2011). The annual solar PV feed-in-tax (STI) capacity between 2012 and 2017 was 64.9, 60.3, 76’4 and 22.5MW, as illustrated by Figure 7 from 2012 to 2017, while the net addition capacity built for solar PV was 31.6, 138.1, 202.9, 2 63.3, 339.7 and 362.2MW (IRENA, 2019).

The implementation of major solar farms in the government has slowly led to a steady increase in energy output with predictions of 200 megawatts per year between 2017 and 2020. After the implementation of the FiT system the energy provided by the producers is initially used and excess selling. The Government approved net energy measurement (NEM) in 2016 to add to the

Figure 6: Renewable energy targets in terms of total installed capacity in the eleventh Malaysia Plan (Malaysia Plan 2016-2020) (EPU, 2016)

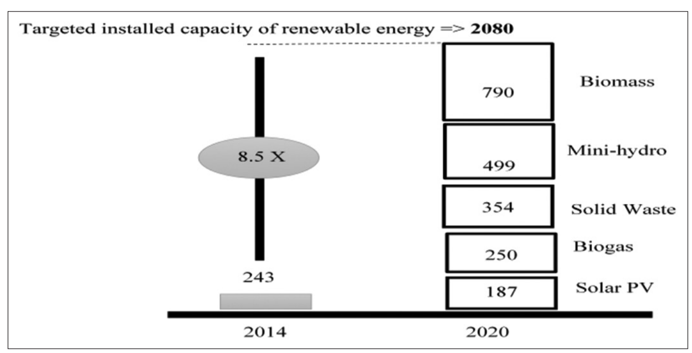


Table 1: Solar PV installations in Malaysia

Year	Installed capacity, MW (Malaysia)	Electricity generation, GWh (Malaysia)	Installed capacity, MW (Rest of the world)	Electricity generation, GWh (Rest of the world)
2010	0.54	0.67	40,276.67	32,160.38
2011	0.54	0.67	72,029.69	62,443.37
2012	25.1	30.88	101,511.21	96,351.81
2013	97.12	53.74	135,740.15	131,701.12
2014	165.78	190.51	171,518.92	183,943.37
2015	229.1	275.41	217,242.54	242,371.88
2016	278.8	326.23	290,961.18	314,053.25
2017	370.07	333.02	383,597.83	425,872.64
2018	536.02	N/A	483,078.20	N/A
2019	882.02	N/A	580,159	N/A

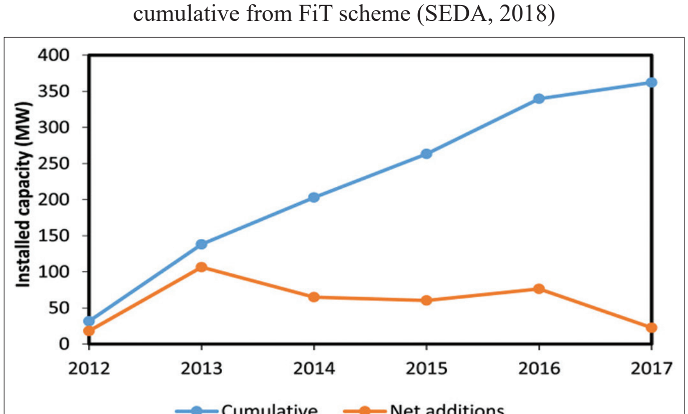
FiT by 2018 in favour of existing FiT and large solar energy (LSSP) projects (SEDA, 2020). The idea of NEM allows users to produce their own energy through the connection of solar panels with any unused power to the power grid. On the other hand, the photovoltaics sector has emphasised the need of translating the NEM paradigm to actual net energy measurement. The aim is to increase the return on solar photovoltaic investments under the NEM. The NEM will be reinforced at the beginning of January 1, 2019 by the use of the real grid metering concept, which allows the one-to-one export of solar surplus photovoltaic energy back to the grid. This implies that each 1 kWh exported from the grid is offset against 1 kWh consumed from the grid instead of being offset at the displaced costs (SEDA, 2019).

The renewable energy generation may be 11,227 GWh by 2020 in accordance with Malaysia's policies and RE action plan (NREPAP). But the power structure signal of Solar PV systems will increase to 13,540 GWh by 2050, 194 GWh by 1950 (1.7%). The availability of sunshine and radiation has led to an increase in the generation of solar power.

1.6. PV installation in Malaysian Homes (1995-2004)

There are two types of solar installations: stand-alone PV and grid-connected PV. In rural areas, stand-alone PV can be installed. Up until 2004, the total grid-connected PV capacity was 468.00kWp (Haris, 2010), but this number was inflated by Technology Park Malaysia's construction of a 362.00kWp network in 2001 (Haris, 2006). The contributions from residential homes, on the other hand, were very small, with only three installations accounting for around 9.00 kWp. In August 2000, a 3.08kWp solar panel was installed for the Tenaga Nasional Berhad (TNB) officer's house in Port Dickson, making it the first grid-connected PV installed in a domestic house in Malaysia. The rooftop was retrofitted with the panel, which covered a total area of 26 m^2. Three months later, another installation was completed in Subang Jaya, this time with a 3.12 kWp performance rating and a 24 m^2 roof area. A year after the second installation, the third installation was completed on the roof of a house in Subang Jaya, with a capacity of 2.82 kWp. The TNB testing team completed both of these installations (Haris, 2008). Figure 8 depicts a rooftop solar panel in Malaysia, which is gaining prominence as a result of the government's renewable energy policies, such as the FiT system and the National Energy Market.

Figure 7: Solar PV annual installed capacities from 2012 to 2017 for cumulative from FiT scheme (SEDA, 2018)



Some unique features of this rooftop solar system are discussed below:

Installing a home solar panel will help the family since it saves money on the cost of utilities every month. As home energy rates in Malaysia increase by around 3% annually, households can protect their finances against the expense of power.

Home spending rises to the bulk of household consumption, comprising accommodation, water, electricity, coal and other fuel (25.1%) according to the 2019 Malaysia Household Expenditure Survey report (DoSM, 2020). The energy expenses for households would be reduced as a result of this project. It also supplies renewable energy, decreasing fossil fuel consumption.

The company has the capacity to return on investment for five years. The economy in Malaysia can attain better solar power since the sun can deliver more energy than before and nobody can own or monopolise sunshine. More companies might instal solar panels with increased demand for sustainable energy. This will continue to develop the economy with new opportunities for competent people. Under this system, incentives and financing can significantly reduce or eliminate upfront costs. It will be possible to earn positive profits once the investment costs have been paid off.

1.7. Policies Regarding Renewable Energy Sources in Malaysia

Various efforts have over the years brought various financial advantages to boost investment in the renewable energy sector in the country. These programmes seek to ensure environmental protection, support renewable energy industries, promote national generation of renewable energy and improve knowledge of renewable energies, etc (Malek, 2010). The measures to support renewable energy growth in the country have been enacted as follows:

The five-fuel policy of Malaysia was introduced in 2001 in order to ensure the utilisation of renewable green energy sources as energy demand increases. Despite the government's 5% renewable energy objective in 2010, renewable energy represented 1.8% of the domestic energy mix through the adoption of five-fuel diversification policies (Kardooni et al., 2016). The main aim of the 5 Fuel Policy was to create 5% of the total energy generated from renewable sources by 2005. However, only 41.5 MW had successfully been linked to the grid by the conclusion of the ninth Malaysian Plan (Mekhilef et al., 2014).

Overall, this programme was introduced to help a large number of agricultural and commodity-based market associates grow and prosper by ensuring stable and profitable prices. Implemented in 2010, the National Renewable Energy Policy and Action Plan

Figure 8: Solar panel systems in Malaysia (Solarvest, 2019)

provides sustainable and secure socioeconomic development (SEDA, 2016).

The main target of the National Renewable Energy Action Plan is to have renewable energy make up 24% of the total energy mix by 2020, thereby avoiding more than 30 million tons of carbon dioxide emissions (IEA, 2014). This target is going to make a huge difference to the renewable energy industry as the energy mix will be moving from 1% in 2011 to 9% in 2020. The NEM scheme was launched in Malaysia in 2016 to replace the FiT scheme. One of the goals of the FiT scheme was to help for the expansion of the RE industry. The FiT scheme, on the other hand, is difficult to maintain since other electrical users are required to finance the scheme by a clean energy fund fee that is incorporated into their power bill. It is collected by levying a 1.6% surcharge on customers' energy demand. TNB's function is limited to that of a fund collector for the government. As a result, in 2016, NEM was adopted to address these issues. NEM 2016 struggled to help RE achieve its development objectives after 2 years of deployment. One of the main reasons is that a kWh unit of imported energy can only be charged at a displaced cost of RM0.31, which isn't too appealing financially. In Malaysia, residential customers are charged according to Tariff A (domestic tariff), as seen in Table 2.

Customers will be paid 21.8 cents per kWh for the first 200 kWh and 33.4 cents per kWh for the next 100 kWh. As they consume more power, the electricity charging rate rises. If their monthly intake hits 300kWh, they will be charged 51.6 cents per kWh from the 301st kWh onwards, which is significantly more than the displaced cost for NEM payment.

As a result, the NEM scheme could not benefit residential houses that use a lot of energy. Small consumers (less than 200kWh a month) would not have benefited financially from installing PV because they still pay a low electricity tariff. To address these flaws, the government launched the latest NEM system in 2018 (SEDA, 2020). On January 1, 2019, the new scheme went into operation.

1.8. NEM Policy

Solar energy is a qualifying technology under NEM 2016, and it is available to residential, commercial, and industrial customers. The maximum residential capacity is 12kW for single phase and 72kW for three phases, while for commercial and industrial is up to 1MW. Excess generation would be paid at displaced expense through the next billing date. The estimated cost of generating and delivering one kilowatt hour of energy from non-renewable supplies via the supply line up to the point of interconnection with the RE installation is referred to as displaced cost. The maximum roll over period is 24 months and any surplus after 24 months will be forfeited.

Table 2: Electricity Tariff in Malaysia

Tariff category	Sen/kWh
For the first 200 kwh (1-200 kwh) per month	21.80
For the next 100 kwh (201-300 kwh) per month	33.40
For the next 300 kwh (301-600 kwh) per month	51.60
For the next 300 kwh (601-900 kwh) per month	54.60
For the next kwh (901 kwh-onwards) per month	57.10

The minimum monthly charge is RM 3.00

In comparison to NEM 2016, minor updates have been introduced in NEM 2019. Residential, private, manufacturing, and agricultural consumers are all permitted. In May 2017, Malaysia made the system more attractive and in 2019, the surplus power generated by the PV system was for the 1st time paid on a "one-on-one" offset basis, which meant that every kilowatt-hour injected into the network was offset against a kilowatt-hour of electricity taken from the grid. Under the previous regime, exported energy carried less value than consumed grid power. The remainder of the scheme is identical to that of NEM 2016.

The advantage of this programme is that it encourages everyone to participate in renewable energy production, which has the potential to address the nation's energy stability and climate change issues. Apart from reducing greenhouse gas emissions, the NEM also protects against any energy tariff increases. Furthermore, a battery or energy storage device may be added to the PV system to improve the self-consumption capability. Finally, certified NEM scheme holders have the ability to obtain power in the event.

2. COST BENEFIT ANALYSIS OF SOLAR PANEL IN RESIDENTIAL HOUSES UNDER NEM 2019 POLICY

The net present value (NPV), the internal rate of return (IRR), the cost-benefit ratio (BCR), and the payback recovery period were used to measure the risks and benefits of solar PV technologies for households under the NEM scheme. If the NPV is positive, the BCR is greater than one, or the IRR is greater than the relevant discount rate, the project is considered viable (Hosking and Du Preez, 2004). CBA (Hosking and Du Preez, 2004) has four fundamental components, which will be considered in the review of this dissertation. The four basic elements are: time which is considered as 25 years, costs and benefits of solar panel installation for the households and the discount rate which is 6%.

The net present value will be determined by subtracting the expense stream's total discounted present worth from the profit stream's total discounted present worth. Gross losses are subtracted from the gross value of spending expense from the net profit to achieve the incremental net gain. The following formula should be used to calculate the current value of net benefit:

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Where B_t is benefit in each year, C_t is cost in each year, t =1,2,……,n;i=discount rate

The payback period is the time it takes for the net value of the incremental output stream to equal the overall cost of the capital expenditure by the time the site is installed. It indicates how long it takes for a total net capital outflow to be recovered as yearly net cash inflows. The following assumption will be made to assess the costs and benefit of solar PV technology for the households under NEM scheme:

- The lifetime of the project
- Discount rate.
  The sensitivity analysis will be performed to check how the domestic tariff and the initial investment cost can influence the payback period. The variation range for both quantities can be considered as 10%. The risk analysis will also focus on this financial indicator. To ease the calculations, a number of assumptions are made:
- Small customers are expected to use 300 kWh per month, median consumers are expected to spend 600 kWh per month and big residential customers are expected to utilise up to 900 kWh per week. Assume that every month the inhabitants utilise the same quantity of energy
- The SEDA (2019) states that a family may instal a solar panel of 1 kWh, costing RM6000 to instal if it consumes 300 kWh of power. The power generated in this panel is expected to be 100 kWh each month. In addition, the cost of installation of this solar panel should be RM18275 for the homes that utilise 600 kWh. Finally, assuming the homes utilise 900KWh, the installation cost for the solar panel should be RM33600. 7,38 kWh
- The installation cost shall be paid in full at the beginning of a project—no loan shall be made for funding it
- The panel shall maintain 100% of its contract performance
- All electricity generated shall be returned to its grid
- The maintenance cost shall be 1% of its capital costs (IEA, 2010), and
- The calculation shall be made for the contract period (i.e., 2%), i.e., Each year a discount of 6% is taken into account.

At first, electricity bill (EB) is calculated with the NEM policy. So, based on the rate of electricity generation and the value of solar insolation, the monthly electricity generation (EG) in kWh is estimated and is later subtracted from monthly electricity consumption (EC) of the customers in kWh to obtain the net energy balance (NEB) in kWh (Eq. 1). The monthly under the NEM policy, is equal to the total NEB multiplied by the domestic tariff (DT) (Eq. 2). The categories of domestic tariff are presented in Table 2. Then, EB is again calculated without NEM (Eq. 3). In this case, monthly EC of the customers will be multiplied with DT to get the monthly EB without NEM policy. Furthermore, monthly electricity bill saving (EBS) is the difference between monthly EB with and without NEM policy (Eq. 4).

Annual benefit (AB) is obtained by subtracting the yearly maintenance cost (M) from the yearly electricity bill saving (Eq. 5). The total benefit (TB) for the whole contract period is calculated by multiplying the annual benefit by the duration of contract (Eq. 6). The net benefit (NB) generated is equal to the difference between the total benefit and the installation cost (IC) (Eq. 7). To get the payback period, this figure is generated by dividing the installation cost with the annual benefit (Eq. 8) while the average annual return on investment is calculated by dividing the total profit with the total cost over the contract period (Eq. 8). The relations between each financial parameter are given in (Eq. 1-5). All the results from the calculations are presented in Table 3.

With NEM 2019 policy

$$NEB = EC\text{-}EG \quad (1)$$

$$EB_{NEM} = NEB*DT \quad (2)$$

Without NEM 2019 Policy

$$EB = EC*DT \quad (3)$$

Total and Net Benefit

$$EBS = EB_{NEM}\text{-}EB \quad (4)$$

$$AB = (EBS*12–M) \quad (5)$$

$$TB = AB*21 \quad (6)$$

$$NB = TB–1C \quad (7)$$

The yearly benefit is computed for each of the three types of households. Small families should receive RM 643.2 year, medium households should receive RM 1271.71 annually, and big households should receive RM 2500.08 annually. For the whole 21-year period, the yearly advantages for each household type equal to a cumulative profit, with large families earning the largest total benefit of about RM 52501.28 and small households having the lowest total benefit of around RM 14347.2. The net benefit's present value is also computed.

Table 3: Cost benefit analysis of solar PV in residential houses

Items	Small (1 kWp PV panel)	Medium (2.38 kWp PV panel)	Large (7.83 kWp PV panel)
Installation cost	6000	18275	33669
Consumption of Electricity (Kwh/month) (EC)	300	600	900
Generation of Electricity from solar panel	100	238	783
Net Energy Balance (NEB)	200	362	117
Electricity Bill with NEM (EC_{NEM})	43.6	186.79	255.06
Electricity Bill without NEM (EC)	102.20	309.6	491.4
Monthly Electricity bill saving (EBS)	58.6	122.81	236.34
Annual Electricity bill saving (EBS)	703.2	1473.72	2836.08
Yearly maintenance cost	60	182	336
Annual Benefit	643.2	1271.72	2500.08
Total benefit at the end of contract year	14347.2	26706.12	52501.28
Net Benefit	8347.2	8431.12	18832.28
Present value of net benefit	2455.05	2479.74	5538.90
Payback period	9.32	14.37	13.46
Benefit cost ratio	2.39	1.46	1.55

Table 4: The socio-economic information of the households

Items	Frequency	Percentage
Gender		
Male	127	53
Female	113	47
Age		
20–30	134	56
31–40	46	19
41–50	31	13
Above 50	29	12
Marital status		
Single	134	56
Married	94	39
Divorced	12	5
Educational Level		
No education	5	2
Secondary school	38	16
Diploma	36	15
Bachelor	130	54
Post graduate	31	13
Income level		
Less than 1000	70	29
1000–2000	36	15
2001–3000	41	17
3001–4000	38	16
4001–5000	26	11
More than 5000	29	12
Type of house		
Rented	142	59
Owned	98	41

Table 5: Monthly electricity usage of the households

Average electricity use (kw/month)	Frequency	Percentage
Below 500 KWh	50	21
500-1000 KWh	72	30
1000-3000 KWh	55	23
3000-5000 KWh	24	10
5000-10,000 KWh	19	8
More than 10,000 KWh	19	8
Total	240	100

Large families' net profit is now valued at about RM 5540, while small households' net benefit is currently valued at around RM 2455.Surprisingly, the payback period for small households is around 9.32 years, while the payback period for medium households is around 14.37 years. The benefit-to-cost ratio for each household demonstrates that solar panel installation is cost-effective.

3. PUBLIC PERCEPTION

A preliminary public opinion poll was conducted in August, 2019 to better understand public opinions of renewable energy policies and benefits, as well as to assess public willingness to participate in the NEM system by putting solar panels on their homes. A total of 260 questionnaires were distributed to the households in five urban areas in Kuala Lumpur and 240 (92.31%) of them being available. The socioeconomic data of the respondents as seen in Table 4. According to Table 5, Male respondents (53%) outnumber female respondents (47%) by a small margin. The majority of the respondents are young, respondents age ranges from 20 to 30 years old (56%) precedes, followed by those ranges from 31 to 40 (19%) years old, and those above 40 (25%) years old. A large number of respondents (56%) are still single, although only 39% are married. Bachelor's degree (54%) is the highest standard of schooling among respondents, followed by secondary (16%) and diploma (16%) (15%). Many respondents earn between RM1000 and RM3000 (32%), with others earning less than RM1000 (29%) and RM3001 to RM5000 (27%). Only 12% of the respondents earn more than RM 5000.

Table 6: Monthly energy usage of the households' water heater

Energy	Frequency	Percentage
Electricity	122	51
Gas	22	9
Electricity and Gas	55	23
Solar	41	17
Total	240	100

Table 7: The levels of public interest in solar energy for developing low carbon consumer society

Opinion	Frequency	Percentage
Agree	182	76
Disagree	17	7
No opinion	41	17
Total	240	100

Table 8: The Obstacles faced by the households to use solar energy

Public obstacles	Most important		Important		Least important		No response	
	Yes	%	Yes	%	Yes	%	Yes	%
Limited information on renewable energy	190	79	11	5	6	3	33	13
Initial cost	210	86	12	5	5	3	13	5
Limited financial information	160	67	17	7	18	8	19	8
Obtaining best possible price	140	58	15	6	14	5	71	30
Lack of awareness	100	42	16	7	12	5	112	47
Lack of access to the technology	98	41	25	10	32	13	85	35

The majority of respondents (59%) lived in rental homes, while the remaining respondents (41%) remained in their own homes. Table 5 shows that 21% of participants use less than 500 kw of electricity each month. However, 79% of respondents claimed that their monthly electricity usage are above 500 kw. Table 6 shows the energy use of water heater by the households. A high figure of 51% of respondents use electricity for water heaters, followed by electric and gas combinations (23%), solar (17%) and gas (9%). It seems that lack of interest in renewable energies in Malaysia is mainly due to the lack of technology available for mass use such as solar panel. Next, the respondents were asked about the attitudes towards the use of solar energy to develop low carbon consumer society (Table 7). Majority (76%) of the respondents are interest in solar energy. Reflecting on this high interest, the use of solar energy has high potential.

Next, respondents were asked on what are the challenges that they faced and the underlying reasons that prevent potential consumers from using solar energy. Table 8 shows the obstacles households faced in using solar energy. The most important and important factors that obstructs the households from using solar energy are led by the initial cost (91%), limited information on renewable energy (84%), limited financial information (74%), obtaining best possible price (64%), lack of access to the technology (51%) and lack of awareness (49%).

This result proves that Malaysia has a large solar energy market if initial installation costs can be reduced, and if it receives accurate information on the purchase and installation process of solar energy devices. It is hoped that the proposed model will gives benefits to the society.

4. CONCLUSIONS AND SUGGESTIONS

There have been considerable advances in Malaysia in the usage of renewable energy in the previous 30 years rather than fossil fuels alone. Malaysia promised to cut the proportion of the greenhouse gas emissions into its gross domestic product by 45% by 2030 compared to 2005, as indicated in the November 2015 "Nationally estimated contributions to the United Nations Framework Convention on Climate Change." In the interest of achieving this objective, Malaysia relies completely on industrialised countries' investment, for instance financial aid and technological transfer.

The initial attempt made by Malaysia to include green power was to utilise biomass profitably in the early 2000s, which resulted in 1% of total energy generation being generated by 2015. The usage of green energy to safeguard the environment and prevent climate change is projected to rise steadily. The time-long incentives are the efforts of the Government of Malaysia to expand and promote the renewable energy sector. The public's views and expectations about clean power and solar PV installation under NEM were more clearly understood from a recent study. The study findings suggest, however, that the majority of Malaysians are ignorant of the incentives and policies of the government for renewable energy sources and hence are unable to engage in the NEM scheme, despite the fact that it is growing in numbers in the solar panel business.

According to the cost-benefit assessment, the NEM system would have a reasonable return on investment. Although photovoltaics solar energy offers an option, Malaysian homes confront a series of obstacles, including high pricing, a lack of physical and financial infrastructure, a lack of knowledge and a shortage of social assistance. This hurdle can be overcome and renewed entry in Malaysia may be seen if there is sufficient information in the media. This initiative, however, will not be able to achieve its maximum capacity until the general population is made aware of it. Furthermore, without broad public support, the initial target of producing 5.5% of energy from renewable sources by 2015 will be missed. A selection of actions is suggested based on the literature reviews, CBA, and the findings of the survey. These are:

4.1. Incorporate Adequate Framework for Regulation

This requires an adequate, strong and efficient regulatory framework, which would solve market failures and encourage companies to enter the RE generating sector. In the legislative framework, FiT should be introduced, a stimulus for the entry into the RE-energy sector, RE industries and research and development (R&D). In addition, the reduction in environmental pollution will also imply that society will have to play a role in contributing to a fund to pay for the RE electricity. This is particularly relevant because retail tariffs contain subsidies and are being decreased and the external expenses are excluded. A technique might be used by including a specified cost into a particular RE fund inside the energy price structure. Consequently, a regulator that would function as a catalyst in the development of RE industries, R&D in RE technology and innovation has a direct spillover impact (e.g. via improved boiler technologies etc.). These results include the pace of increase in the usage of RE, progressive (or constant) decrease in the consumption of fossil fuels for the conventional generation of electricity and the reduction of CO_2 emissions.

4.2. Support Re Companies With Conducive Environments

The expression "EM industry" refers to the manufacture of the RE or completed goods (e.g. boiler, turbines, PV modules, etc.), RE production support industries (e.g., technicians, consultants, engineers, building workers). The emphasis is on the RE and RE industries (which collectively are referred to as RE businesses). Included in the incentive package are fiscal stimuli and indirect support for the reduction of transaction costs and support to SMEs in the RE sector. This goes beyond the NEM strategy, in which individuals are encouraged to enter the RE power generation industry.

RE is a novel technology in Malaysia, which requires human resource development in support of RE industry development. A short-term response to the human resources shortfall by encouraging scientists to relocate to Malaysia is necessary in Malaysia, nonetheless. Invention is the objective of research and development (R&D) instead of innovation.

Innovation (that is, "the concept of the giants standing on the shoulders") contributed to progress in the microprocessor, for example. A comprehensive R&D plan, which leads to new items and services, must thus be established to accelerate the growth in RE industries. Innovation also helps the spread of RE by making the use of the technology cheaper and easier. Therefore, an R&D strategy to define demand has to be developed, regulations are used to stimulate innovation and R&E activities must be supported.

Advocacy programmes should be tailored to specific messages for certain populations. For example, an investment advocacy campaign and a RE market entry must communicate a message significantly different from a common public advocacy programme, aimed to achieve a buy-in to the notion of clean social payments. The common objective of all advocacy programmes is to raise knowledge of the benefits and benefits of utilizing RE and involvement in RE companies by all stakeholders.

Once the foundation has been established, the policy mission should be evaluated and (if required) enhanced for time. For example, if the policy is revised in 5 years' time, a suitable regulatory structure would have fulfilled to incorporate the regulation. Nevertheless, as part of the continuous policy vision mission, it might need to be further enhanced or replaced as needed by a fresh impetus.

4.3. Human Capital Development

Human capital development is a crucial driving force, because it may be the country's biggest influence. The government of Malaysia acknowledges the importance of human development, as it may increase Malaysian economy's entire productivity and flexibility, which is essential for the transition between the community and the economy, and urges the government to provide the necessary infrastructure. However, given that the proportions of people with university education in the country are modest (about 13.9% in 2001) it is essential to encourage people to join tertiary colleges. This entails determining what motivates a person to receive a high school education and how the government might encourage these people.

So, RE experts should be generated simultaneously to promote the development of new skills and capacities for regular people. However, such procedures are subject to a sunset condition. institutional preparations to achieve this goal must be coordinated by the Ministry of Finance, Higher Education, Human Resources Minister and other governmental bodies concerned.

5. ACKNOWLEDGMENT

The authors would like to acknowledge the fundamental research grant scheme (FRGS), Malaysia, for funding of "Developing Shariah Complaint equity-based crowdfund model towards Malaysian low-carbon society-A Case of Kuala Lumpur." (Ref: FRGS/1/2018/SS08/UIAM/01/01).

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