TOWARDS NET ZERO: REFORMING MALAYSIA'S ENERGY FRAMEWORK IN THE WAKE OF GLOBAL CLIMATE IMPERATIVES

SHEILA RAMALINGAM*

Abstract

This article examines Malaysia's energy transition in the context of global climate imperatives and its legal and policy framework. It traces Malaysia's commitments under the Paris Agreement and national energy policies, reviews the potential role of renewables such as solar, biomass, and hydropower, and evaluates barriers including fossil fuel subsidies, financing gaps, and governance weaknesses. Comparative insights from countries like Germany, Sweden, Finland, and Vietnam highlight how consistent policies, carbon pricing, and targeted incentives have enabled faster adoption of renewable energy elsewhere. The analysis argues that Malaysia's transition requires not only stronger governance and financial innovation but also inclusive approaches to rural electrification and social equity. Ultimately, phasing out fossil fuels, strengthening renewable energy laws, and ensuring community participation are essential if Malaysia is to achieve its net-zero 2050 target and build a resilient, low-carbon future.

Keywords: climate change, net zero, energy framework, law, policy

I INTRODUCTION

The World Economic Forum Global Risk Report 2025[1] continues to identify extreme weather patterns as a major global risk in the next 10 years. The international community's answer to this predicament is witnessed through various international conventions aimed at tackling climate change, including the United Nations Framework Convention on Climate Change ('UNFCCC'), the Paris Agreement, United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD), plus the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks (REDD+).

Within this framework, the energy sector emerges as a cornerstone of mitigation efforts, holding the greatest potential to deliver rapid and sustained cuts in global greenhouse gas (GHG') emissions. Transforming the energy sector to cut GHG emissions relies on phasing out fossil fuels, expanding zero-carbon electricity sources, modernising grids with storage and demand management, improving efficiency, scaling carbon removal, ensuring universal access, and pursuing a just transition.[2] Many countries are advancing rapidly: Denmark, Lithuania, and Uruguay have exceeded global benchmarks in scaling solar and wind; China, the United States of America, Brazil, India, and Germany together account for over 60% of installed renewable capacity; and several nations, including Greece and the United Kingdom, are phasing out coal faster than needed to stay within 1.5°C targets.[3] The electricity sector's biggest mitigation potential comes from solar and wind, with full deployment capable of cutting energy-sector emissions by 65% by 2030 and 76% by 2035 compared to current trajectories.[4]

Pursuant to Article 4(2) of the Paris Agreement, Malaysia has pledged to reduce its GHG emissions intensity per GDP by 45% by 2030 as compared to its 2005 levels, with 35% being unconditional and the remaining 10% contingent on support from

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* LL.B (Hons) (Universiti Malaya), LL.M (Universiti Malaya), Ph.D (Universiti Malaya). Senior Lecturer, Faculty of Law, Universiti Malaya. Advocate & Solicitor, High Court in Malaya (non-practicing). The author can be contacted at <sheila.lingam@um.edu.my>

1 World Economic Forum, *Global Risks Report 2025* (Report, 2025) <https://reports.weforum.org/docs/WEF_Global_Risks_Report_2025.pdf>.

2 See United Nations Environment Programme, *Emissions Gap Report 2024* (Report, 2024) 49–52 <https://www.unep.org/resources/emissions-gap-report-2024>. See also the Intergovernmental Panel on Climate Change, *Sixth Assessment Report – Chapter 6: Energy Systems* (Report, 2022) 672, 681, 688–92 <https://www.ipcc.ch/report/ar6/wg3/chapter/chapter-6/>.

3 *Emissions Gap Report 2024* (n 2).

4 Ibid.

developed countries.[5] Malaysia has also pledged to achieve net-zero GHG emissions by 2050.[6] However, Malaysia ranks low overall in the Climate Change Performance Index (CCPI) 2025, with medium performance in GHG emissions but low to very low scores for renewable energy, energy use, and climate policy. Weaknesses are particularly evident in the transport sector, where petrol subsidies persist despite some reforms, and in land governance, where rising deforestation is compounded by state-level control over forest use, often exercised with limited transparency or public consultation.[7]

This article argues that the central challenge in Malaysia's energy transition does not lie in the absence of laws or policy frameworks, but in their structural and operational limitations. While Malaysia has developed an extensive suite of energy and climate-related instruments, these remain fragmented, inconsistently implemented, and insufficiently aligned with long-term decarbonisation goals. In particular, gaps persist in the coherence of legal mandates, the enforceability of renewable energy obligations, and the integration of climate considerations across sectoral policies. As a result, existing frameworks have been unable to effectively displace fossil fuel dependence or catalyse large-scale renewable energy adoption. This article, therefore, advances the claim that meaningful progress towards net-zero requires not merely additional policies, but a reconfiguration of Malaysia's legal and institutional architecture to ensure accountability, coordination, and enforceable transition pathways.

II MALAYSIA'S CURRENT ENERGY LANDSCAPE

A. *Overview*

Malaysia predominantly relies on coal and natural gas as its main source of electricity supply. Figure 1 demonstrates the continued dominance of coal and natural gas in electricity generation, reflecting historical policy preferences for centralised, fuel-based power generation supported by long-term supply arrangements and regulated tariffs.

[5] Ministry of Foreign Affairs (Malaysia), 'Malaysia Upholds That Access to Clean, Healthy and Sustainable Environment Is a Human Right' (Press Release, 12 October 2021) <https://www.kln.gov.my/web/guest/-/malaysia-upholds-that-access-to-clean-healthy-and-sustainable-environment-is-a-human-rig-1>.

[6] Ministry of Economy (Malaysia), *National Energy Transition Roadmap* (Report, 2023) 6 <https://ekonomi.gov.my/sites/default/files/2023-08/National%20Energy%20Transition%20Roadmap.pdf>.

[7] Climate Change Performance Index, *Malaysia – Climate Performance Ranking 2025* (Web Page) <https://ccpi.org/country/mys/>.

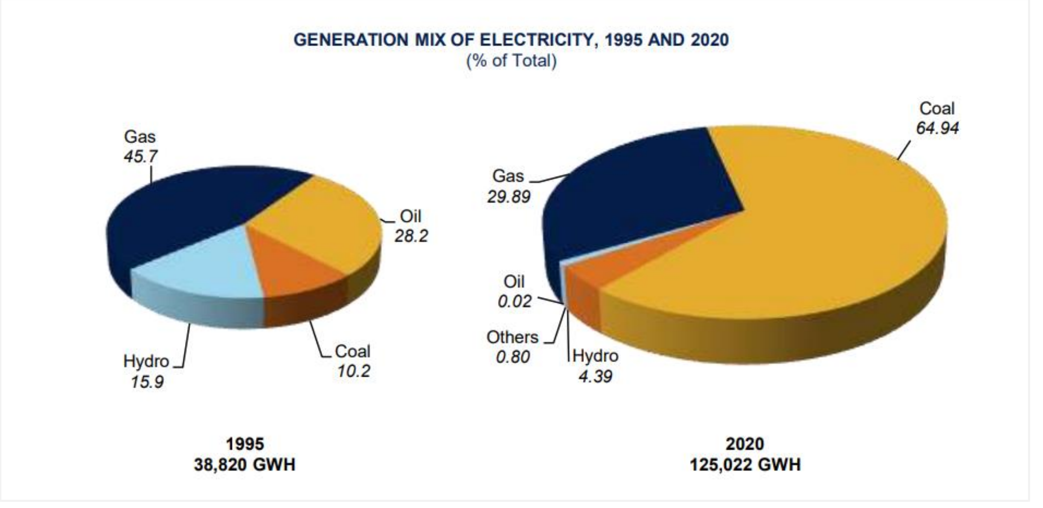

Figure 1: Sources of Electricity in Malaysia
Source: Economic Planning Unit at www.epu.gov.my

Figure 2 reinforces this trend over time, showing the limited penetration of renewable energy despite existing policy instruments, suggesting that current regulatory mechanisms have been insufficient to displace fossil fuel-based generation.

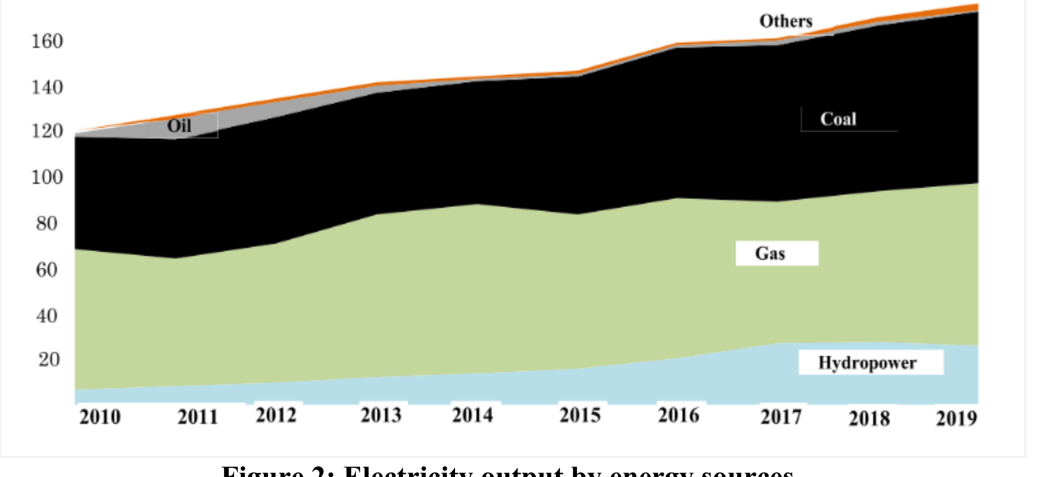

Figure 2: Electricity output by energy sources
Source: NHM Salleh, F Chatri and L Huixin, 'Economic and Environmental Analysis of Malaysia's 2025 Renewable and Sustainable Energy Targets in the Generation Mix' (2024) 10(9) *Heliyon* 6.

Figure 3 highlights the electricity sector as the largest contributor to overall carbon emissions, which shows an upward trend. This is followed by the transport sector. The figure is illustrative of how energy-related legal and policy choices directly shape Malaysia's emissions profile.

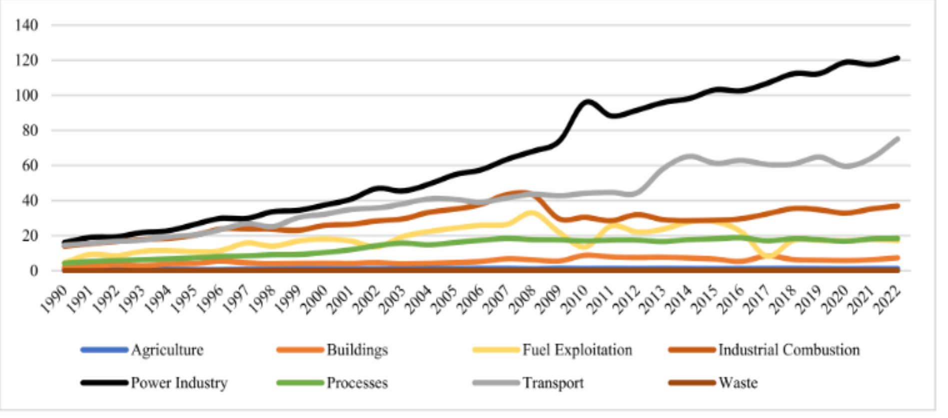

Figure 3: Malaysia's CO_2 emissions by sector (Mt)
Source: NHM Salleh, F Chatri and L Huixin, 'Economic and Environmental Analysis of Malaysia's 2025 Renewable and Sustainable Energy Targets in the Generation Mix' (2024) 10(9) *Heliyon* 6.

Figure 4 illustrates that fossil fuel dependence extends beyond electricity into the broader energy system, reflecting regulatory and subsidy structures that continue to favour petroleum and natural gas in national energy planning.

Year	Primary Energy Supply Breakdown (ktoe)				
	Natural Gas	Crude Oil and Petroleum Products	Coal and Coke	Renewable Energy	Total
2005	33,913	24,096	6,889	446	65,344
2015	41,853	29,165	17,406	2,017	90,441
2016	41,257	31,327	18,744	2,420	93,748
2017	41,200	29,380	20,771	2,994	94,345
2018	40,939	29,429	22,280	3,261	95,909
2019	41,461	32,813	21,057	3,349	98,680

Figure 4: Primary energy supply breakdown in Malaysia
Source: Malaysia's Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change submitted in December 2022

Figure 5 shows that final energy consumption remains concentrated in fossil fuel-intensive sectors such as transport and industry, where regulatory reforms and incentives for cleaner alternatives have been comparatively limited.

Year	Final Energy Consumption (ktoe)					
	Transport	Industry	Residential and Commercial	Non-energy use	Agriculture	Total
2005	15,293	15,583	5,134	2,173	101	38,284
2015	23,435	13,971	7,600	5,928	895	51,829
2016	24,004	16,019	8,051	8,729	415	57,218
2017	24,039	17,463	7,796	12,517	674	62,489
2018	23,555	19,046	7,773	13,262	1,021	64,657
2019	25,004	18,921	8,000	13,631	927	66,483

Figure 5: Energy consumption by sectors in Malaysia
Source: Malaysia's Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change submitted in December 2022

Figures 1 to 5 illustrate a consistent structural pattern: Malaysia's energy system remains deeply anchored in fossil fuels across both electricity generation and overall energy consumption. Coal and natural gas dominate the electricity mix, while petroleum and gas continue to underpin primary energy supply and end-use consumption, particularly in the transport and industrial sectors. This entrenched reliance is not merely a matter of resource availability or market forces, but is reinforced by the existing legal and regulatory framework. Longstanding policies such as fuel subsidies, centralised generation models, and grid access arrangements have historically prioritised conventional energy sources, while renewable energy mechanisms, while present, remain limited in scope and enforceability. As a result, the legal framework has functioned less as a driver of transition and more as a stabiliser of fossil fuel dependence, constraining the pace and scale of renewable energy deployment.

B. *Laws and Policies*

Malaysia has recognised the urgency of addressing climate change and is responding by putting in place a comprehensive framework of laws and policies that target the energy sector, undoubtedly one of the country's largest sources of GHG emissions. These measures aim to drive the transition toward renewable energy, enhance energy efficiency, modernise infrastructure, and ensure a just and sustainable shift to a low-carbon economy. The current laws and policies are summarised in Table 1.

Table 1: Current energy-related laws and policies in Malaysia

Law/Policy	Category	Short Description
National Energy Policy (DTN) 2022-2040	Energy (Overarching)	Long-term vision for sustainable energy, balancing economic growth, social equality, energy security, and environmental sustainability through four thrusts. Aligns with Malaysia's Shared Prosperity Vision 2030, SDGs, and net-zero 2050.

Low Carbon Aspiration 2040 (under DTN)	Energy (Strategy)	Sets sectoral low-carbon targets: higher public transport share, EV adoption, low-carbon fuels, efficiency in all sectors, and higher renewable energy (RE') penetration.
National Energy Transition Roadmap (NETR)	Energy Transition	Roadmap to shift from fossil fuels to a green economy, with two phases; supported by Hydrogen, Natural Gas, and Carbon Pricing sub-roadmaps.
Responsible Transition Pathway 2050 (RT Pathway)	Energy Transition	Sub-framework under NETR; balances energy trilemma. Targets phasing out coal, expanding RE, efficiency, and electrification/biofuels in transport.
National Renewable Energy Policy	Renewables	Expands RE in the power mix through Net Energy Metering, Solar Leasing, Large Scale Solar (LSS3), and Non-Solar RE initiatives.
Renewable Energy Act 2011 (Act 725)	Renewables	Establishes regulatory framework for RE, introduces Feed-in Tariff (FiT) system, and incentivises RE investment.
National Biofuel Policy	Renewables/Transport	Mandates palm biodiesel blending (B5–B30 by 2030) for transport and industrial sectors.
National Energy Efficiency Action Plan (NEEAP)	Efficiency	Aims to save 52,233 GWh (2016–2025) via 5-Star appliances, MEPS, energy audits, co-generation, and efficient building design.
Energy Efficiency and Conservation Act (EECA) 2024 (Act 861)	Efficiency	Replaces the Efficient Management of Electrical Energy Regulations (EMEER) 2008 under the Electricity Supply Act 1990 (Act 447). Requires Registered Energy Managers, audits, reporting, and energy management systems; supports carbon neutrality 2050.
National Transport Policy (NTP) 2019–2030	Transport	Provides sustainable transport strategy; promotes energy-efficient vehicles, public transport modal shift, and GHG reductions.
Low Carbon Mobility Blueprint (LCMB)	Transport	Targets reduced transport emissions via electrification, fuel alternatives, efficiency, and EV expansion (10,000 charging points by 2025).
Climate Change Bill (proposed)	Climate Governance	Creates legal framework for climate governance, with national GHG reduction targets to guide Malaysia's transition.
Carbon Capture, Utilization and Storage (CCUS) Act	Climate Governance/Industry	First legal framework for CCUS; establishes national agency, regulates capture/storage, ensures transparency

2025 (Act 870)		and safety; fosters new green industry.
Sarawak Environment (Reduction of GHG Emission) Ordinance 2023	State-level	Sarawak law targeting net zero by 2050; regulates reduction, capture, and storage of GHGs; complements carbon storage and forest carbon rules.

While Table 1 illustrates the breadth of Malaysia's energy-related legal and policy instruments, this multiplicity does not necessarily translate into coherence or effectiveness. Rather than undertaking a provision-by-provision doctrinal analysis of each instrument, this article adopts a structural perspective to examine how these frameworks operate collectively. Despite their apparent comprehensiveness, many of these laws and policies are sector-specific, loosely coordinated, and uneven in their enforceability, resulting in a fragmented regulatory landscape. This fragmentation limits their capacity to function as a unified legal driver of renewable energy transition. As will be explored in Part III, these structural weaknesses manifest in practical barriers to renewable energy deployment, including financing constraints, regulatory uncertainty, and continued fossil fuel dominance.

III. RENEWABLE ENERGY ('RE')

A. *Overview*

The total installed RE capacity in Malaysia was around 9.8 GW in 2021, dominated by hydropower and followed by solar power.[8] However, large hydropower projects are no longer counted as RE due to their adverse environmental and social impacts, financial risks, sedimentation and resettlement issues.

A poignant example of such a project is the Bakun Dam Project. The Bakun Dam, one of Southeast Asia's most ambitious megaprojects, has been plagued by overlapping technical, economic, political, social, legal, and environmental challenges since its inception.[9] Technically, the project struggled with Sarawak's heavy rainfall,

8 Masoud Yahoo et al, 'Economic and Environmental Analysis of Malaysia's 2025 Renewable and Sustainable Energy Targets in the Generation Mix' (2024) 10(9) *Heliyon* e30157:1–15, 14–15.

9 Benjamin K Sovacool and LC Bulan, 'Behind an Ambitious Megaproject in Asia: The History and Implications of the Bakun Hydroelectric Dam in Borneo' (2011) 39(9) *Energy Policy* 4842-4859; Hydropower Sustainability Alliance, *The Bakun Hydroelectric Project Sustainability Assessment Report* (Report, August 2025) <https://www.hs-alliance.org/published-assessments/bakun>; Bruno Manser Fonds, *Slow Down the River – How Sarawak Dam Plans Compromise the Future of Malaysia's Indigenous Peoples* (Report, November 2012) <https://www.stop-corruption-dams.org/resources/Sold_down_the_river_BMF_dams_report.pdf>; Benjamin K Sovacool and LC Bulan, 'Meeting Targets, Missing People: The Energy Security Implications of the Sarawak Corridor of Renewable Energy (SCORE)' (2011) 33(1) *Contemporary Southeast Asia* 56-82; Ming Chee Ang and Ashok Swain,

high sedimentation rates, lack of supporting infrastructure, and complex excavation demands, all of which drove up costs and delayed completion.[10] Economically, financing relied heavily on public funds, cost overruns reached as high as 600%, and power purchase agreements proved difficult to settle.[11] Despite its 2,400 MW capacity, the dam has failed to secure reliable buyers: the proposed undersea cable to Peninsular Malaysia was cancelled, and an investor, Rio Tinto, withdrew from building an aluminium smelter, leaving Sarawak with surplus energy and limited outlets for distribution.[12]

The project's human and environmental consequences have been equally severe. Around 10,000 people were forcibly relocated to Sungai Asap, where inadequate land, lack of livelihoods, and the loss of access to the rainforest devastated community resilience.[13] Some resisted relocation, choosing instead to live in precarious floating houses on the reservoir. Communities downstream also faced declining fisheries, degraded water quality, and heightened fears of dam failure.[14] The environmental costs include mass deforestation, biodiversity loss, and significant GHG emissions from decomposing biomass, compounding global climate concerns.[15] Meanwhile, reports of watered-down concrete, poor safety standards, and construction-related deaths raised questions about the dam's structural integrity.[16]

Underlying these failures were systemic governance issues, including corruption, nepotism, opaque tendering processes, and a lack of genuine public participation in environmental and social assessments.[17] Indigenous peoples were excluded from decision-making and political representation, while protests were suppressed through

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'Political Structure and Dam Conflicts: Comparing Cases in Southeast Asia' in *World Water Council 4th World Water Forum* (World Water Council, 2004) 95-114.

10 Ibid.

11 Ibid.

12 Ibid.

13 Jacqueline K Carino, 'The Resettlement of Indigenous Peoples Affected by the Bakun Hydro-electric Project in Sarawak' (1999) (3–4) *Indigenous Affairs* 90-101. See also *Ketua Pengarah Jabatan Alam Sekitar v Kajing Tubek* [1997] 4 CLJ 253 (Court of Appeal of Malaysia).

14 Ibid.

15 Ibid.

16 Benjamin K Sovacool and LC Bulan, 'Behind an Ambitious Megaproject in Asia: The History and Implications of the Bakun Hydroelectric Dam in Borneo' (2011) 39(9) *Energy Policy* 4842-4859; Hydropower Sustainability Alliance, *The Bakun Hydroelectric Project Sustainability Assessment Report* (Report, August 2025) <https://www.hs-alliance.org/published-assessments/bakun>; Bruno Manser Fonds, *Slow Down the River – How Sarawak Dam Plans Compromise the Future of Malaysia's Indigenous Peoples* (Report, November 2012) <https://www.stop-corruption-dams.org/resources/Sold_down_the_river_BMF_dams_report.pdf>; Benjamin K Sovacool and LC Bulan, 'Meeting Targets, Missing People: The Energy Security Implications of the Sarawak Corridor of Renewable Energy (SCORE)' (2011) 33(1) *Contemporary Southeast Asia* 56-82; Ming Chee Ang and Ashok Swain, 'Political Structure and Dam Conflicts: Comparing Cases in Southeast Asia' in *World Water Council 4th World Water Forum* (World Water Council, 2004) 95-114.

17 Ibid.

intimidation, violence, and restrictive laws.[18] Critics argue that the Bakun project was less about meeting energy needs than about political and corporate gain, with local communities bearing the brunt of its risks and losses while receiving little benefit.[19] In hindsight, alternative investments such as solar power or sustainable forest industries could have generated greater long-term value for Sarawak without the immense social and environmental toll.

B. *The Renewable Energy Act 2011 (Act 725)*

This Act provides for the establishment and implementation of the Feed-in Tariff system ('FiT') to catalyse the generation of RE.[20] FiT is a policy mechanism designed to accelerate investment in RE technologies by offering long-term contracts to RE producers, whereby electricity generated from renewable sources is sold to a utility or transmission system operator at a fixed price.[21] This creates certainty for investors and encourages greater participation in the RE sector. In Malaysia, the FiT framework requires Distribution Licensees (DLs) to purchase electricity produced by Feed-in Approval Holders (FIAHs) using renewable resources. The electricity supplied to the national grid is paid for at a predetermined FiT rate, and for a specified duration.[22] Thus, the FiT system provides a clear buy-back mechanism that allows locally produced electricity to be sold to power utilities at a fixed premium over a specific period, which could spur investment in RE.

The Act also established the Renewable Energy Fund[23], which comprises a 1% surcharge collected from electricity consumers, funding from the Treasury and interest from fund investments. This is established mainly on the polluter-pays principle, which rationalises consumers' duty to contribute to the fund through electricity bills, since GHG emissions are predominantly caused by electricity generation.[24]

The Sustainable Energy Development Authority ('SEDA') was then formed to provide impetus for greater use of RE in electricity generation, including promoting and implementing national policy objectives for RE, encouraging private-sector investment, and managing the FiT system.[25] According to SEDA, four resources are

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18 Ibid.

19 Ibid.

20 See *Renewable Energy Act 2011* (Act 725) (Malaysia), long title.

21 Siti Masyita Noraziman et al, 'Renewable Energy Support Policy in Malaysia: A Comparative Analysis with Two Successful Countries' (Conference Paper, 1st GCC International Conference on Industrial Engineering and Operations Management, Riyadh, Saudi Arabia, 26–28 November 2019).

22 Ibid.

23 See generally, *Renewable Energy Act 2011*(Act 725) (Malaysia) pt V.

24 CL Tan, 'Paying for Clean Power', *The Star Online* (online, 24 February 2014) <https://www.thestar.com.my/news/environment/2014/02/24/paying-for-clean-power/>.

25 The Sustainable Energy Development Authority (SEDA) Malaysia is a statutory body formed under the *Sustainable Energy Development Authority Act 2011* (Act 726) (Malaysia). The key role of SEDA is to administer and manage the implementation of the feed-in tariff mechanism which is mandated under the *Renewable Energy Act 2011* (Act 725) (Malaysia).

currently eligible under the FiT system: biomass, biogas, small hydro, and solar photovoltaic.[26]

Other technologies, such as wind, geothermal, and tidal power, have yet to be fully assessed in terms of their potential within Malaysia. These may eventually become eligible for tariff support once sufficient data on their resource availability is available. For biomass specifically, further categorisation may be required to ensure that only sustainable forms are utilised, thereby preventing overexploitation of resources.[27]

However, it should be noted that SEDA's role under the FiT framework was not to spearhead RE development directly, but rather to act as a coordinating body. The Act primarily mandates SEDA to administer and implement the feed-in tariff (FiT) mechanism, including processing applications, managing the Renewable Energy Fund, and advising the Government on renewable energy matters. While these functions are important, they position SEDA largely as a regulatory and coordinating body rather than as a driver of technological innovation or long-term energy planning. The absence of an explicit statutory mandate to undertake research, develop renewable energy projects, or direct market transformation limits SEDA's ability to proactively shape the growth of the sector. As a result, its current role may inadvertently constrain the pace of renewable energy development, particularly in a context where stronger institutional leadership and innovation are required to overcome entrenched fossil fuel dependence.[28]

C. *Potential RE in Malaysia*

1 *Solar Energy*

In Malaysia, the government has introduced a mix of financial and non-financial policies to promote solar energy, including the Large Scale Solar Programme (LSS3), Net Energy Metering 3.0 (NEM 3.0), and the Green Incentive Tax Allowance (GITA) Project. The Kuala Ketil Solar Farm in Kedah, developed by Edra Solar Sdn Bhd, is a 50 MWac ground-mounted solar photovoltaic (PV) project spanning approximately 260 acres.[29] Commissioned in February 2019, the farm generates an estimated 78,400 MWh of electricity annually, contributing significantly to Malaysia's RE capacity.[30]

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26 Sustainable Energy Development Authority Malaysia, 'Feed-in Tariff (FIT)', *Renewable Energy Malaysia* (Web Page) <https://www.seda.gov.my/reportal/fit/>.

27 Siti Masyita Noraziman et al, 'Renewable Energy Support Policy in Malaysia: A Comparative Analysis with Two Successful Countries' (Conference Paper, 1st GCC International Conference on Industrial Engineering and Operations Management, Riyadh, Saudi Arabia, 26–28 November 2019).

28 Ibid.

29 Mohd Noor Aswad, 'Shining Example: Kedah Launches Photovoltaic Solar Farm', *New Straits Times* (online, 8 September 2019) <https://www.nst.com.my/news/nation/2019/09/519689/shining-example-kedah-launches-photovoltaic-solar-farm>.

30 'Power Plant Profile: TNB-Kedah Solar PV Park, Malaysia', *Power Technology* (Web Page, 21 October 2024) <https://www.power-technology.com/marketdata/power-plant-profile-tnb-kedah-solar-pv-park-malaysia/>.

The project reduces around 36,000 tonnes of CO_2 emissions each year and produces enough electricity to power about 30,000 homes over its 25-year lifespan.

While these initiatives mark progress, gaps remain, particularly in high initial investment costs. An example is a large solar farm in Melaka, which generates positive financial returns under the FiT system, but incurred significant upfront investment compared to similar projects abroad.[31] Additional incentives, such as credits for reducing GHG emissions, could improve financial performance, though they would need to be significant to make a real difference.[32] By contrast, Germany's solar projects benefit from much lower installation costs and a supportive FiT framework. A comparable solar farm in Leipzig required a far smaller initial outlay yet delivered stronger financial results, highlighting how policy design and lower capital costs are critical in making solar energy financially attractive.[33] Table 2 is a summary of the comparisons between solar projects in Malaysia and Germany.

Table 2: Malaysia vs Germany solar photovoltaic (PV) project comparison[34]

Feature	Malaysia (Melaka)	Germany (Leipzig)
Plant Type	Solar PV farm	Solar PV farm
Capacity (MW)	7 MW	5 MW
Modules	29,092 Yingli monocrystalline panels, 30° tilt	50,000 Shell PV modules, 30° tilt
Total Cost	~84 million MYR	~5.17 million Euro
Project Life	21 years	20 years
FiT Rate	0.5041 MYR/kWh	0.457 Euro/kWh
Incentives	FiT is the primary policy lever	FiT plus lower capital costs
O&M Savings	90 MYR	75 Euro
Financials	Positive NPV but high upfront cost, weaker than Germany	Higher NPV and stronger returns
Policy Notes	FiT applied; high cost makes projects less attractive	Lower installation costs and FiT drive success

Vietnam's solar energy expansion between 2018-2020 is a striking example of how far ambitious policy and incentives can drive change. In 2018, Vietnam had very little

31 Siti Masyita Noraziman et al, 'Renewable Energy Support Policy in Malaysia: A Comparative Analysis with Two Successful Countries' (Conference Paper, 1st GCC International Conference on Industrial Engineering and Operations Management, Riyadh, Saudi Arabia, 26–28 November 2019).

32 Ibid.

33 Ibid.

34 The data in this table is adapted from Siti Masyita Noraziman et al, 'Renewable Energy Support Policy in Malaysia: A Comparative Analysis with Two Successful Countries' (Conference Paper, 1st GCC International Conference on Industrial Engineering and Operations Management, Riyadh, Saudi Arabia, 26–28 November 2019).

solar capacity (just tens of megawatts), but by the end of 2020, it had installed about 16,500 MW of solar photovoltaic (PV) capacity.[35] This ran far ahead of its earlier 2020 target (about 850 MW) and reflected a sharp scaling up enabled by feed-in tariffs, tax incentives, land-lease exemptions, and strong investor confidence.[36] Key to Vietnam's success were enabling policy features: attractive economics (high enough tariffs for developers over long periods), streamlined licensing and land permissions, and strong regulatory signals, coupled with public demand for cleaner air and energy security.[37] For Malaysia, the Vietnam case suggests that increasing the predictability of policy, improving permit and land-use processes, and offering financial incentives aligned with stakeholder expectations could accelerate its own transition.

It should also be noted that while solar power is often promoted as an infinite clean energy source, its expansion carries significant hidden costs. Large-scale projects in rural areas risk displacing communities, inflating land prices, and even driving deforestation under the banner of sustainability. Malaysia's tropical climate presents further challenges: solar output is intermittent, installation in remote areas is costly, and panels suffer reduced lifespans due to heavy rainfall and cloudy conditions.[38] The technology itself remains resource-intensive, with expensive production processes and serious end-of-life disposal issues, as solar panels contain toxic materials such as lead and cadmium.[39] Moreover, the batteries required to store solar energy rely on rare minerals mined through environmentally damaging and socially exploitative practices, raising concerns that future sourcing, including deep-sea mining, could create new ecological hazards.[40]

2 *Hydropower*

Hydropower forms a key part of Malaysia's low-carbon electricity mix, contributing about 16-17% of the country's generation as of 2024, with major capacity concentrated in the state of Sarawak.[41] One of the largest projects is the Bakun Hydroelectric Dam, boasting a 2,400 MW capacity, which is central to Sarawak's RE ambitions and plays a critical role in supplying power for both local demand and energy-intensive industry.[42] Building on this foundation, Sarawak has begun exporting

35 Thang Nam Do and Paul J Burke, 'Vietnam's Solar Power Boom: Policy Implications for ASEAN', *UOB ASEAN Insights* (Web Page, 22 March 2021) <https://www.uobgroup.com/asean-insights/articles/vietnam-solar-power-boom.page>.

36 Ibid.

37 Ibid.

38 Serina Rahman, *Renewable Energy: Malaysia's Climate Change Solution or Placebo?* (ISEAS–Yusof Ishak Institute, 2020).

39 Ibid.

40 Ibid.

41 See 'Malaysia', *Low Carbon Power*, (Web Page) <https://lowcarbonpower.org/region/Malaysia>.

42 Alvin Tang, 'Floating Solar Farm Project at Sarawak's Bakun Dam in the Pipeline', *The Star* (online, 16 June 2025) <https://www.thestar.com.my/business/business-news/2025/06/16/floating-solar-farm-project-at-sarawaks-bakun-damin-the-pipeline>.

electricity. Since 2016, it has been sending power to West Kalimantan in Indonesia, and it is also preparing infrastructure to export 30-50 MW of RE to Sabah by the end of 2025.[43]

3 *Biogas*

Biogas in Malaysia primarily comes from palm oil mill effluent (POME), a by-product of the palm oil industry, as well as landfill gas.[44] The government has promoted biogas under the National Renewable Energy Policy and the Feed-in Tariff (FiT) scheme managed by the Sustainable Energy Development Authority (SEDA). By 2023, Malaysia had around 150-200 operational biogas plants, mostly linked to palm oil mills, with more in development.[45] However, only a fraction are grid-connected due to the cost of upgrading and the distance to transmission infrastructure. Biogas contributed less than 1% of total electricity generation in Malaysia, though its potential is estimated at several thousand gigawatt-hours annually if more plants were grid-linked.[46]

Biogas development in Malaysia faces several structural and technical hurdles despite its potential as a RE source. The government has targeted diverting 40% of food waste from landfills to energy generation, but the lack of waste sorting at source makes this goal difficult to achieve.[47] Compounding the challenge, many biogas plants are located far from urban centres where the bulk of waste is generated, reducing the projects' financial viability.[48] Plants linked to palm oil mills or landfills are only considered feasible if located within 10 kilometres of the electricity grid, limiting scalability. Moreover, upgrading biogas to the purity levels required for injection into the national gas grid incurs high costs, as it demands advanced refining processes and modifications to gas infrastructure such as storage tanks and filling stations.[49] There are also health and consistency concerns: pyrolysis must be carefully managed to avoid hazards from human waste, and the energy potential of such feedstock is highly variable, depending on factors like diet and seasonal consumption patterns.[50]

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43 'S'wak Power Capacity Exceeds Demand', *The Star* (online, 27 May 2025) <https://www.thestar.com.my/news/nation/2025/05/27/swak-power-capacity-exceeds-demand>.

44 Yik Fu Lim et al, 'Review of Biowastes to Energy in Malaysia: Current Technology, Scalability and Socioeconomic Analysis' (2021) 4 *Cleaner Engineering and Technology* 100257.

45 See Sustainable Energy Development Authority, *Malaysia Renewable Energy Roadmap* (Report, 2021) <https://www.seda.gov.my/reportal/wp-content/uploads/2021/12/MyRER_webVer-1.pdf>.

46 Ibid.

47 Ibid.

48 Serina Rahman, *Renewable Energy: Malaysia's Climate Change Solution or Placebo?* (ISEAS–Yusof Ishak Institute, 2020) 17.

49 Ibid.

50 Ibid.

4 *Biomass*

Biomass energy in Malaysia has been supported by a range of environmental policies introduced over the past two decades. The Fifth Fuel Policy (5FP2000), launched in 2000, officially integrated RE as the eighth fuel under the Eighth Malaysia Plan (2001–2005). To complement this, the Small Renewable Energy Power (SREP) Program was introduced in 2001, encouraging small generators to produce renewable electricity and sell it to utilities. Incentives such as the Investment Tax Allowance and Pioneer Status further promoted RE adoption under SREP. The National Biofuel Policy (NBP 2006) marked a strategic step in embedding biofuels into the transportation, industrial, and export sectors, driving Malaysia's biodiesel industry by mandating palm oil-petroleum diesel blends. Subsequent Malaysia Plans (9MP, 10MP, and 11MP from 2006-2020) also emphasised bioenergy as a recurring development target.

Later, the Renewable Energy Act 2011 and the Sustainable Energy Development Authority (SEDA) Act 2011 established the feed-in tariff (FiT) system and created SEDA to oversee its implementation. The National Biomass Strategy 2020, also introduced in 2011, outlined a roadmap to transform biomass resources into high-value downstream technologies that could boost economic growth, create skilled jobs, and reduce carbon emissions. Biomass remains the largest renewable resource in Malaysia, with an estimated 19,000 MW potential, more than 85% of which comes from palm oil residues.[51]

Despite these frameworks, biomass energy development in Malaysia faces significant challenges. As of 2020, only about 800 MW of biomass capacity had been installed,[52] contributing roughly 14% of the RE mix but less than 3% of national electricity generation.[53] In Malaysia, a proposed biomass project in Kluang shows promise but comes with significant financial hurdles. Although the project benefits from the feed-in tariff (FiT) and certain tax exemptions, no direct grants or incentives are provided.[54] This results in a much higher upfront cost and a longer time before investors can recover their capital, making the project less appealing compared to international benchmarks.[55]

In Sweden, for example, a similar biomass project in Karlstad required a far smaller investment and enjoyed substantial government support through grants. These incentives, combined with Sweden's long-standing carbon pricing policy, led to

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51 Agensi Inovasi Malaysia, *National Biomass Strategy 2020* (Report, 2013) <https://faolex.fao.org/docs/pdf/mal228571.pdf>.

52 Sustainable Energy Development Authority Malaysia, 'Feed-in Tariff (FIT)', *Renewable Energy Malaysia* (Web Page) <https://www.seda.gov.my/reportal/fit/>.

53 Ibid.

54 Siti Masyita Noraziman et al, 'Renewable Energy Support Policy in Malaysia: A Comparative Analysis with Two Successful Countries' (Conference Paper, 1st GCC International Conference on Industrial Engineering and Operations Management, Riyadh, Saudi Arabia, 26–28 November 2019).

55 Ibid.

immediate payback and stronger overall financial performance.[56] Table 3 is a summary of the comparisons between the project in Kluang, Malaysia and the project in Karlstad, Sweden.

Table 3: Malaysia vs Sweden biomass project comparison[57]

Feature	Malaysia (Kluang)	Sweden (Karlstad)
Plant Type	Biomass CHP	Biomass CHP
Capacity (MW)	12.5 electricity, 10 heating	11.7 electricity, 33.4 heating
Total Cost	~88 million MYR	~14 million Euro (~68 million MYR)
Project Life	16 years	20 years
Debt Terms	10 years, 70% debt, 8% interest	10 years, 70% debt, 7% interest
Incentives	FiT 0.3868 MYR/kWh; tax exemptions	Grant ~4 million Euro (~28% of cost)
Simple Payback	~2.9 years	Immediate (0 years)
NPV Performance	Positive, but lower than Sweden	Higher NPV, strong returns
Policy Notes	No direct grants; FiT applies	Carbon pricing since 1991; strong incentives

Technical barriers include limited local expertise and reliance on costly imported technologies, while financial barriers involve high capital expenditure, investor hesitancy, limited financing schemes, and competition from subsidized fossil fuels.[58] Social barriers such as low market acceptance and political resistance further slow progress.[59] Environmental concerns are also critical; expanding bioenergy plantations risks land conversion, food security issues, deforestation, biodiversity loss, and changes in carbon storage.[60] Ensuring sustainability is another hurdle, as feedstock supply remains inconsistent. Institutional weaknesses, including poor policy execution and fragmented coordination among stakeholders, compound these difficulties.[61]

56 Ibid.

57 The data in the table is adapted from Siti Masyita Noraziman et al, 'Renewable Energy Support Policy in Malaysia: A Comparative Analysis with Two Successful Countries' (Conference Paper, 1st GCC International Conference on Industrial Engineering and Operations Management, Riyadh, Saudi Arabia, 26–28 November 2019).

58 Nor Adilla Rashidi, Yee Ho Chai and Suzana Yusup, 'Biomass Energy in Malaysia: Current Scenario, Policies, and Implementation Challenges' (2022) 15(3) *Bioenergy Research* 1371, 1371-1386.

59 Ibid.

60 Ibid.

61 Ibid.

On the operational side, biomass has practical limitations. When used for co-firing in conventional power plants, it can corrode boilers, lower efficiency, and increase fly ash production.[62] The reliability of biomass fuel is also uncertain, as mill by-products are often diverted for other uses like fibreboard, pulp and paper, mulching, or fertiliser, making a consistent supply to power generation difficult.[63] High generation costs relative to conventional energy further discourage millers from participation. Lastly, sustainability must be measured holistically, accounting for emissions from transportation and processing to ensure that biomass delivers genuine environmental benefits rather than simply economic gains.[64]

5 *Nuclear energy*

At the international level, Malaysia's potential deployment of nuclear energy would need to align with key legal instruments such as the Treaty on the Non-Proliferation of Nuclear Weapons, the Convention on Nuclear Safety, and relevant safeguards agreements administered by the International Atomic Energy Agency. Domestically, the Atomic Energy Licensing Act 1984 provides the principal regulatory framework governing nuclear activities, including licensing, radiation protection, and enforcement. However, the Act was not originally designed to regulate large-scale nuclear power generation, and questions remain as to whether it provides a sufficiently comprehensive and independent framework for reactor oversight, particularly in relation to safety governance, emergency preparedness, and regulatory autonomy. These gaps suggest that significant legal and institutional reforms would be required before nuclear energy can be safely and effectively integrated into Malaysia's energy mix.

Malaysia's engagement with nuclear energy has been cautious and contested. The Atomic Energy Licensing Board[65] was established in 1985, and later, in 1994, the Malaysian Institute for Nuclear Technology Research was created under the Ministry of Science, Technology and Innovation (MOSTI), later renamed Nuclear Malaysia in 2006.[66] Its role has largely been research, technology transfer, and managing nuclear-related affairs rather than pursuing large-scale power generation. Political opposition kept nuclear power off the agenda for decades, though attitudes shifted somewhat after 2003.[67] In 2010, the government introduced a national nuclear policy and set up the Malaysian Nuclear Power Corporation to explore the possibility of nuclear plants.[68]

Despite these steps, nuclear energy has faced strong criticism. The risks of radiation exposure, accidents, and long-lasting radioactive waste have raised public

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62 Serina Rahman, *Renewable Energy: Malaysia's Climate Change Solution or Placebo?* (ISEAS–Yusof Ishak Institute, 2020) 17–18.

63 Ibid.

64 Ibid.

65 Established under the *Atomic Energy Licensing Act 1984* (Act 304) (Malaysia).

66 Farahdilah Ghazali et al, 'Legal Perspectives on Nuclear Energy and Sustainable Development in Malaysia' (2020) 5(1) *Journal of Nusantara Studies* 169, 176-177.

67 Ibid.

68 Ibid.

health and safety concerns. Communities near nuclear plants are at greater risk of cancer and genetic damage, while nuclear waste remains hazardous for thousands of years with no proven safe disposal method.[69] Nuclear facilities are also vulnerable to natural disasters, human error, and potential sabotage, making them highly controversial in terms of safety and security.[70]

The economic arguments are equally challenging. Nuclear power requires a very high upfront investment, long construction timelines, and often exceeds its projected costs. Post-Fukushima safety upgrades and stricter regulations have only added to this financial burden.[71] Financing is especially sensitive to interest rates, and projects typically require government guarantees, placing heavy risks on public finances.[72]

For Malaysia, the hurdles remain steep. Nuclear projects would lock the country into foreign technology, imported fuel supplies, and long-term liabilities, reducing rather than enhancing energy security.[73] Moreover, deployment would depend on meeting four critical enablers: public acceptance, adherence to international treaties, an independent and robust regulatory framework, and the consent of local communities where reactors might be built.[74] Until these challenges are resolved, nuclear power remains an expensive, risky diversion from Malaysia's transition toward cleaner and more sustainable energy sources.

Be that as it may, the 13th Malaysia Plan (2026-2030) outlines the introduction of nuclear energy as part of Malaysia's clean electricity mix. Nuclear power is projected to enter the national grid by 2031, providing a low-carbon and reliable source of energy. The initiative will be spearheaded by MyPower Corp, an agency under the Ministry of Energy and Water Transformation (PETRA), and developed in line with the standards and safeguards of the International Atomic Energy Agency.[75]

To support this goal, PETRA is currently conducting a comprehensive feasibility study on nuclear energy, including the potential use of small modular reactors. This study aims to evaluate the viability of nuclear power as a stable baseload supply, complementing Malaysia's broader efforts to diversify its energy portfolio and reduce GHG emissions.[76]

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69 Greenpeace Malaysia, 'Sahabat Alam Malaysia and Greenpeace Call for Genuine Reform of the Energy Sector, No to Nuclear Power Pathway' (Press Release, 9 October 2023) <https://www.greenpeace.org/malaysia/press/51380/no-to-nuclear-power-pathway/>.

70 Ibid.

71 Ibid. See also Mohd Zamzam Jaafar, Nurul Huda Nazaruddin and Jonathan Tan Thiam Lye, 'Challenges of Deploying Nuclear Energy for Power Generation in Malaysia' (2017) 1799(1) AIP Conference Proceedings 020001.

72 Ibid.

73 Ibid.

74 Ibid.

75 Ministry of Economy, *13th Malaysia Plan, 2026-2030* (Report, 15 July 2025) 2–9 <https://rmk13.ekonomi.gov.my/wp-content/uploads/2025/09/120925-Main-Document-e-Book.pdf>.

76 'DPM: Malaysia Studying Nuclear Energy Potential with Small Modular Reactors', *Malay Mail* (online, 19 August

6 *Wind energy*

Wind energy in Malaysia faces several challenges that limit its large-scale adoption. One of the most pressing issues is that wind power is inherently seasonal, which makes it an unreliable source of energy if used in isolation.[77] Climate change has further complicated this by altering wind speeds and patterns, reducing their predictability.[78] Unlike solar or hydropower, which can be more consistently harnessed in Malaysia's climate, wind energy has a less dependable profile.

The financial and infrastructural requirements also pose hurdles. Wind power demands significant capital investment, not only for the turbines themselves but also for the infrastructure needed to connect them to the grid.[79] In Malaysia, suitable wind sites are typically found in rural or coastal areas, which are often far from existing transmission networks. This increases the overall cost of development. Moreover, wind power is not currently covered under Malaysia's Feed-in Tariff (FiT) scheme, meaning that developers lack guaranteed purchase agreements for the electricity generated. This policy gap diminishes investor confidence and slows deployment.

Technical and environmental concerns further complicate the picture. The large fibreglass blades used in turbines are extremely difficult to recycle or dispose of sustainably once they reach their 20-25 year lifespan.[80] Maintenance and repair have also been problematic due to the lack of locally available spare parts and technical expertise. On top of these logistical issues, wind farms face criticism for noise pollution, visual impact on landscapes, and their hazard to bird populations.[81]

Despite these challenges, wind energy has some potential in Malaysia, but on a limited scale. Studies indicate that areas with the greatest promise include Kudat and Kota Marudu in Sabah,[82] Kuala Terengganu in Terengganu,[83] and Mersing in Johor,[84] where average wind speeds are higher than in much of the country. Pilot projects have been tested in these locations, particularly in Sabah, to explore feasibility. However, Malaysia's overall wind profile is considered low to moderate compared to countries like Vietnam or the Philippines, where stronger and more consistent winds make

2025) <https://www.malaymail.com/news/malaysia/2025/08/19/dpm-malaysia-studying-nuclear-energy-potential-with-small-modular-reactors/188195>.

77 Serina Rahman, *Renewable Energy: Malaysia's Climate Change Solution or Placebo?* (ISEAS–Yusof Ishak Institute, 2020) 18–19.

78 Ibid.

79 Ibid.

80 Ibid.

81 Ibid.

82 Anis Farhana Abu Bakar et al, 'Wind Energy Potentials in Kudat, Sabah: Weibull Distribution Method' (2024) 6(1) *Journal of Design for Sustainable and Environment* 1, 1-7.

83 Kamaruzzaman Sopian and Tamer Khatib, 'Wind Energy Potential in Nine Coastal Sites in Malaysia' (2013) 1(1) مجلة جامعة فلسطين التقنية للأبحاث 10-15.

84 NAQNM Shuhaimi et al, 'Assessment and Potentiality of Wind Farm in Mersing, Malaysia' (2022) 4(1) *Journal of Design for Sustainable and Environment* 19-24.

large-scale wind farms viable.[85] As a result, wind in Malaysia is often viewed as a supplementary renewable source rather than a major contributor to the energy mix.

D. *Barriers to RE Transition*

The persistence of fossil fuel subsidies continues to undermine the expansion of RE in Malaysia's power generation sector. By lowering the relative cost of conventional fuels, these subsidies make investments in cleaner alternatives less attractive and delay the shift toward sustainable energy. Electricity tariffs in Malaysia are among the lowest in the region, designed to keep the cost of living affordable. However, this policy has become increasingly expensive to maintain as global coal, oil, and natural gas prices rise, leading to a growing burden of subsidies to meet domestic energy demand.[86]

Decades of entrenched subsidies for fossil fuels, combined with depreciating market prices, make it difficult for renewable producers to increase their market share. This remains true despite encouraging advances in infrastructure and the falling cost of RE materials. Ultimately, electricity prices in Malaysia are still tied to the price of coal and natural gas, while RE generation remains more costly due to its infrastructure requirements.[87] These costs are passed on to consumers, forcing RE to compete directly with heavily subsidised fossil fuels. Without sufficient incentives such as feed-in tariffs (FiT), solar and other renewable options struggle to achieve competitiveness.

Land use and permitting processes add further complications. Renewable projects often require land acquisition, zoning approvals, and environmental impact assessments, all of which can be time-consuming, expensive, and vulnerable to legal disputes. These delays not only increase costs but also discourage potential investors.[88]

Finally, the lack of accessible transition finance remains a critical barrier, particularly for small and medium-sized enterprises (SMEs). Many businesses struggle to obtain affordable green financing through mechanisms such as green bonds or sustainability-linked loans due to stringent eligibility criteria and limited awareness. Coupled with the high upfront capital costs of renewable projects, this financing gap continues to slow Malaysia's shift towards a low-carbon economy.[89] By comparison, Japan offers clear criteria for funding emission-reducing projects.[90] These differences are also shaped by broader policy instruments, including carbon pricing and fiscal

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85 Ibid.

86 Masoud Yahoo et al, 'Economic and Environmental Analysis of Malaysia's 2025 Renewable and Sustainable Energy Targets in the Generation Mix' (2024) 10(9) *Heliyon* e30157:1–15, 5, 14.

87 Serina Rahman, *Renewable Energy: Malaysia's Climate Change Solution or Placebo?* (ISEAS–Yusof Ishak Institute, 2020).

88 Ibid.

89 Ibid.

90 'Toward a Transition to Decarbonisation Transition Finance', *Ministry of Economy, Trade and Industry* (Japan) (Web Page) <https://www.meti.go.jp/english/policy/energy_environment/transition_finance/index.html>.

incentives in jurisdictions such as Germany and Sweden, which further enhance the financial attractiveness of renewable energy investments compared to Malaysia's more limited incentive framework.

While electric vehicles (EVs) are increasingly promoted as part of Malaysia's low-carbon transition strategy, their overall impact on emissions reduction remains dependent on the carbon intensity of the national electricity grid. In the absence of substantial decarbonisation in power generation, the widespread adoption of EVs may have a limited effect in addressing the structural reliance on fossil fuels within the energy sector.

Addressing these barriers requires targeted legal and regulatory interventions. Fossil fuel subsidies, for instance, may be gradually rationalised through statutory reform, coupled with the introduction of carbon pricing mechanisms or renewable portfolio standards to rebalance market incentives in favour of clean energy. Delays in land use and permitting processes can be mitigated through streamlined approval frameworks, such as a centralised 'one-stop' regulatory body or statutory time limits for environmental and planning approvals, thereby reducing uncertainty and transaction costs for developers. In relation to financing, legal mechanisms can play a catalytic role by establishing clear frameworks for green bonds, sustainability-linked loans, and blended finance instruments, while also mandating greater disclosure and standardisation to improve investor confidence. Collectively, these measures demonstrate that the law is not merely a passive backdrop, but a critical tool in dismantling structural barriers and enabling Malaysia's transition towards renewable energy.

IV. THE WAY FORWARD

A. *International benchmarks*

The International Energy Agency (IEA) ranks Finland and Sweden as global leaders in bioenergy use per capita, reflecting decades of sustained policy commitment.[91] Both countries recognised early on the importance of reducing reliance on fossil fuels and developed comprehensive strategies that combined taxation, subsidies, research, and industrial integration.

Finland's bioenergy journey began with its Energy Programme of 1979, designed to meet the challenges of a cold climate, energy-intensive industries, and dispersed populations.[92] Early measures included CO_2 taxation, fossil fuel taxes, and support for RE. Over time, Finland directed research and investment funds toward efficient energy use, bioenergy, and national power programmes. The introduction of a carbon tax in 1990 further boosted biomass utilisation, with refunds available for energy-

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91 'IEA - International Energy Agency' (Web Page) <https://www.iea.org/>.

92 Nor Adilla Rashidi, Yee Ho Chai and Suzana Yusup, 'Biomass Energy in Malaysia: Current Scenario, Policies, and Implementation Challenges' (2022) 15(3) *Bioenergy Research* 1371, 1371-1386.

intensive industries.[93] Investment support covered 10-25% of costs for peat and biomass facilities, while subsidies promoted biomass electricity.[94] Strong links between bioenergy and forestry ensured large-scale resource use without undermining Finland's pulp and paper sector. Today, the National Energy and Climate Strategy 2030 charts a course toward phasing out coal by 2029, expanding transport biofuels, and reducing GHG emissions by up to 95% by mid-century.[95]

Sweden's policies, meanwhile, have been closely tied to its commitments under the Paris Climate Accord and the European Union's 2030 Climate and Energy Framework. Like Finland, Sweden began supporting renewable heating and imposing carbon taxes in the late 1970s, which created a stable foundation for bioenergy expansion. Over time, the Swedish government consolidated policies to target net-zero emissions by 2045 and 100% renewable electricity by 2040, with bioenergy playing a central role. Industrial initiatives such as Jämtkraft's near-total reliance on biomass residues for its Combined Heat and Power (CHP) plant illustrate how deeply integrated bioenergy has become.[96] Innovative projects like the Green Highway, a Sweden-Norway partnership, also highlight the role of bioenergy in decarbonising transport through renewable fuel stations powered by forestry and aquaculture by-products.[97]

China also adopts a more comprehensive approach, employing a wide range of policy tools that extend beyond financial incentives. Notably, the Solar Energy Poverty Alleviation Program has been implemented to improve both energy access and equality, ensuring that RE development contributes directly to addressing social as well as environmental challenges.[98]

The developments in these countries demonstrate how long-term policy consistency, strong industrial ties, and carbon pricing can make bioenergy a cornerstone of national energy systems and climate strategies.

B. *Malaysia*

Malaysia's energy transition requires a deliberate phase-out of fossil fuels, accompanied by stronger policies that promote efficiency and RE. Reducing energy demand through more efficient appliances, public education, and better transmission systems not only cuts GHG emissions but also saves costs for consumers. Even a modest one percent reduction in energy loss could save the country RM300 million annually,[99] making energy efficiency a critical first step.

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93 Ibid.
94 Ibid.
95 Ibid.
96 Ibid.
97 Ibid.
98 Efy Azirah Majid et al, 'A Review of Renewable Energy Laws in Malaysia: Comparing Solar Energy Policies in Malaysia, United States, and China' (2022) 7(SI7) *Environment-Behaviour Proceedings Journal* 429-432.
99 Serina Rahman, *Renewable Energy: Malaysia's Climate Change Solution or Placebo?* (ISEAS–Yusof Ishak Institute, 2020).

Strong governance is equally important. A clear, empowered authority must drive transition policies and ensure an even playing field in the energy market. An overarching Energy Plan should consolidate targets, eliminate policy overlaps, and address corruption so that projects are awarded based on merit rather than connections. Expanding the RE portfolio under the feed-in tariff, easing subsidies for coal and gas, and introducing measures such as a Renewable Portfolio Standard would also help stabilise prices, encourage RE uptake, and attract private sector investment.[100] A dedicated framework for transition finance, similar to Japan's guidelines, could provide further clarity and assurance for investors.

Equity and inclusiveness must remain central. Rural communities in Sabah and Sarawak continue to face serious energy access issues, which can be addressed through hybrid RE solutions feeding into micro-grids.[101] Combining micro-hydro with small-scale solar, while training local communities in maintenance, offers a sustainable model for rural electrification without damaging habitats or displacing people.[102] Where necessary, limited coal or diesel backup could provide stability. However, the expansion of rural development must be carefully managed to preserve rivers, which are vital for micro-hydro potential.[103]

Beyond solar, biomass, and hydro, Malaysia should also explore emerging renewable sources such as marine energy and geothermal power.[104] Institutions like SEDA and local research bodies can play a key role in developing such innovations, provided they receive adequate funding and manpower. Assigning energy managers in major organisations and energy production units can further drive efficiency.[105] With corruption addressed, subsidies redirected from fossil fuels, and social impacts prioritised, Malaysia could realistically design a phased and equitable transition toward renewables anchored not only in technology and finance, but also in public trust and participation.

V. CONCLUSION

Malaysia stands at a critical juncture in its energy future. The country has set ambitious goals under the Paris Agreement and its own national roadmaps, but translating these into reality requires a decisive break from fossil fuel dependence, stronger governance, and consistent support for RE. Lessons from countries like Finland, Sweden, Germany, and Vietnam illustrate that sustained policies, carbon pricing, and public participation can transform energy systems rapidly and equitably.

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100 Efy Azirah Majid et al, 'A Review of Renewable Energy Laws in Malaysia: Comparing Solar Energy Policies in Malaysia, United States, and China' (2022) 7(SI7) *Environment-Behaviour Proceedings Journal* 429-432.

101 Ibid.

102 Serina Rahman, *Renewable Energy: Malaysia's Climate Change Solution or Placebo?* (ISEAS–Yusof Ishak Institute, 2020).

103 Ibid.

104 Ibid.

105 Ibid.

For Malaysia, success will depend not only on adopting the right technologies but also on aligning laws, institutions, and financial frameworks to create a level playing field. Equally important is ensuring that the transition is inclusive by addressing rural electrification, social equity, and community consent. If these elements are prioritised, Malaysia can not only meet its net-zero 2050 pledge but also emerge as a regional leader in RE innovation. The path forward is challenging, but the costs of delay are far greater. With urgent and coordinated action, Malaysia can turn climate imperatives into opportunities for sustainable growth and resilience.