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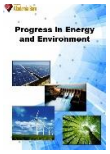

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Original Article

The role of current and future renewable energy policies in fortifying Malaysia's energy security: PESTLE and SWOT analysis through stakeholder engagement

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Abstract

Renewable Energy (RE) is a vital source of energy for the future. Measuring the levels of RE penetration is now an important indicator to ascertain the environmental sustainability dimension in the context of Energy Security (ES) that supports Malaysia's goal to move towards a low-carbon and greener economy. In this study, the role of RE policies in fortifying Malaysia's ES has been assessed through deep engagement with stakeholders from Malaysia, the Philippines, and Singapore. A semi-structured interview was conducted individually with 16 stakeholders with more than 10 years of experience in the field of ES and sustainability. A PESTLE framework and SWOT analysis were utilized to analyse the data collected on RE for Malaysia's ES. Results suggested that the strengths of RE in Malaysia lie in government policies to increase its penetration at a faster rate and to adopt more RE technologies soon, while the main weakness lies in the intermittency issue of RE, integration within the national grid, and the strategies to reach the targets set in the policies. There are vast opportunities in terms of geographical location for solar and marine RE exploration, availability of regulatory body for RE via Sustainable Energy Development Authority (SEDA) in Malaysia, a gradual decrease of RE deployment cost, and improving RE technologies. While the threats remain at the capital cost of RE projects, the high per-unit cost of RE as fuel and fear of unstable supply that can disrupt the national grid and hence loss of consumer confidence.

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1 Introduction

The development and deployment of RE in Malaysia's energy mix for the total primary energy supply (TPES) and electricity generation are still at an early stage despite the early initiation of RE in the 1980s. There is a scope for higher RE penetration in Malaysia than its current status of 9% capacity of the energy mix in 2020 [1] which has increased by 3% over 2 years from 2018 [2]. There are certain challenges in the form of intermittency and integration of RE in the national grid and policy implementation of RE that is holding the development of RE further in Malaysia. The development of RE policies

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that promote new and enhanced RE projects is of utmost importance for Malaysia to move towards long-term ES leading to more sustainable resources at its disposal. There is a need to engage stakeholders from the public and private sector to understand from their perspective what are the key challenges faced by RE as a fuel in Malaysia and what initiatives are to be taken to tackle these challenges. This study aims to fulfil the gap by engaging various stakeholders in an in-depth discussion on the role of the RE policies that were in place previously and the future RE policies in power generation mostly to shape the ES of Malaysia towards a more secure status. RE's prospect for power generation is the key focus of this study as the transport sector relies primarily on petroleum fuels which is a threat to the ES and CO_2 emissions contribution as stated in the report by 'Economic Research Institute for ASEAN and East Asia' [3].

RE policies in Malaysia can be drawn back to as early as the 1980's when RE was introduced as one of the fuels in the Four-Fuel policy [4]. Ever since, there has been a gradual deployment of RE in the national energy mix alongside the more dominant fossil fuel sources like oil, coal, and natural gas. RE in Malaysia plays a vital role in securing energy sustainability by moving towards a low-carbon economy and decreasing fossil imports from other countries. The RE initiatives undertaken proves that the government's vision is in line with the global RE prospects. The RE industry is now primed to enter a new phase of growth in 2020. This is consistent with the Shared Prosperity Vision 2030 which stresses RE and green economy as two of the 15 proposed Key Economic Growth Activities [5].

Hence, the contribution of RE towards ES in Malaysia needs to be studied more in-depth with relevant stakeholders who understand the relation of RE and ES of Malaysia. Literature reviews on the current Malaysian RE scenario have been discussed with RE policies that were in place historically and the current ones in this study. An in-depth engagement with the stakeholders has been carried out which led to qualitative data collection towards understanding the role of RE in fortifying the ES of Malaysia. The term ES has been defined by these stakeholders as what is most suited for Malaysia and discussed further in this study. These data have been analysed using the PESTLE framework and SWOT analysis indicating the direction the RE policies are heading towards in terms of strengths, weaknesses, opportunities, and threats to RE in Malaysia. This study aims to consolidate the role of RE in ensuring that Malaysia as a nation is secured in terms of its sustained energy supply in the long run especially in the context of its existing reserves of natural resources.

2 Literature Review

In the year 2017, 1,894 Mtoe of TPES of the world was generated from RE which is 13.5% of the total TPES of 13,972 Mtoe [6]. Out of the 13.5%, the major contributors were biofuels and waste with 9.2%, hydro with 2.5%, and 1.8% of solar, wind, and rest of the renewable sources [6]. Renewables accounted for the second-largest contribution towards global electricity generation after coal (38.5% share) with a contribution of 24.5% just above natural gas at 23% [6]. At the end of 2018, RE contributed to 33% of the total installed power generation capacity globally [2]. This statistic is promising for the environmental sustainability of the world as there is an increasing trend towards the use of RE in the TPES and electricity generation.

Having said that, South East Asian (SEA) region is yet to increase its RE capacity for TPES and electricity generation in the energy mix substantially to be environmentally sustainable and secure in terms of long-term energy security because it relies on fossils fuels with high availability of cheaper forms of fuel like coal, natural gas, and oil in the region. Association of Southeast Asian Nations (ASEAN) has also set a target for itself in RE – 23% of RE in the TPES by 2025 [7]. Since the year 2000, the primary energy demand has increased by 80% in this region of the world [8] and this demand has been met by an ever-increasing fossil fuel consumption. The use of fossil fuels is believed to have doubled since 2000 to meet 85% of the increase in primary energy demand [8]. With an increasing population and economic activities, it is predicted that business as usual the total final energy consumption (TFEC) in this region will increase from 427 Mtoe in 2015 to 1,046 Mtoe by the end of 2040 in all the sectors including industry, transport, and residence and the TPES is expected to increase by 2.3 times within the same timeline [9]. Oil contributes 40-50% of the share in meeting these demands, holding the largest share followed by coal and natural gas [9]. The RE sources in the SEA region meet less than 20% of this primary energy demand, which is not sufficient keeping in mind the regions' long-

term energy security and sustainability of the natural resources are at stake. The generation of electricity is still dominated by coal and gas-fired power plants. There is a decreasing cost of RE technologies within this region that encourages higher use of RE in electricity generation, which is a positive sign towards the short-term energy security for the region. The major contributors being hydropower, geo-thermal, and bioenergy, while solar and wind are explored as well for increasing the further capacity of RE in both TPES and electricity generation [8].

In the year 2017, Malaysia's electricity generation using RE was just below 30 TW h [8], which is still lower than Vietnam, Thailand, and Indonesia in the SEA region. This explains to some extent that Malaysia is not too keen yet to make a bold move towards RE as one of the major fuels for electricity generation as Malaysia has a safe and high reserve margin for electricity for the coming years. The reserve margin for Peninsular Malaysia for the year 2020 is at 32% and is expected to increase to 48% in 2021 and remain at around 44% in 2022 according to 'Peninsular Malaysia Generation Development plan (2020-2030)' by Energy Commission [1]. However, the 'Peninsular Malaysia Generation Development plan (2020-2030)' [1] predicts that there will be a further increase in RE share for electricity generation from 9% in 2020 to 23% in 2030 and hence reducing thermal power generation capacity from 82% to 70%. The increase in RE capacity does not show a proportional decrease in thermal power plants capacity which reflects the dependence of Malaysia on thermal power plants. In the year 2018, the gas component occupied a share of 35% of the total energy mix while coal is still the most dominant source with a share of 57% with the rest coming from RE sources [10]. This is an indicator of threat towards long-term ES of Malaysia as fossil fuels dominate the energy mix with RE holding a comparatively negligible share. In the same year, Malaysia recorded approximately 6% of RE total installed capacity including hydropower with capacity up to 100 MW, bringing the total capacity to 2,057 MW [2]. Fig. 1 represents the share of TPES by fuel type in Malaysia in the year 2017, which gives a clear contribution of different fuel types [11].

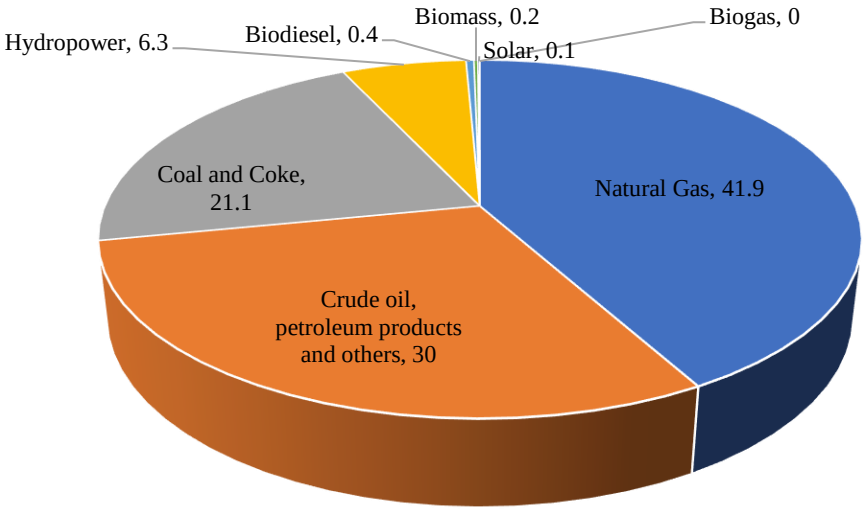

Fig. 1 TPES by fuel for Malaysia in 2017 [11].

Fig. 2 shows the installed capacity (MW) of commissioned RE installations in Malaysia for the years 2017 and 2018 [4].

The most recent RE target set by the Malaysian government is to reach a total capacity of 20% with hydropower up to 100 MW by the end of 2025 according to the 11th Malaysia plan or RMK11 [2,10]. There is a gap of 11% from the target to the current status of 9% and there are 5 years of period to narrow the gap. Whether narrowing the gap is possible and the future of RE projects and policies for Malaysia was discussed in depth with stakeholders of Malaysian energy and sustainability in this study.

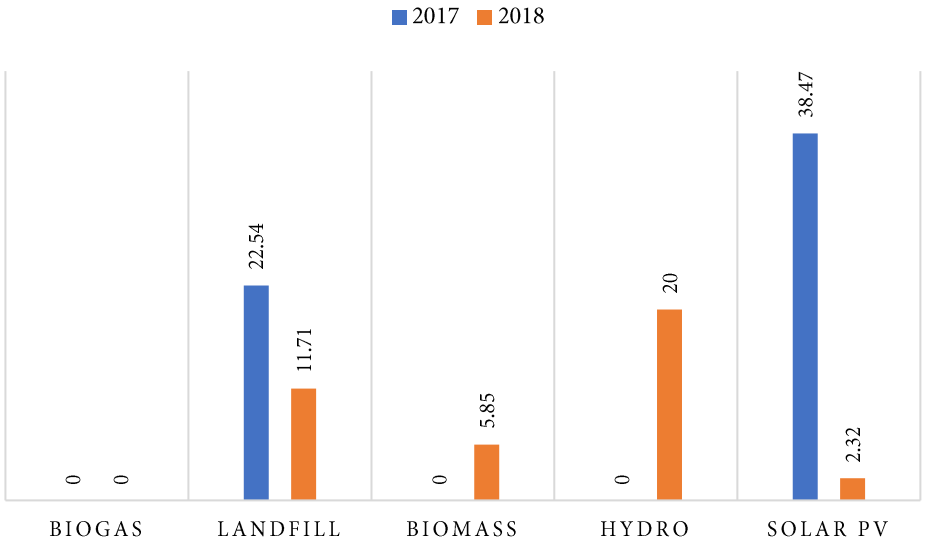

Fig. 2 RE installed capacity (MW) in 2017 and 2018 in Malaysia (Data from SEDA) [4].

ES is a term that has been defined over the decades by a different group of researchers and energy institutes. The concept of ES can be drawn back to as early as the stone age where wood or other flammable materials were an absolute necessity in the form of fuel. Having a safe and stable supply of these materials, which needed to be adequate in amount and without any external factor disrupting the supply would define how secure the civilization is in terms of energy [10]. In the present time, the paradigm remains the same, and the concept of ES has not changed much from that of the stone age but with developing research techniques and resources, the concept has evolved to adapt to the current needs. The most common definition of ES is given by the International Energy Agency (IEA) as "the uninterrupted availability of energy sources at an affordable price" [12]. Martchamodol and Kumar [13] have given a more structured definition of ES, emphasising the importance of the availability of energy, affordability of energy, energy tariff, social acceptance, and environmental sustainability later quoted in the study of [14] as "enough energy supply (quality and quantity) to meet all requirements at all times of all citizens in affordable and stable price, and it also leads to sustained economic performance and poverty alleviation, a better quality of life without harming the environment."

Similarly, ES has been studied based on several dimensions over the decades and the most common ones are affordability, availability, accessibility, acceptability, environmental sustainability, socio-economy, and political dimensions. In this study, one of the key indicators of ES for Malaysia has been identified as "renewable energy" from the stakeholder engagement. The angle of RE is used in this study to define ES of Malaysia simply as the security of energy required for building a nation or a region in the context of the economy, environment, technology, social aspects, political and legal aspects. This is because an increase of RE is at the forefront as the main objective these days for any nation to achieve long-term ES [15].

One of the key findings from this study suggested that RE plays a vital role in ensuring the ES of Malaysia mostly in terms of the availability of future energy resources and its acceptability amongst the citizens of the nation as it has a reputation of being clean energy. This is where the PESTLE framework is useful in the study as it analyses in detail the impact that RE has on each of the six dimensions of PESTLE in securing energy for the nation. The PESTLE framework takes care of the political, environmental, social, technological, legal, and economic aspects of the phenomenon being studied. It analyses these six macro environmental dimensions that have an impact on any organisation or in this case an entire nation [16]. PESTLE framework is used in combination with SWOT analysis which stands for strengths, weaknesses, opportunities, and threats, in various studies as it adds depth to the dimensions of PESTLE. SWOT analysis is known for its ability to address current problems and the future action that can be taken to solve them [17] at the same time it has the capability to address the strengths of a certain project or policy in place. SWOT analysis is particularly a popular method of analysis in energy research because of its ability to analyse both positive and negative impacts on the internal and

external factors on a system [18] and has been used in many studies [19–22]. The next section looks into the current RE policies that are in place to understand whether it is viable to secure long-term ES for Malaysia.

3 An Overview of the Current RE Policies in Malaysia

Historically, Malaysia has never been a nation relying on RE for electricity generation or the use in the transport, industry, residential and commercial sectors. The National Energy Policy was established in 1979 with the aim to supply adequate energy to meet the demand, to minimize the impact on the environment, and to utilize the resources efficiently [23]. In 1981, the Four-Fuel policy was established to diversify the fuel sources and mostly introduced hydropower alongside oil, coal, and natural gas. Similarly, in the year 2000, the Fifth-Fuel policy was established on the potential of biogas, biomass, mini-hydro, and solar for electricity generation mostly [24]. Most of the RE policies mentioned in the research of [24,25] did not reach their ultimate targets but have managed to secure and establish RE as one of the new fuels in the energy mix. One of them was the 'Small Renewable Energy Power (SREP) Program' in 2001, which only managed to fulfil 3% of its target by 2005 due to lack of stakeholder intervention, lengthy approval process, lack of monitoring, and capacity caps [26].

The 'National Renewable Energy Policy and Action Plan' (NREPAP) was the successor of the SREP Program after 8 years of its implementation from 2001. The policy statement for NREPAP is quoted as "Enhancing the utilisation of indigenous renewable energy resources to contribute towards National electricity supply security and sustainable socio-economic development" [27]. The primary objective was to increase the RE share in the national power generation mix alongside ensuring a regular growth of RE, reduce the cost of RE generation, ensure sustainable use of the RE sources, and to increase awareness of the role of RE [27]. There were 5 strategic thrusts designed to achieve these targets. It is believed that the success of the NREPAP not only depends on the government intervention but also the private sector and third sector. This action plan aimed at increasing jobs and improving new growth areas to lead Malaysia towards a lower carbon economy.

In the 8th Malaysia plan, there was a target of generating 5% electricity or 600 MW from RE by 2005, however, only a total capacity of 12 MW by 2005 was built [23]. Then, in the 9th Malaysia Plan (2006-2010) the government set a target of 300 MW in Peninsular Malaysia and 50 MW of RE capacity in Sabah for electricity generation [23]. In 2010, another target was set to achieve 2000 MW of RE capacity by 2020 and that target was established in 2018 with a capacity of 2,057 MW of electricity from RE [2]. Moving forward, the latest and current policy has a target of 20% RE penetration with hydro projects smaller than 100 MW by the year 2025 set in the 11th Malaysia plan and currently have achieved 9% of RE capacity for electricity generation in 2020 [1], with another 5 years in hand to achieve the target. Given that the development of renewables has not taken off as fast as expected in Malaysia, there is a need for a roadmap of the future electricity system to spur renewables penetration. The Renewable Energy Transition Roadmap ("RETR") 2035 is being developed by SEDA in collaboration with industry stakeholders to determine strategies, comprehensive action plans and resources that are required, in-line with the energy transition of future electricity system and achieve the set RE targets. The RETR 2035 aims to strike a balance between 3 key boundary conditions [10]:

Environmental targets and policies: Aim is to reduce greenhouse gas emissions and to fulfil the target of 20% RE penetration by 2025.

Affordability and economic benefits: Affordability of inputs from key stakeholders while maintaining it at all times while moving towards RE.

System stability: To reach at a high level for the consumers.

The outcome for these strategies will be embedded in the 12th Malaysia plan (2021-2025). These boundary conditions give an indication of higher RE penetration in the future for Malaysia which will indeed satisfy the ES needs to ensure long-term ES for the nation. The most promising results shown so far in the field of RE is from solar projects. Large scale solar (LSS) projects and net energy metering (NEM) have been at the forefront of increasing the RE capacity for electricity in Malaysia. Four LSS projects have been sanctioned by the government and out of which two LSS projects have an installed capacity of 958 MW [10] while LSS3 and LSS4 currently have been open for tender and bidding is under process by the energy commission. While NEM has also received a good response under the

current policy. As of 31st December 2018, 27.81 MW of NEM had been approved and 9.01 MW total capacity had been commissioned [2] and approximately 4.12 million buildings in Peninsular Malaysia have been installed with rooftop solar plants which have encouraged to adopt more NEM scheme in the near future [28].

It can be summarized that the current RE policies in Malaysia are showing promising growth towards achieving a more sustainable and low-carbon economy for Malaysia. Malaysian will have to wait until 2025 to see the results of the current policies in place and how they shape. In this study, the stakeholders have shared their opinions on the current RE policies of Malaysia and their effectiveness. The next section discusses in-depth the methods employed to carry out the data collection and analysis.

4 Methodology

In this study, data were collected via the conduct of an in-depth interview with stakeholders from Malaysia, the Philippines, and Singapore who are experts in the field of ES and sustainability. A total of 16 stakeholders were interviewed for this study. The list of stakeholders is available in Table 2 in Appendix A.

4.1 Stakeholder Selection and Sample Justification

The stakeholder selection criteria and process are shown in Fig. 3. It is crucial to ensure that the selected stakeholders have sufficient experience to understand, articulate, and scaffold a relation between the dimensions and indicators that affect the ES of a country. In this study, the RE indicator from the environmental sustainability dimension was chosen to understand how it affects the PESTLE dimensions of ES.

There is a certain limitation on the number of stakeholders that can be engaged due to the selection process in Fig. 3. Considering the process of data collection was carried out by a single researcher [29] with time and resource constraints, the number of stakeholders is considered sufficient to get emerging themes as outputs from the semi-structured interviews (SSI). For determining sample size, on the grounded theory approach of coding, the number of interviews to be conducted depends on data saturation. Data saturation is critical to qualitative results as failure to reach saturation can hamper the quality and validity of data [30]. There is no "one-size-fits-all" method to data saturation because of the differences in study design and context of the problem depends on whether it is ethnography, meta-analysis, or phenomenological study [30]. The uniqueness of each study requires researchers to determine how much data is enough for analysis, depending on if no new theme, new data, and concept can be further generated from the data been collected. Data triangulation and data saturation are dependent on each other in the way that one ensures the other [30].

4.2 Semi-Structured Interview

SSI method is used to extract rich descriptive data from the professional experiences and to ascertain participants' perspectives regarding an experience pertaining to the research topic [31]. In this study, SSI's were conducted with 16 stakeholders on how RE impacts the ES of Malaysia. The objective behind using SSI's was to extract high-quality data on (1) challenges faced by Malaysia's ES and how to mitigate them (2) national energy policies that address the role of RE in tackling ES challenges and (3) strategies to improve the country's ES by enhancing the use of RE and energy-efficient technologies in the energy mix. The SSI's questions were based on different dimensions of ES as well as related to RE that have been highlighted concerning the problem statement. According to Charmaz, it is very important to frame the correct questions as it requires skills that a researcher can develop as he/she continues to carry out more interviews on different topics. The questions must explore the interviewees' topic and fit the participants' experience [32]. Charmaz further explains in-depth how questions are to be framed and to conduct interviews to extract the best possible outputs from the participants in [32]. In the study of Turner [33] as well, there are important steps mentioned which were followed in designing the semi-structured interview questions. The data collected from SSI were coded using qualitative data analysis software Quirkos. The grounded theory approach of emerging coding was used to extract data according to themes and one such theme was "Role of RE." This study only deals with this theme out of all the emerging themes that evolved from the SSI's.

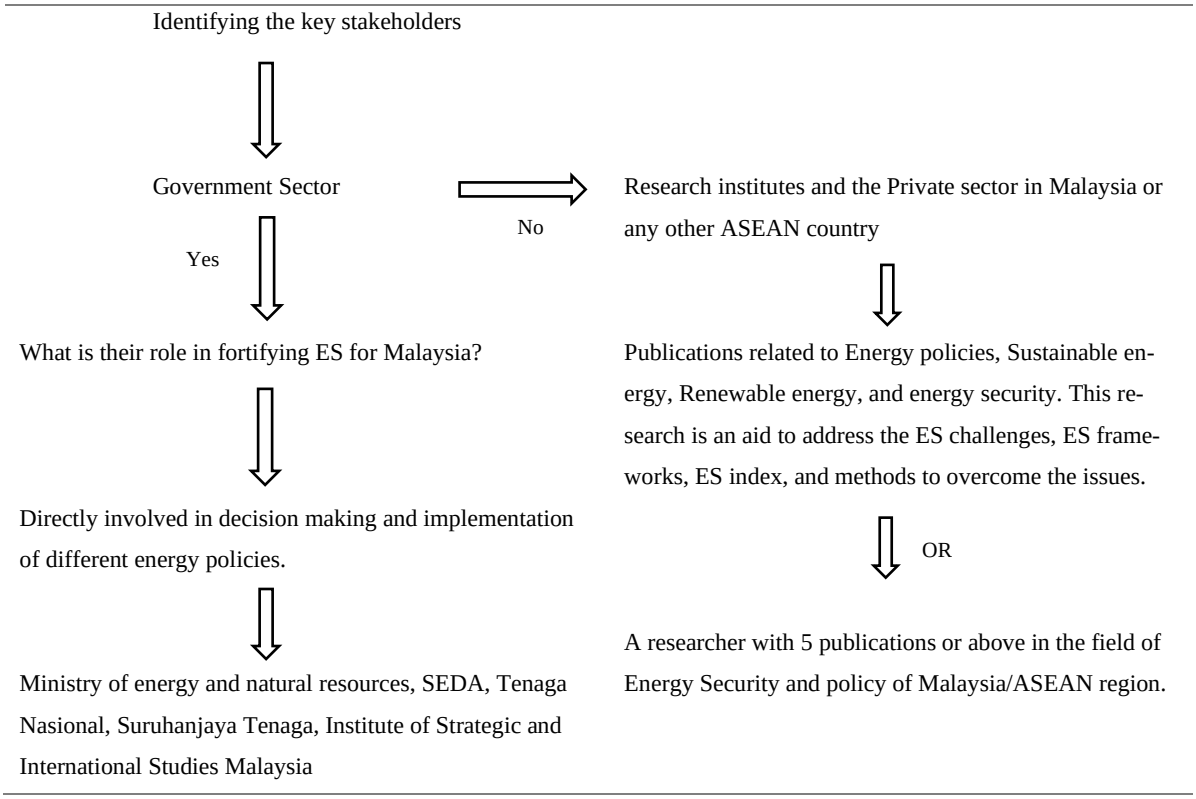

Fig. 3 Stakeholder selection criteria and process.

4.3 PESTLE and SWOT Analysis

A combination of PESTLE and SWOT analysis has been practiced in the study [22] to understand the positives and negatives of adoption of the port energy management system and it is evident from this study that a combination of these two analyses enhances the overall results of the research. Similarly, in this study, both the PESTLE framework and SWOT analysis are used in combination to understand how RE affects each of the dimensions of PESTLE in Malaysia's ES and to identify the strengths and weaknesses alongside the threats and opportunities of RE. PESTLE framework looks at the macro-environmental factors that have an impact on the ES of Malaysia in terms of the political, environmental, social, technological, legal, and economic sectors. PESTLE framework also creates the basis of identifying the opportunities and threats along with the strengths and weaknesses in the six dimensions which are later helpful in SWOT analysis. The data collected using SSI in this study have been categorized based on these six macro-environmental dimensions of PESTLE. This allows organising the bulk amount of data in a more structured manner. The PESTLE framework makes it easier for the researcher to draw a conclusion from each of the dimensions and to understand each of the dimensions in depth. Then, SWOT analysis is carried out after the data is organized in the PESTLE framework. A SWOT analysis of the overall data from these 6 dimensions represents the strength and weaknesses of RE and also gives an insight into the threats and opportunities to explore more RE capacity in the nation. One of the similar studies that implement the PESTLE framework to provide a stakeholder analysis of actors in the renewable and sustainable energy sector in Indonesia [34] has been adopted in this study to design the PESTLE framework. On the other hand, the SWOT analysis studies of [35–37] have been adopted to design and develop the SWOT framework in this study. The uniqueness of these two methods to analyze data lies in the fact that it has a widespread application in the field of social research, engineering, and science research. One of the studies that implement a combined approach of PESTLE/SWOT analysis to study the factors that have a positive or negative effect on the adoption and successful implementation of a port energy management system [22] is similar to the approach taken in this study.

5 Results and Discussion

The results of this study are discussed in this section based on the data collected using SSI from stakeholder engagement on the impact of RE on the ES dimensions of Malaysia. The key findings of the data collected from the 16 stakeholders are summarised in Table 1. The PESTLE and SWOT analysis in this discussion is carried out based on the data in Table 1, where ST represents stakeholders e.g. ST1 is stakeholder 1 and the list of stakeholders is provided in Appendix A Table 2.

Table 1 Key findings from stakeholder data.

No.	Summary note from stakeholders
ST1	• 20% RE penetration target by 2025. • 4 Large scale solar (LSS) projects opened by the Malaysian government with a total target of 2GW capacity. • Total RE capacity of 6GW excluding large hydro.
ST2	• A stable and affordable supply of energy is needed before looking into RE. • Gradual decreasing cost of RE deployment. • RE integration challenges and deployment of RE in large scale challenges. • RE per unit price is still not competitive with coal and gas in Malaysia. • RE projects will lead to more employment and boost the economy.
ST3	• Geographically Malaysia has the land needed to develop large-scale solar projects but there has been a concern about competing fertile agricultural land in Malaysia. • RE will lead to low carbon emissions and low carbon electricity. • RE is self-sufficient but needs to be stored hence storage system technology needs to be improved. • Businesses can be attracted to RE by proving there are benefits and returns in this investment. • Integration of RE is a challenge and the small-scale RE plants need to be upscaled to be able to contribute to the national grid.
ST4	• In developing economy businesses look at RE as more of a business deal rather than to mitigate climate challenges. • RE per unit price is yet to be more competitive. • Intermittency challenges of RE. • RE will gradually take away share from conventional power plant businesses. • An improved storage system is needed for RE to replace the aging conventional plants. • Malaysia needs to manufacture its solar PV cells and equipment to generate income, jobs and hence boost the economy. • The rules and regulations in the policies should be more friendly towards the investors of RE. • Malaysia should aim at 5% RE in TPES and higher than 20% share for electricity.
ST5	• Singapore is working towards Combined Cycle Gas Turbine (CCGT) plants as all their electricity comes from gas. • Floating solar projects in Singapore have started which indicates that neighbouring countries like Malaysia can look into this prospect too. • Intermittency remains the main challenge of RE in Singapore, Malaysia, and the neighbouring ASEAN countries.
ST6	• There are political repercussions of not eliminating fossil fuel-based power generation. • RE policies in the Philippines are not dominant yet. • Necessary resources are not in place to become a sustainable and green economy in the Philippines. • RE will remain as the backup only for conventional plants for quite some time even in the coming years. • Singapore should have led the way for RE and EE technologies in the region but that did not happen. • Poverty and the economy take priority over environmental sustainability in developing economies.
ST7	• Intermittency challenges of RE for Malaysia. • Energy storage is required to store RE for use when there is no generation from solar for example. • More emphasis should be given towards nuclear energy which is cleanest.
ST8	• RE penetration is not enough because energy density, energy efficiency, and energy technologies are not advanced yet in Malaysia. • Energy shortage can appear if indigenous resources run out and RE technologies do not mature over time. • It is important to ensure that a certain percentage of our energy portfolio is coming from RE like solar, hydro, and biomass.
ST9	• RE is important to address the depleting fossil challenges. • Malaysia is headed in the right direction in terms of RE but not fulfilling its targets yet.

	• There are technical and engineering challenges faced by RE in Malaysia as well as business model challenges. • Businesses need to invest in RE projects and they have to look into their returns keeping in mind the poor feasibility and intermittency of RE in the national grid. • The cost of production and transmission also needs to be taken into consideration and whether Tenaga Nasional Berhad (TnB) is willing to purchase power from these projects.
ST10	• The communal use of RE needs to be increased. • Philippines is pushing towards higher RE penetration by 2030, which is around 3 times that of the current value of 23-25% capacity. • Malaysia has the scope to look forward to the ocean and marine RE because of its water space. The high cost of ocean RE deployment can be a reason behind its underdevelopment in RE or lesser attention in Malaysia. • Lack of governance on marine RE in ASEAN countries.
ST11 **ST12**	• RE will contribute towards better ES for Malaysia in terms of socio-economics and environmental sustainability. • Intermittency of RE is a challenge. • RE policies are not matured yet in Malaysia.
ST13	• 20% RE capacity target by 2025. • For peninsular Malaysia achieving a high target of RE has to be met through solar energy because hydro is no longer available for Peninsular Malaysia. Also, have to take note that hydropower plants above 100 MW are not counted as RE source in Malaysia which is also backed by data from energy commission [10]. • Intermittency issue is one of the biggest challenges for RE in electricity generation. • The maximum that solar can contribute is 27% of the grid off-peak demand which will be 21% if converted to the total capacity. • The need for energy storage systems increases with an increase in RE penetration. • In terms of tariff, solar can compete with natural gas but it is not cheap enough to compete with coal.
ST14	• By 2018 the RE capacity for electricity generation was 6% in the energy mix. • RETR 2035 will address more strategies of policy, frameworks, and technology towards achieving a higher RE penetration rate in Malaysia. • The compound annual growth rate (CAGR) is increased to reach the 20% RE penetration target by 2025. • The best way forward to achieve sustainability and hence securing energy is through moving towards RE technologies, conservation technologies, and energy-efficient technologies.
ST15	• RE policies not in sync with the RE objectives because the capacity is still at 70% of thermal power plants. • A new power purchase agreement (PPA) will give a new reserve margin of 25-30% for electricity for the next 10-20 years. • Having a 20% share of RE should mean a 20% reduction in conventional thermal powerplants but that is not the case. • Intermittency is an issue.
ST16	• Malaysia aims to go green like many other developed economies and the government is putting efforts to do so but the challenge remains in terms of affordability. • RE price is not competitive with fossil yet. • There are intermittency issues and how much RE or solar the grid can hold at one time. • High infrastructural cost of RE projects and parallel running conventional plants due to intermittency issues. • A group of population reluctant to move towards smart metering.

The key motive behind engaging stakeholders from the Philippines and Singapore is to understand how their RE policies are compared to that of Malaysia and to get their opinion on what Malaysia can do from a neutral point of view to improve the ES scenario in context to RE. ST 5 has discussed how the implementation of floating solar in Singapore can inspire neighbouring countries like Malaysia to look into that prospect. ST6 discusses the context of both the Philippines and Singapore's RE policies and their implementation compared to that of Malaysia. The PESTLE dimensions and SWOT-analysis carried out to understand the role that RE plays to secure long-term ES for Malaysia are elaborated below.

PESTLE dimensions

Politics: The role of the government is significant in deciding the fate of the ES of a nation. In this case, it is quite rightly in the hand of the government, government agencies under the Economic planning unit (EPU), Ministry of Energy and Natural Resources (KeTSA) along with statutory agencies such as the Energy Commission and SEDA plays a key role in shaping the ES of the nation. The ministry decides the targets and policies to be in place while it is executed and implemented by the statutory and regulatory body, hence they play the most important role as the policymakers of the national energy policies and national security policies as well and responsible for regulating and monitoring once they are in place. The Malaysian government aspires to have cleaner sources of energy in the form of RE and has currently placed importance on RE initiatives like the LSS, Feed-in-tariff, and NEM. All of these are in place to ensure the share of RE increases in TPES and electricity generation for the nation. The initiatives are motivating from the government's perspective, but the implementation of these policies needs to be well addressed to ensure that the targets are fulfilled.

The amount of foreign trade of fossil fuels is decided by the government as well, and in Malaysia, there is a net export of natural gas and oil while they are an importer of all the coals that are used in the thermal power plants. In 2010, the total coal import was 13013 Ktoe and it jumped to 19181 Ktoe in 2017 [28]. There is a significant increase in the annual growth in terms of coal import which is a sign of dependency on coal as one of the primary sources of fuel. The over-dependency of coal affects the ES status of a nation in the long-term.

The current Covid-19 pandemic has taken an overall toll on mostly the political and economic dimensions of the nation worldwide. The Malaysian government has been working relentlessly to ensure that the community of people is well protected during this pandemic by enforcing movement control orders (MCO) at different levels namely, enhanced movement control order (EMCO), conditional movement control order (CMCO), and recovery movement control order (RMCO). In the process, they had to make some strict decisions like closing international tourism, restricting the amount of workforce in workplaces, restriction on timings of eateries and food delivery, and many more. These changes will lead to business closures and hence job losses, as such government budget deficit targets will need to be overshot that add huge financial pressures on the banking sector, demanding action from the monetary policymakers as stated in the report by 'Institute of Strategic and International Studies' Malaysia [27]. This will lead to certain policy shifts towards the overall RE usage and RE research which is inevitable as the nation will gradually bounce back from the losses incurred due to the pandemic.

Hence, it can be concluded that the RE policies that are in place for the nation are decided and implemented by the Malaysian government and this makes the political dimension of utmost importance for Malaysia in deciding the future and current ES status of the nation.

Environment: RE is one of the key indicators of the environmental dimension of ES. RE contributes to environmental sustainability most positively in terms of reducing carbon footprint and carbon-based emission. Likewise, in Malaysia, the use of RE has a high acceptability rate amongst the local community due to its reputation of being environmentally friendly and carbon neutral. It might not be easy to improve the RE penetration rate in Malaysia because (1) per unit cost of electricity per kW.h is still not the most competitive with thermal power plants, (2) there is an additional capital cost in establishing large scale RE power plants and projects as there is a need of conventional thermal plants to mitigate the intermittency issues of RE, hence leading to opportunity cost and (3) environmental sustainability being the last priority in the energy trilemma in Malaysia. Hence, the priority always goes to the economic development of the nation rather than mitigating climate change. This stands valid when it comes to Malaysia at the moment like any other developing economy.

Social: The social acceptability of RE in Malaysia is quite high. This is because RE has the growing reputation of being a clean source of energy and people who are concerned about climate change want a transition towards RE for the nation. The NEM scheme has done well in contributing to the national grid by supplying extra power to the residential sector. SEDA Malaysia had approved a total cumulative quota of 108 MW by the end of November 2019 which shows a growth of 7.8 times compared to the previous 3 years from 13.86 MW uptake rate [38]. At the same time, a certain group of people is also aware of the depleting natural resources for the nation as it is bound to happen due to the heavy share of fossils in the energy mix. The concerns are there amongst the public, but not taking any bold measures

to ensure the immediate transition towards RE because affordability is one of the aspects to be prioritized. The dilemma of clean energy versus cheap electricity tariff is there and for the majority of the people cheap electricity tariff is of utmost priority alongside stable supply. Hence, the social dimension in Malaysia for ES does not have high importance amongst the rest of the dimensions as there will not be a push from the community towards the national decision-makers to make an immediate shift towards RE.

Technology: There are a positive development and adoption trend towards RE technologies worldwide and Malaysia is keeping up well with it. There are new RE technologies like floating solar implemented by neighbouring countries like Singapore which can be seen as a probable prospect in the future for Malaysia. The transport sector aims to change the ratio of energy-efficient vehicles (EEV) to private vehicles from 32.6% in 2015 to 100% in 2030 [3]. There are certain drawbacks in terms of the RE capacity that can contribute towards the national grid for electricity e.g. Malaysia solar can contribute to 27% of the off-peak demand only which leaves a huge gap for the thermal power generators to fulfil. This is because RE technologies are not efficient compared to thermal generators as there is a scope of improvement when it comes to efficiency. RE technology comes with cost hence the challenges remain for the investors whether to take the risk or not because the returns from the investments need to be good enough to sustain. New technologies always have a risk of failing and hence the cost of failing is very high and there are not many risk-takers in Malaysia in this case as there is a business risk of indulging in RE. RE integration in the national grid will always remain a challenge and the intermittency issues pose a threat of disrupting supply, placing supply security at stake, and being compensated by thermal power generators. Overall, for RE technologies and energy-efficient technologies in Malaysia, there is a scope of improvement which will in turn improve the ES of the nation.

Legal: Legality factors are due to different laws in place by the nation such as employment law, copyright law, consumer protection law, etc [16]. It is important to know what is legal and not when it comes to the policies in place and rules set by the government bodies of a nation. In Malaysia, for ES there are no such laws set in particular neither there is any policy towards ES solely. Having said that, there are national energy policies, national depletion policy, and national RE policies that do address the ES of the nation and their goals towards improving RE penetration in Malaysia to achieve long-term energy sustainability and security.

Economics: This dimension is given the most priority in terms of ES by all the stakeholders involved in this study. The importance of economic aspects for a developing economy cannot be overlooked and for a country that has an economic growth rate of 5.4% since 2010 and is expected to become a high-income country by 2024 [39]. RE does not only secure the environmental sustainability of Malaysia but also large-scale projects bring in opportunity for businesses to invest and bid for the projects just like LSS projects in Malaysia. The latest is LSS4 in 2020 for which the initial bidding has already started hence allowing new and existing businesses to invest in something eco-friendly at the same time economically viable. For businesses to invest, trust has to be built and the government needs to ensure businesses will get the return to sustain and invest further in near future, else there is a risk of losing future investment. The issues of poor feasibility, efficiency, and intermittency will always remain in the back of the mind of the RE investors as the RE technologies in Malaysia have not matured with time. One of the concerns for solar panel manufacturers is the inclusion of the Chinese solar panel manufacturers relocating to the SEA region which increased the competitiveness in the market [40]. Even until 2016 Malaysia was the largest exporter of PV solar panels to the US [40] and 3rd largest solar cell manufacturer in the world behind China and Taiwan [41]. Creating jobs through the RE industries will contribute hugely towards the national economy and hence the GDP. Hence, it can be concluded that a higher RE penetration in the energy mix of the nation will prove to be a boon for the economy in terms of economies of scale and also create job opportunities within Malaysia.

From the PESTLE framework, it can be concluded that the overall contribution of RE towards Malaysia's ES is positive and will secure long-term ES and sustainability for Malaysia. The following discussion on SWOT analysis of these dimensions is carried out to understand within these dimensions what are the strengths, weaknesses, opportunities, and threats for Malaysia's ES. The SWOT analysis is represented in Fig. 4.

Strengths: The strength of RE in Malaysia lies within the documented energy policies that address the RE targets and the carbon emission reduction targets. Historically RE has been introduced in 1981 as the Fourth Fuel in the energy mix and since then there has been a gradual deployment of RE in Malaysia mostly in electricity production. Currently, in TPES the capacity is 2% and stakeholders' believes that by 2030 this might only increase to as much as 5% while for electricity generation the share is higher at approximately 9% now and this will increase over the year but unsure if it can reach the target of 20% by 2025. Policy documentation is very important for RE in Malaysia and most importantly having viable strategies to fulfil the targets in these policies. These policies do reflect the ambition of the government to go green and improve its sustainability over the period and this can be seen as a strength for RE in the nation.

Weaknesses: Intermittency challenges remains to be the primary weakness of RE in Malaysia. Malaysia being a tropical country records a high amount of rainfall throughout the year which means lower sun exposure during the monsoon season. Keeping this in mind, the efficiency of solar PV decreases leading to instability thus delivering poor supply security. This means the thermal powerplants work as a back up to solve this intermittency issue which requires further funding and capital cost. Thus, increasing the overall cost of the entire project. The price per unit in kW.h is not competitive enough as of now to cope up with that of fossil fuels like coal and natural gas. To avoid the intermittency issue, batteries can be used as a solution to store energy but the energy storage system in Malaysia is immature for large-scale use. The RE policies of Malaysia are in place on behalf of the government and the governing bodies. The challenge remains in the implementation. Most of the previous RE policies have successfully managed to introduce RE to the picture in TPES and electricity generation but fails to reach the penultimate targets. SEDA is looking to improve this by laying out the new strategies mentioned in Section 3 of this paper in its RETR 2035.

Strengths	**Weakness**
• Strong national energy policies, national RE policies and energy act. • Presence of a regulatory body in the form of SEDA for RE policies. • The intentions are strong to reach 20% RE penetration capacity in the energy mix.	• Intermittency issues of RE. • High capital cost of RE projects due to additional back up thermal powerplants. • Price for RE per unit (kW.h) is still not competitive enough to compete with that of fossil fuels. • Implementation of the RE policies have always been a weakness in Malaysia failing to reach their ultimate targets.
Opportunities	**Threats**
• Geographical advantage for solar power and scope of exploring marine RE. • There is a gradual decrease in RE capital cost and price per unit. • New and improved RE technologies worldwide like floating solar can become a prospect. • Opportunity to move towards energy-efficient technologies like green buildings and EV.	• Poor intermittency can lead to unstable supply which needs to be mitigated or else the threat of consumer dissatisfaction remains. • Weather can be a threat towards RE generation in certain parts of Malaysia mostly for solar power.

Fig. 4 SWOT analysis.

Opportunities: There are opportunities to exploit the geographical advantage of Malaysia in terms of marine RE as Malaysia is surrounded by water bodies on its east and west coast. However, due to lack of governance within the SEA countries towards marine RE has led to a poor marine RE share in the mix for most of the SEA countries. There is also a scope to increase solar PV projects on both small and large scales. It is important to introduce it on a communal scale be it small or large to increase its share while larger projects like LSS should be allowed to grow further with more incentives and price competitiveness to attract more business for returns. Although the current RE project capital costs are high compared to the conventional thermal plants, it is in a downward move which poses a big opportunity to capitalize and have more RE plants installed in the nation. There is also an improvement in the technology towards RE to be more efficient and allow greater productivity. Energy-efficient (EE)

technologies are also booming recently with green buildings and EVs being the key prospect as Malaysia should be able to have a fair share of the EE technologies in near future [3].

Threats: One of the weaknesses found in this study is the intermittency of RE in Malaysia. This issue can lead to a further threat in terms of losing consumer confidence if there is any sort of supply security disruption ever due to the intermittency. Keeping the consumers satisfied is challenging as consumers always want affordable tariffs at the same time having an undisrupted supply of energy. Weather can sometimes pose a threat in places where less sun is recorded for solar PV plants to work efficiently at all times. The last potential threat can be the price competitiveness of coal and natural gas either in TPES or electricity generation. RE needs to become cheaper for the government to build full confidence that the same tariff of electricity and other forms of energy can be provided to the consumers to have consistent support from them.

6 Conclusion

There is an urgent need for RE in Malaysia to mature and to have a higher share in TPES and electricity generation to ensure that it contributes towards the long-term ES for the country. There is no second opinion in this from the stakeholders that RE will only positively contribute to every dimension of ES in Malaysia except for the thermal power generation business who may have the concern of losing market share with increasing RE. This can be a growing tension but can be mitigated by the government with changes in certain policies towards the use of fossils over a prolonged period. Looking at fossil fuels as the primary source of energy for a long period can be a threat to the national ES for Malaysia. This high demand for fossil energy cannot be swiftly fulfilled by RE, but it can gradually take over as one of the leading fuels in the energy mix. Only then Malaysia's ES will move towards a more secure status.

The PESTLE framework suggests that Malaysia's social, technological, and environmental dimensions can be listed as the last three priorities. There is little social concern in terms of the use of RE or the understanding towards ES amongst the local community hence, it can be listed as the last while technologically Malaysia still needs to catch up with countries like China in terms of advancement of its RE technology. In the meantime, the environmental dimension is not overlooked as there are regulatory bodies like SEDA to monitor the policies and their implementation, yet it is not prioritized over the economic health benefits of the nation. The key dimensions deciding the fate of ES in Malaysia are political, legal, and economic dimensions. The government of the day is pivotal in marking crucial decisions especially in determining the share of coal power and RE generation. It is a matter of prioritizing what is important for the ES of the country, leveraging upon necessary legal and or policy instruments. The health of economic growth is one of the most important aspects of a developing economy like Malaysia. People are more concerned about their financial well-being rather than a contribution to climate change in developing economies. This is justifiable because Malaysia's overall contribution to a deteriorating climate change will be comparatively negligible to that of the larger economies like China or Russia hence, the community here has little concern about these factors.

On the other hand, the SWOT analysis finding suggests that the government's intervention through policymaking and initiatives to go green presents the greatest strength while the weakness lies in the intermittency challenges and the implementation of these policies to their best. There are opportunities to exploit the geographical conditions of the sun for solar and large water bodies for marine RE in Malaysia and the potent threats towards RE are being poor in price competitiveness compared to coal and natural gas in Malaysia. This study gives a depth knowledge of the key role that RE plays in defining ES for a nation and how RE can be used to the best of its potential to ensure that Malaysia is long-term energy secured as a nation.

Abbreviation

ES	Energy Security
RE	Renewable Energy
SEDA	Sustainable Energy Development Authority
ASEAN	Association of Southeast Asian Nations
SEA	South East Asian
TPES	Total Primary Energy Supply, (Mtoe)
TFEC	Total Final Energy Consumption, (Mtoe)
RETR	Renewable Energy Transition Roadmap
SSI	Semi-Structured Interview

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The authors declared that there is no conflict of interest with any other party on the publication of the current work.

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Appendix A

Table 2. List of stakeholders.

Stakeholder	Organisation
1	Energy Commission, Malaysia
2	Energy Commission, Malaysia
3	Energy Studies Institute, National University of Singapore
4	UiTM Energy and Facilities and UiTM Solar Power, Malaysia
5	Energy Studies Institute, National University of Singapore
6	Saab-NTU Joint Lab, Nanyang Technological University, Singapore
7	Tenaga Nasional Berhad Malaysia
8	Agilent Technologies, Malaysia
9	University of Technology Sydney, Australia
10	Energy Studies Institute, National University of Singapore
11	Institute of Strategic and International Studies Malaysia
12	Institute of Strategic and International Studies Malaysia
13	Ministry of Energy and Natural Resources, Malaysia
14	Sustainable Energy Development Authority (SEDA), Malaysia
15	Tenaga Nasional Berhad Malaysia
16	Single Buyer, Malaysia