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Shifting Tides: Affordability of Malaysia's Energy Transition

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Abstract: *The Energy Commission of Malaysia (EC) harnesses the Energy Trilemma, focusing on security, affordability, and sustainability, to strategically navigate the nation's energy transition towards increasing the share of Renewable Energy (RE). This transition aims to balance the need for reliable and cost-effective energy while reducing carbon emissions and dependency on thermal sources. Despite the potential of RE to contribute to a sustainable energy pathway, there are significant challenges concerning the affordability of this shift, especially when compared to conventional coal plants. The study aims to examine the affordability aspect of RE through a SWOT analysis, assessing the strengths, weaknesses, opportunities, and threats associated with the transition from coal to renewable sources. Employing a qualitative approach, this research relies on structured interviews with experts from a key utility company to delve into the complexities of Malaysia's energy transition. The findings highlight the cost-effectiveness and innovative potential of RE, particularly solar power, against the backdrop of its intermittent nature and land acquisition costs. Moreover, the SWOT analysis points to opportunities for decentralized energy models and technological advancements that can ensure the affordability of solar energy. The research underscores the need for strategic partnerships and policy frameworks that support scalable and economically viable energy solutions, despite the high initial costs and reliance on tariff mechanisms. In conclusion, while coal plants currently offer more stable and cost-effective energy production, the future of Malaysia's energy affordability hinges on a balanced integration of renewable sources, addressing the highlighted SWOT elements. This integrated approach is vital for a sustainable energy economy that is both environmentally responsible and economically feasible.*

Keywords: Energy Trilemma, SWOT Analysis, Renewable Energy, Affordability

1. Introduction

The Energy Commission of Malaysia (EC) employs the Energy Trilemma framework, emphasizing Security, Affordability, and Sustainability, to guide the nation's energy planning (Suruhanjaya Tenaga, 2021). This approach ensures a reliable, cost-effective, and environmentally conscious energy supply.

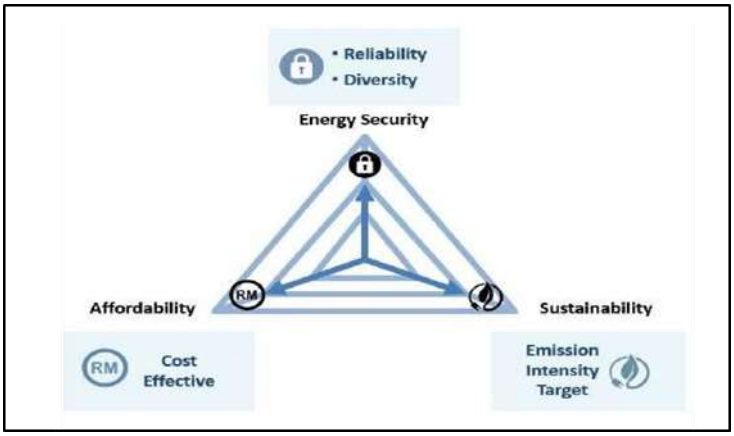

Figure 1: Energy Trilemma Infographic (Source: Suruhanjaya Tenaga, 2021)

In addressing the Energy Trilemma, the EC has committed to amplifying renewable energy (RE) share in Peninsular Malaysia's energy mix, targeting an increase from 17% to 31% by 2025, thereby reducing reliance on thermal sources (Energy Watch, 2021). This initiative supports Malaysia's sustainable energy pathway and aims to decrease carbon emissions.

In the sphere of affordability, the EC's strategies focus on balancing energy costs, ensuring they are manageable for consumers while remaining economically viable for producers. This key element of the Energy Trilemma intertwines with the commission's drive to increase RE. The expansion of RE is seen as a pivotal move towards a more cost-effective and sustainable energy framework, aligning with Malaysia's goal of a balanced energy economy (MIDA, 2021).

The aim of this research is to conduct a SWOT analysis focusing on the affordability aspect of energy supply, comparing renewable sources with conventional plants. Malaysia's EC is transitioning from conventional plants of coal to RE such as solar, focusing on cost-efficient, sustainable electricity generation while navigating energy storage and supply stability challenges (Suruhanjaya Tenaga, 2021). Hence, it is imperative to assess the affordability of this shift.

2. Literature Review

The Malaysian energy landscape is undergoing a transformative shift towards RE, as outlined in the Energy Commission Peninsular Malaysia Generation Development Plan (Suruhanjaya Tenaga, 2021). This transition reflects Malaysia's commitment to sustainable development and reduced reliance on fossil fuels, with the goal of achieving carbon neutrality. However, this shift also poses significant challenges in terms of affordability, global energy dynamics, and national energy security.

One of the key components of the EC plan is the gradual reduction of coal-fired power plants, aiming to decrease their contribution from 37% in 2021 to 22% by 2039 (Suruhanjaya Tenaga, 2021). This move is essential to align Malaysia’s energy sector with global sustainability objectives, but it raises concerns about the affordability of energy. Renewable energy sources, despite decreasing costs, often require higher initial investment compared to traditional energy sources. This aspect poses a challenge in maintaining energy prices within a reasonable range, crucial for ensuring accessibility for all citizens (The World Bank, 2023).

Globally, the escalating tensions in the South China Sea add another layer of complexity to Malaysia's energy strategy (Brigham, 2023). The struggle for control over natural resources,

primarily oil and natural gas, in this region impacts Malaysia's energy security and underscores the importance of diversifying energy sources. These geopolitical dynamic influences Malaysia's energy affordability, as the country navigates through the interplay of regional power struggles and its own energy needs (Alatas, 2016).

Within Malaysia, the focus on renewable energy sources, such as hydroelectric power, solar energy, biogas, and biomass energy, presents both challenges and opportunities (Aiman, 2023). The adoption of Battery Energy Storage Systems (BESS) is an innovative approach to enhance grid stability, but the financial and technological viability of these systems is still under debate (Laajimi & Go, 2021). While these technologies promise a more sustainable energy future, the initial costs and ongoing development may impact the affordability of energy in the short term.

Additionally, the plan to fully utilize Combined Cycle Gas Turbine (CCGT) plants post-2030 is aimed at achieving high efficiency and reduced greenhouse gas emissions. However, this reliance on CCGT plants raises concerns about the availability and security of natural gas supply, as evidenced by past shortfalls in gas supply from Petronas (Suruhanjaya Tenaga, 2010). Ensuring a stable supply of natural gas is crucial for the successful integration of CCGT plants into Malaysia's energy mix, which again ties back to the issue of energy affordability and security.

Malaysia's transition towards a sustainable energy future, as guided by the EC's Generation Development Plan, is marked by a complex interplay of global challenges, national security concerns, and the pressing need for affordable energy. While the shift towards renewable energy sources and innovative technologies like BESS and CCGT plants presents a path towards a more sustainable future, it also brings to the forefront the critical issue of balancing environmental commitments with the economic and practical realities of energy affordability and security.

3. Methodology

The methodology of this research is rooted in a qualitative framework, leveraging structured interviews with expert informants from prominent utility company, a pivotal entity in Malaysia's electrical infrastructure development (Suruhanjaya Tenaga, 2021). The research is conducted in two main phases: a review of documentation for parameter identification and structured interviews. These components are designed to explore the complexities and various aspects of electrical infrastructure implementation and the energy transition process (Suruhanjaya Tenaga, 2021). The structured interviews, a cornerstone of this methodology, are meticulously designed to extract comprehensive insights from the utility company's experts directly involved in the energy transition process. This approach ensures the consistency and reliability of the data collected, with questions tailored to the identified parameters and expert informants selected for their profound knowledge and firsthand experience in the sector (Suruhanjaya Tenaga, 2021).

A pivotal part of the data analysis is the SWOT analysis, a strategic planning tool that comprehensively assesses the strengths, weaknesses, opportunities, and threats associated with the shift from conventional power plants to renewable energy sources (Srdjevic et. al. 2012). This analysis offers a structured comparison, shedding light on various factors like the environmental impact, potential for innovation, sustainability, technological limitations, and the variability of energy production. It also explores the opportunities and threats posed by market dynamics, regulatory changes, and stakeholder resistance, providing a balanced

perspective on the feasibility and affordability of the energy transition in Malaysia (Srdjevic et. al. 2012).

This qualitative research methodology, underpinned by semi-structured interviews with expert informants involve directly in energy supply sector and a robust SWOT analysis, provides a thorough understanding of Malaysia's energy transition, considering the complex aspects of affordability in line with sustainability.

4. Findings and Discussion

The following results from semi-structured interviews show that affordability as one of pivotal in the Energy Trilemma, balances generation and dispatch costs against low consumer prices, promoting reliable, economically feasible electricity. This not only protects consumers from high prices but also secures energy providers' profitability.

Expert informants highlighted land size's role in affordability, informing the SWOT analysis below:

Table 1: SWOT Analysis Findings of Affordability and Land for Solar Energy

Strengths	Weaknesses
1. Innovative Solutions for Land Constraints: Malaysia is exploring diverse solutions such as floating solar installations.	**1. Land Requirements**: Solar farms require vast land areas for substantial energy production. The land-to-energy ratio is less favorable for solar than coal.
2. Initiatives like National Energy Transition Roadmap (NETR): The government's move to aggregate solar energy from individual rooftops is an innovative approach to decentralize energy production.	**3. Comparative Advantage of Other Energies**: In terms of land use efficiency, coal requires less land than solar for equivalent energy production.
4. Existing Infrastructure Potential: Utilizing large rooftop areas, such as those on barracks, to install solar panels leverages available spaces for energy production.	-
Opportunities	**Threats**
1. Advance technology Solar Energy: Advanced, compact solar panels capable of generating substantial power indicate potential for advance technology solar energy.	**1. Over-reliance on a Single Energy Source**: Sole dependence on solar energy, given the land constraints and efficiency challenges, can be risky.
2. Decentralized Energy Production: Small clusters of energy producers or local aggregators can streamline energy production and distribution.	**2. Limited Alternative Renewable Resources**: Malaysia lacks abundant wind or water resources as alternatives to solar energy.

Malaysia's abundant sunlight and innovative solutions, like floating solar installations and rooftop aggregations, feature its solar energy strengths. However, challenges like vast land requirements for old type solar farm and non-commercialized advanced technologies highlight weaknesses. Opportunities lie in advanced technology solar panel and best practices from abroad, but over-reliance on solar and climatic challenges threaten its potential. To harness its solar potential effectively, Malaysia must blend innovation with lessons from global best practices.

Collaborative strategies and technological innovation can tackle land challenges, positioning solar energy as a pivotal element in Malaysia's sustainable energy landscape, ensuring a robust and prosperous future.

During this research, the expert informant was consulted to provide insights regarding the comparative construction costs and operational cost between the two energy generation sources. Their feedback was meticulously analyzed and subsequently integrated into a comprehensive SWOT Table 2 analysis to explain the complex considerations surrounding the topic.

Table 2: SWOT Analysis Findings on Comparative Energy Costs.

Strengths	Weaknesses
1. Cost-Effective Rule of Thumb: Renewable Energy (RE), particularly solar, can be cost-effective at RM1 million per 1MW, offering competitive capital (CAPEX) and operational (OPEX) expenditures when compared to coal.	**1. Intermittency:** RE sources, especially solar, are not consistently stable and can be unpredictable. Their intermittent nature can make them less reliable than coal, which provides steady power.
2. Decentralized Production: The nature of RE allows individuals to generate, consume, and possibly distribute their own energy, fostering a decentralized energy model.	**2. Land Costs:** The primary cost in setting up solar is associated with acquiring or securing land. This can drive up the overall expenditure for solar projects.

The SWOT analysis above highlights renewable energy's potential cost-effectiveness and decentralized production model, placing it as a viable alternative to conventional energy sources like coal. Successful trials, such as peer-to peer (P2P) energy sharing, further highlight its innovative adaptability. However, challenges remain, particularly the intermittent nature of RE, land acquisition costs, and regulatory complexities. Collaborative models with property developers and flexible consumption and sales options signal promise for the future.

To fully tap into the potential of solar energy, a comprehensive approach is needed. While its cost benefits and adaptability to decentralized models are evident, challenges like intermittency and land costs persist. Embracing innovative solutions, partnerships, and robust aggregator models can ensure solar role as a sustainable and cost-effective power source for the future. Further, the next question was asked to the expert informant whereas per current situation, will the Battery Energy Storage Systems (BESS) become commercially viable and affordable in Malaysia?

The following SWOT table analysing the respond for the question.

Table 3: SWOT Analysis Findings on BESS Affordability and Viability in Malaysia.

Strengths	Weaknesses
1. Tariff Manipulation: Ability to manipulate tariffs allows for cost-effective charging and discharging of batteries, taking advantage of off-peak and on-peak rates.	**1. Public Perception**: Mention of government involvement can lead to misunderstandings about subsidies, potentially affecting public trust.
2. Low Operational Cost: Batteries involve a one-time installation cost (CAPEX) and, similar to solar, have low maintenance due to no moving parts.	**2. High Initial CAPEX**: The upfront installation cost of batteries might deter some potential adopters.
Opportunities	**Threats**
1. Peak and Off-Peak Tariffs: Leveraging these tariffs can make battery usage economically viable, charging during low rates and discharging during high rates.	**1. Dependency on Mechanisms**: Relying solely on certain mechanisms like tariffs might pose risks if these mechanisms change or are discontinued.
2. Penalty and Reward Mechanism: The carbon tax mechanism, where penalized factories fund rewards for those implementing sustainable solutions like CCS, encourages responsible behaviour without direct subsidies.	**2. Cost of Fuel**: The current high operational costs associated with fuel pose a challenge to transitioning to alternative energy solutions.

3. Feed-In Tariff: Government initiatives like this can expedite the adoption and maturity of new technologies, leading to scalability and reduced costs over time.	**3. Delay in Technology Maturity**: Waiting for technologies to mature might delay the widespread adoption and realization of benefits.

The potential of battery usage in Malaysia is highlighted by its economic viability through tariff adjustments and low operational costs. While there's an initial high installation cost and potential misunderstandings about government subsidies, opportunities abound with mechanisms like peak and off-peak tariffs, and the carbon tax's penalty-reward system.

However, dependency on these mechanisms and the current high cost of fuel could hinder progress. Malaysia's energy landscape is on the verge of transformation, with strategic tariff strategies and incentives poised to drive sustainable adoption. Embracing these approaches, while addressing inherent challenges, is pivotal for a successful energy transition. Malaysia's potential in harnessing solar energy is highlighted by its natural sunlight abundance and innovative solutions such as floating solar installations.

Yet, considerable challenges like land requirements and high costs of advanced technology commercialization persist. The country has explored decentralized production models, and blockchain-based peer-to-peer energy sharing has showed promise. Nonetheless, solar harvest intermittency, the inherent costs in land acquisition, and potential public resistance are hurdles to overcome. Strategic partnerships, innovative aggregator models, and adoption of global best practices are crucial for ensuring solar energy's affordable and sustainable role in Malaysia's energy matrix.

5. Conclusion

Based on the overall SWOT analysis on affordability of energy supply in Malaysia, supplemented by input from expert informants, it is evident that Malaysia's energy sector, particularly solar energy, is at a pivotal juncture. The nation's abundant sunlight, innovative floating solar installations, and rooftop solar aggregation initiatives showcase its strengths in harnessing solar energy. However, the vast land requirements for traditional solar farms and the initial high costs associated with advanced solar technologies pose significant challenges. The opportunities for Malaysia lie in adopting advanced solar technologies and learning from global best practices, as evidenced by successful decentralized production models and peer-to-peer energy sharing trials. Moreover, the potential of BESS in managing tariff costs and ensuring operational efficiency underscores the evolving dynamics of Malaysia's energy landscape.

Conversely, the threats include over-reliance on solar energy, climatic challenges affecting alternative renewable resources, and the inherent intermittency of renewable energy sources. Public perception and acceptance, alongside the need for substantial initial investment, further complicate the transition towards a more sustainable energy framework.

To navigate these complexities, Malaysia must pursue a balanced and integrated approach. This involves blending innovation with practical strategies, fostering collaborative efforts with entities possessing large rooftop areas, and adopting aggregator models to streamline energy distribution. Furthermore, addressing the operational challenges of solar energy, such as its intermittency and land costs, is crucial.

While Malaysia is positioned to leverage its natural resources and innovative approaches to strengthen its energy sector, a complicated strategy that incorporates technological innovation, strategic partnerships, and effective policy frameworks is imperative. This approach will not only address the current challenges but also pave the way for a robust and sustainable energy future for Malaysia.

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