A Review of the Relationship Between Sustainable Energy and the Principle of Energy Resilience: A Case Study of Malaysia

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ABSTRACT

Malaysia is a country that heavily relies on non-renewable energy to produce electricity. However, emerging from the pandemic that began in late 2019, one problem has been highlighted about Malaysia's energy sector, which is the resilience of the energy system and the industry itself. Hence, this paper will provide an insight into the nexus between the use of sustainable energy and the principle of energy resilience. It will attempt to describe the situation regarding the use of sustainable energy in Malaysia, as well as the current phase of resilience that Malaysia is in right now, as this is to address the issue of energy security and reliability in the country. In addition, the paper will also discuss the energy industry in Germany as a point of reference since it is a country that has progressed significantly in transitioning towards renewable and sustainable energy, which the Malaysian government can emulate the law in that country for reforming the energy industry/sector in Malaysia. Lastly, the paper will also provide recommendations and suggestions based on the findings of the possible alternatives of sustainable energy resources that Malaysia may adopt to achieve the principle of energy resilience.

Keywords: Sustainable energy, Renewable and non-renewable energy, Energy Resilience, Energy Security.

INTRODUCTION

The energy industry in the world as a whole is shifting towards a faster non-reliance on fossil fuels as a result of growing fears of energy resource depletion, environmental devastation and the non-durable nature of carbonbased energy sources. With the non-renewable energy sources (coal, oil, natural gas) being limited, many states are starting to consider the shift towards renewable energy, not only as a sustainability demand but also as a strategic requirement to national stability. In a similar study, Rajapakse Mudiyanselage Gamini (2007) argues against the structural threat of long-term development in the continued use of non-renewable resources, especially at a time when energy consumption is on the increase. This opinion supports the recent knowledge that sustainability is closely associated with resource security and transition planning (Golusin et al., 2013). Furthermore, it is proven that traditional energy sources have a substantial number of unfavourable externalities in the context of human health and environment, which makes the dependency on fossil fuels even less and less consistent with the goals of sustainable development (Union of Concerned Scientists, 2018).

The issue of energy transition is especially urgent in the case of Malaysia. The empirical research findings are consistent in implicating the electricity generation profile of Malaysia as highly reliant on non-renewable energy sources, which warrants issues relating to long-term sustainability, energy security and vulnerability of the system in the future (Shafie et al., 2011; Khor & Lalchand, 2014). The need to come up with renewable alternatives is thus not only driven by the need to focus on the environment but also by the long-term energy resilience planning. Bekhet and Haroun (2015) suggest that Malaysia requires an increased balance between the use of renewable and non-renewable energy to achieve a sustainable electricity supply in the long term. As part

of this national context, Malaysia has a wide array of renewable energy sources, including biomass, hydro and solar photovoltaic energy; however, the use of renewable energy is still low as compared to traditional fuels (Abdullah et al., 2019). Therefore, the problem is not the lack of renewable potential, but the effectiveness of governance institutions and implementation systems that may facilitate a shift to resilient energy systems.

The recent upheavals have increased the argument for energy resilience. The COVID-19 pandemic demonstrated the rapid destabilisation of the energy systems due to economic instability and demand shock exposure, which revealed the weakness of the current supply structures (Peng et al., 2021). Analysing resilience, Holling (1973) brought up the notion of resilience to denote the capacity of a system to absorb shocks and maintain its core functionality and structure and later scholarship extended this argumentation into social-ecological governance systems (Walker et al., 2004). Using this framework in the energy sector, energy resilience is a system that can be functional and reliable even in times of crisis, like war and pandemics, where there is a crisis in supply chains and the availability of fuel. Regarding that, Gatto and Drago (2020) claim that energy resilience should not be reduced to the concept of technical continuity per se, but it must also embrace the social, economic and governance aspects in order to provide security and reliability. Equally, Jesse et al. (2019) argue that energy resilience frameworks should be operationalised into real-world energy governance mechanisms to generate real-world results rather than merely being discussed theoretically.

Although there has been an increasing trend towards the implementation of renewable energy, the nexus between sustainable energy governance and energy resilience has still not been explored from a legal and policy perspective. Literature reviews tend to locate sustainability results, technological advancement, or financial goals, but do not provide legal-policy evaluation of whether institutional organisations are adequate to sustain resilience indicators, including security of supply, reliability, affordability and enforceability (Roseberry et al., 2021). The regulatory framework of Malaysia is mainly backed by such tools as the Renewable Energy Act 2011 and national transition programs, which should be systematically analysed to identify whether they can provide a way to turn the growth of renewable energy into quantifiable resilience results (Abdullah et al., 2019; Shamsuddin, 2012). As a result, this paper will discuss sustainable energy concerning energy resilience with reference to Malaysia as a case study.

In line with this, the paper will assess the sustainable energy transition in Malaysia in the legal-policy resilience framework by using the core indicators based on the aspects of security of supply, reliability, affordability, sustainability and enforceability of governance. The paper also looks at the experience of the renewable transition in Germany, especially the Energiewende, which is often used as a reference point regarding the fruitful implementation of the renewable development based on the coherent governance strategy (Gawel et al., 2014; Rechsteiner, 2021). Although the situation in Malaysia is different in terms of the market structure and resource combination, comparative learning can be employed since the design of governance is a strong predictor of transition effectiveness. Finally, using guided pointers of the energy governance setting in Malaysia, this paper will add a critical evaluation of how improved sustainable energy regulations and legislations can be reinforced to help in ensuring long-term energy resilience.

LITERATURE REVIEW

Sustainable energy and its importance

In general, the root of sustainable energy stems from a variety of ideas regarding its concepts and understandings, but with a similar focus, which is to attain the efficient use of energy. Thus, it can be inferred that energy sustainability is the efficient use of energy resources, their operations, as well as the utilisation of renewable energy sources. On top of that, the attempt to put the concepts of sustainable development into practice has given way to the notion of sustainable energy.

In justifying the need to adopt the concept of sustainable energy, three dimensions that best delineate the concept of sustainability will need to be discussed (Golušin et al., 2013). Firstly, as the ecological dimension is concerned with the utilisation of renewable and non-renewable energy resources and also their impacts on human health and the environment, it is undeniable that non-renewable energy, such as fossil fuel, is proven to cause more

harm than good in many possible measures. Thus, non-renewable energy is not compatible with the concept of sustainability (Union of Concerned Scientists, 2018).

Secondly, as far as the economic dimension is concerned, it connotes the idea of the repercussions on the national economy, meeting the energy needs, limited supply of resources, relevant costs and reliance on raw material supply. Energy plays a dominant role in ensuring economic growth and development. In Malaysia, reliance on non-renewable energy sources remains substantial in meeting increasing energy demand, particularly within the power sector (International Energy Agency, 2023; Energy Commission Malaysia, 2024). The Ministry of Economy Malaysia (2023) has formally acknowledged this challenge in the National Energy Transition Roadmap, which frames the transition as necessary for long-term energy security, resilience and sustainability. Regional transition frameworks also stress that meeting demand growth without substantial alternative energy expansion increases vulnerability to price volatility and supply risks (International Renewable Energy Agency, 2023; United Nations Economic and Social Commission for Asia and the Pacific, 2023). Renewable energy is therefore important because it provides sustainable energy, which has no finite lifespan.

Thirdly, the socio-cultural dimension refers to social tolerance, continuous supply guarantee, integration with existing infrastructure and lastly avoidance of involvement in global conflicts. In our current global energy system, sustainable energy is proposed to be energy from renewable resources. Malaysia has various renewable energy resources such as wind, biomass, hydro and Solar PV (Shafie et al., 2011). However, its usage is not as significant as fossil fuels or natural gas, which are mainly used to supply energy to many important sectors in Malaysia, such as transportation and the industrial sector. Despite that, renewable energy plays an important role in Malaysia as it can provide secure and reliable power supplies. Over-reliance on non-renewable energy to generate country development will raise issues such as fossil fuel depletion in the future and subsequently will halt the development of this country. In that case, our consideration on utilising renewable energy as a backup energy for Malaysia is crucial (Ahmad & Abdul-Ghani, 2011). There is no doubt that renewable energy is the most suited to be recognised as sustainable energy, considering its features and its lesser impact on the environment compared to non-renewable energy.

The concept of Energy Resilience

Holling (1973) introduced the concept of resilience as the ability of a system to go back to its equilibrium state even when there is movement to it (Walker et al., 2004). Resilience, in literal terms, can be defined as the capability to recover quickly from any sudden or unexpected difficulties. This concept can be applied in the energy system. As an illustration, according to statistics, more than 80% of the world's Total Primary Energy Supply is contributed by non-renewable sources such as coal, natural gas, etc. At this pace, without intervention, it is clear that those sources will be exhausted and subsequently cause disruption to our current energy supply. Energy resilience is when the energy system can continue its function even after such a disruption (Jesse et al., 2019).

For clear views, we concede with the definition of energy resilience that has been put forward by Gatto and Drago (2020) as they defined energy resilience not only it extent to where that the energy system should be able to adapt and prevail over unprecedented events, but also the energy system should be sustainable and resilience in the aspects of social, economic and governance: in which by achieving this principle, it will result in the energy system to be more secure and reliable enough to withstand any shocks that were brought by any force majeure situations (Gatto & Drago, 2020). In the Malaysian context, the central concern is whether the national energy system can maintain continuity in the event of fossil fuel depletion or significant supply disruption, particularly where such disruption results in grid instability or outages. Where sufficient alternative energy sources are unavailable to replace fossil fuels on a large scale, the continuation of industrial activity and socioeconomic functions may be significantly affected. The capacity of an energy system to anticipate, absorb and recover from such disruptions is captured by the concept of energy resilience, which supports sustained societal functioning and long-term development.

The relationship between the usage of Renewable Energy sources and Energy Resilience.

As previously covered, to test the theory of whether the source of energy is genuinely sustainable and able to attain the principle of resilience, an observation should be made on whether the chain of supply can be effectively operated even in the event of disruptions. PETRONAS, for instance, faced a considerable challenge to strengthen its resilience and long-term sustainability due to the uncertainties brought by the Covid-19 pandemic (PETRONAS, 2020). This is a clear illustration to contend that there is no guarantee for nonrenewable sources like oil and natural gas to remain uninterrupted in all events, especially in unexpected tough times, substantially making it non-resilient. Unlike non-renewable sources, renewable energy sources like biomass and solar are better able to withstand global shocks than fossil fuel-based energy systems and they also carry less detrimental effects to the environment, which substantially influences the overall achievement of the principle of energy resilience.

Analytical Framework: Legal-Policy Indicators for Energy Resilience

The energy resilience concept is understood as the ability of an energy system to continue providing reliable services during times of stress, as well as optimising towards sustainable goals. In the current work, the operationalisation of energy resilience is considered based on the legal-policy framework consisting of five indicators connected with each other. First, Reliability: the consistency of energy supply, which includes grid robustness, redundancy and responding to system shocks. Second on Security of supply: the extent to which national legislation and policies promote energy source diversification and reduce reliance on individual fuels or import-based directions. Third, on Sustainability: the legal and governance frameworks that facilitate the long-term decarbonisation and incorporation of renewable energy. Fourth, Regarding Affordability: Does the policy structure maintain price stability and insulate consumers against the volatility of energy costs without undermining transition incentives? Finally, on Governance and enforceability: how well policies dealing with energy are supported by binding legal obligations, regulatory responsibility, oversight and measurement.

By using these pointers, the study evaluates existing legal and policy tools in Malaysia on sustainable energy to determine whether these tools are sufficient in supporting energy resilience. It provides a system of analysis, which is strictly used throughout the findings and discussion, thus going beyond the description of exposition and allows a critical analysis of legal adequacy and effectiveness of the policies.

RESEARCH METHODOLOGY

This paper uses a research approach that combines qualitative doctrinal and library-based research methods to evaluate the connection between sustainable energy governance and energy resilience in Malaysia. The legal design, institutional responsibility and enforceability aspects of the significant laws and regulatory tools on sustainable energy in Malaysia are analysed through the doctrinal approach. The library approach promotes the doctrinal approach using reviews of peer-reviewed scholarly publications, policy reports and official energy statistics related to resilience and transition governance.

The primary sources of law are the Malaysian laws and the regulatory documents applicable to the sustainable energy governance, including the Renewable Energy Act of 2011, the Efficient Management of Electrical Energy Regulations of 2008 and the national documents on energy policies. Secondary sources include journal articles, institutional reports and comparative legal sources based on established legal and scientific databases such as HeinOnline and ScienceDirect.

To guarantee the selective choice of sources, the study will give priority to the peer-reviewed literature of the journals and the official institutional reports. Selection of materials has been done based on relevance to the thematic scope of the study- renal energy governance, energy resilience, regulatory enforceability and transition outcomes and comparative references have been added where they have something to say to the study about legal relevance, especially in the energy governance experience in Germany.

The analytical framework used to guide the analysis comprises five energy resilience indicators, namely security of supply, reliability, affordability, sustainability and enforceability of governance. These indicators are used to assess the sufficiency of the current framework in the realisation of energy resilience in relation to the Malaysian

laws and policies. This will make the paper go beyond the descriptive exposition to a systematic and critical analysis of the effectiveness of the law and policy.

FINDINGS & DISCUSSION

Malaysia's Energy Mix and Vulnerability Profile

The energy system of Malaysia remains defined mainly by dependency on fossil fuel consumption, thus putting the country at risk of energy insecurity, price fluctuations and supply shocks. The evidence-based literature has repeatedly shown that Malaysia is still significantly relying on the use of non-renewable resources in its power generation profile, which can hardly be maintained over the long term because of pressure on its depletion and environmental impacts (Khor & Lalchand, 2014; Shafie et al., 2011). These weaknesses were further clarified by the COVID-19 pandemic, which revealed how demand patterns and economic activity disruption exposed how much a shock can destabilise energy systems (Peng et al., 2021). As such, energy resilience in Malaysia should not be viewed as a technical target per se, but it has turned into a governance issue that is growing in prominence and requiring coherent legal and policy responses to curb risks of dependency and enable a sustainable transition (Jesse et al., 2019; Gatto & Drago, 2020).

Legal and Policy Framework for Renewable Transition

Malaysia has developed a stepping-stone to sustainable energy using regulatory and planning instruments to help in adopting renewable energy, energy conservation and strengthening the sustainability of supply in the long run. One of the most important aspects in this line is the management of energy efficiency and especially the Efficient Management of Electrical Energy Regulations 2008 (EMEER 2008), which facilitates the better management of demand and energy control (Shamsuddin, 2012). Also, the institutional support of renewable governance is determined by the Renewable Energy Act 2011, which indicates that Malaysia is willing to gradually decrease its overdependence on non-renewable energy sources and to enhance the stability of domestic energy (Abdullah et al., 2019). Taken together, these models represent a national recognition of the idea that sustainable energy is one of the pillars of resilience. However, the legal tools cannot ensure the resilience results unless they are supported by reliable enforcement tools and quantifiable transition implementation capacity (Jesse et al., 2019; Gatto & Drago, 2020).

Resilience Assessment Using the Analytical Criteria

The interconnection between the aspects of sustainable energy governance and energy resilience in Malaysia is explained by assessing it with the key resilience metrics, i.e. security of supply, reliability, affordability, sustainability and enforceability of governance (Jesse et al., 2019; Gatto & Drago, 2020). Concerning the security of supply, the ongoing dependence on the source of energy that is based on fossil fuels implies that, in the context of Malaysia, the diversification process is not yet adequate to address structural vulnerability. Even though the introduction of renewable energy initiatives and significant potential of solar, biomass and hydro are introduced, the use of renewables is relatively low compared to traditional fuels (Abdullah et al., 2019; Shafie et al., 2011; Andersen, 2021). Diversification under a resilience concept cannot be obtained only by commitment to policy but requires the means of governance that can expand the implementation of renewable resources to reduce reliance on non-renewable ones (Gatto & Drago, 2020; Roseberry et al., 2021).

Reliability requires that the energy system be stable in response to shocks as well as effective recovery following disruptions (Holling, 1973; Jesse et al., 2019). The experience of Malaysia with COVID-19 showed that the patterns of energy demand may change very quickly, in an unpredictable manner, especially when there is an increase in residential and healthcare consumption and a decrease in commercial and industrial one (Peng et al., 2021). Such an interruption emphasises the fragility of traditional energy systems and supports the idea that renewable-based systems could provide a more resilient route with the careful management (Andre, 2020; Roseberry et al., 2021).

Energy resilience is also heavily focused on the issue of affordability, since no resilience can be maintained in case energy becomes unstable economically or financially and unavailable to consumers. Unless the transition is implemented in an efficient manner, the sustainability agenda can create new vulnerabilities in the form of

cost pressures, investment gaps, or delays in governance (Roseberry et al., 2021). At the same time, sustainability is also one of the fundamental resilience drivers, as the continued dependence on finite fossil resources implies predetermined long-term risks and environmental costs (Union of Concerned Scientists, 2018). The outlook of Malaysia regarding resilience is therefore not related to increasing renewable capacity alone, but also to harmonising the energy governance with sustainability outcomes.

Lastly, the governance and enforceability are conclusive in whether the sustainable transition in Malaysia brings resilience results. In spite of the recognition of policy efforts, it has been shown that the current trend in power generation that is followed by Malaysia is not sustainable without long-term legal and governance reform (Khor & Lalchand, 2014; Jesse et al., 2019). This argument is enhanced by similar experience in Germany, which has been credited with high rates of successful renewable penetration and transition, in which renewable generation grew significantly over the years with consistent transition policies (Burgermeester, 2019; Rechsteiner, 2021). The example of Germany, the Energiewende, shows that a resilience-oriented transition requires a sustained policy effort, institutional consistency and decentralising strategies that support grid resilience (Gawel et al., 2014; Rechsteiner, 2021). To this end, Malaysia might need to have stricter governance design and enforceability to turn the intentions of sustainability into quantifiable effects of energy resilience.

RECOMMENDATIONS

There is a strong conceptual relationship between the use of renewable energy and the concept of energy resilience because it has minimal impact on the environment and is less likely to be disrupted by any unexpected event. Utilisation of renewable energy could support and improve the chances of achieving energy resilience, which is currently what Malaysia hopes to achieve through its own renewable energy sources.

In practical terms, this study finds that Malaysia is still in its initial stage of achieving energy resilience through renewable energy. Despite some changes being made to utilise it more, the country still relies heavily on nonrenewable sources to meet the current demand for energy. Although the current situation has improved a lot compared to years ago, Malaysia needs to ramp up its efforts to achieve energy resilience by carefully managing and developing its renewable energy. There are some recommendations that can be taken into consideration. The government should encourage and focus on the development of solar, hydro and biomass as renewable energy sources in Malaysia and take advantage of the decreasing cost for generating these types of energy. This encouragement should not remain at the policy level only. However, it should be complemented with regulatory mechanisms that create predictable investment signals, such as legally structured incentives, transparent approval procedures and stronger grid access frameworks for renewable project integration.

The decrease is caused by technological advancement coming from an experienced European market, especially the annual solar power cost (Sivaprasad & Kumbhare, 2021). The hydropower industry has high potential for development by taking advantage of Malaysia's high rainfall rate and hilly landscape in small-scale hydropower plants. Development of biomass energy should also be observed because Malaysia's reliance on palm oil and coconut husk and other biomass fuel sources can support its production in the long run (Afrouzi et al., 2021). This would ultimately move Malaysia closer to securing its sustainable energy resources by focusing our development on them. At the legal governance level, renewable development should also be guided by stronger sustainability safeguards, including more precise statutory requirements for environmental impact assessment compliance, community consultation (particularly for hydropower siting) and mandatory monitoring obligations to reduce environmental trade-offs that may undermine resilience in the long term.

Although wind energy in Malaysia lacks promising prospects for energy generation due to low wind speed needed to power wind turbines, research by the University of Malaya, Terengganu, has shown that some places like Kudat and Kota Marudu have the potential to generate such energy (*The Star*, 2017). The government should invest some capital in these places to develop more sustainable energy. In addition, policy planning for wind energy should include enforceable technical standards (such as minimum wind yield thresholds and safety requirements), as well as clearer licensing pathways so that pilot projects can be scaled only when feasibility is demonstrated.

Additionally, amendments to the Renewable Energy Act 2011 or a completely new law that would comprehensively cover renewable energy matters in Malaysia should also be made. Changes and additional rules like setting out statutory obligations, mandatory reporting and punishment for its violation on renewable energy matters must be adequately implemented and enforced using this law. These amendments should define institutional roles and enforcement powers more explicitly, including which agency has supervisory authority, the scope of inspection powers, the form and frequency of compliance reporting and the specific nature of penalties for non-compliance. The law should also introduce measurable renewable deployment targets with clear timelines and mechanisms to ensure implementation, such as renewable portfolio obligations for relevant electricity market participants, reporting duties for utilities on renewable integration progress and legally supported grid access requirements for renewable producers. Further, energy resilience requires system reliability; therefore, regulatory updates should address grid modernisation and integration readiness by introducing planning obligations for transmission upgrades, system balancing responsibilities and legal recognition of storage solutions as part of the renewable governance ecosystem.

The legislator can observe and take inspiration from some European countries in amending such laws for the better management of renewable energy in achieving energy resilience. Comparative reference may be drawn not merely from general transition outcomes, but from specific legal mechanisms adopted in European renewable governance, such as priority grid connection rules, transparent tariff mechanisms and accountability structures that require annual reporting and parliamentary or regulatory oversight of renewable energy performance indicators.

CONCLUSION

The purpose of this paper is to understand and be aware of the concept of energy resilience and its relation to sustainable energy. For an action or plan to be executed efficiently, it is important for everyone to understand the concept first. To simplify, energy resilience is a concept that allows us to withstand any problem in the future when our non-renewable energy, which we are relying on, is no longer available. There is a close relationship between sustainable energy and energy resilience through the usage of renewable energy. Without a proper and organised strategy to achieve energy resilience, Malaysia might be entering into a possibility of exhausting its non-renewable energy and stalling its development. Non-renewable energy, which has been an important element for us, will be a significant threat upon its exhaustion. Clearly, without alternative energy to replace it, we have no chance of surviving such a delayed catastrophe. The clock is ticking, but we are still walking instead of running. Despite significant progress made in the utilisation of renewable energy in the energy mix, the country still falls short in achieving energy resilience. Hence, it must focus more on developing and using its renewable energy available and achieve energy resilience. More research and development on renewable energy are desperately needed for us to achieve energy resilience in Malaysia.

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