Solar and Beyond:

Diversification and complementary options for fulfilling Malaysia's National Energy Transition Roadmap

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Contents

Abstract

Power consumption in Peninsular Malaysia will grow by 4.5% per year over the medium term, driven by economic and population growth, electrification, and rising cooling demand.[1] The National Energy Transition Roadmap (NETR) plans to meet much of that demand growth through renewables, expanding installed capacity from 14.86 GW in 2025 to 68 GW by 2050. This would see renewables comprise 70% of Malaysia's total generation capacity.

Plans to meet the NETR's targets rely largely on a single technology. Solar photovoltaic (PV) generation accounts for most of the renewable capacity added since the 2010s and has been the investment focus of every major renewable energy (RE) development mechanism introduced in the years since.[2]

While this non-firm capacity increases, firm generation capacity will be gradually reduced. Malaysia has committed to halting new coal plant buildout, aiming for a complete phase-out of coal power by 2044. Peninsular Malaysia plans to retire 7.2 GW, roughly half of its coal fleet, as early as 2030–31.[3] Malaysia is therefore adding mostly non-firm renewable capacity at the same time it is removing firm capacity. The balance between the two determines whether the system that emerges can meet demand every hour of every day.

This structural shift in the national energy mix is set to take place as the load profile of its largest consumers is changing. The Ministry of Energy Transition and Water Transformation (PETRA) projects power consumption by data centers alone will rise from around 7% of demand in 2026 to as much as 31% by 2035, or 73,274 GWh.[4] Data centers require constant, round-the-clock power. This kind of predictable load is an advantage for planning and the economics of renewable investments. Meeting a constant load with a non-firm daytime resource like solar requires either storage at scale or complementary firm technologies alongside it.

As Malaysia's focus for the energy transition shifts toward system reliability,[5] this white paper argues that renewable energy diversification is essential to Malaysia's energy transition pathway. Renewable energy diversification requires strategic decisions to expand the national clean power portfolio to limit reliance on a single source. Diversification complements Malaysia's solar buildout with firm, dispatchable power and addresses the specific constraints Malaysia faces in its energy transition.

Part 1 of this paper outlines the case for diversification in renewable energy technologies. Overall, three structural constraints support the case for diversification:

1) Land: Replacing baseload in Peninsular Malaysia on a solar-heavy pathway requires four to five times the stated generation capacity compared to firm solutions, plus contiguous land for storage and power system infrastructure in a region where developable land is already contested.

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1 Beyond Coal: Building a Flexible, Resilient and Clean Power System for Malaysia (July 2026), by PETRA and KPMG. Available at: https://reports.weforum.org/docs/WEF_Beyond_Coal_Clean_Power_Malaysia_2026.pdf

2 Solar and grid flexibility critical for Malaysia's future electricity affordability and security, Ember. Available at: https://ember-energy.org/app/uploads/2024/10/Report-Solar-and-grid-flexibility-critical-for-Malaysias-future.pdf

3 Beyond Coal, PETRA and KPMG

4 Ministry of Energy Transition and Water Transformation (PETRA), parliamentary written reply, July 6, 2026. Available at: https://www.parlimen.gov.my/files/jindex/pdf/JDR06072026.pdf

5 Malaysia must build resilient energy system for higher-value growth, says Akmal, The Star. Available at: https://www.thestar.com.my/news/nation/2026/09/08/malaysia-must-build-resilient-energy-system-for-higher-value-growth-says-akmal

2) Storage: Battery energy storage system (BESS) deployment has not kept up with solar capacity buildout. Analysis places the power system's comfortable absorption ceiling for non-firm renewables below the trajectory of current storage buildout plans.
3) Demand: Hyperscale data center load is constant and round-the-clock. This increasing demand is arriving as firm generation capacity in coal leaves the system, turning a demand issue into a reliability challenge.

Part 2 identifies three potential renewable or carbon-free energy solutions based on their ability to complement solar's non-firm generation profile. This assessment was based on the domestic availability of the resource base, its ability to supply firm output to the power system, and the potential to deploy at scale. The technologies identified include:

Next-generation geothermal: Advanced geothermal systems (AGS) circulate a working fluid through sealed underground wellbores to extract heat from hot, dry rock, without requiring naturally occurring reservoirs that conventional geothermal systems depend on. This removes the geological constraint that puts conventional geothermal out of reach in Peninsular Malaysia, making next-generation geothermal a candidate for firm, round-the-clock supply. In addition, Malaysia's oil and gas sector holds drilling capabilities that are transferable to next-generation geothermal development.

Long-duration energy storage (LDES): LDES solutions convert non-firm renewable energy into stored or potential energy through a variety of thermal, mechanical, and electrochemical solutions. LDES complements non-firm generation and short-duration BESS by covering overnight and multi-day shortfalls.

Nuclear (conventional and small modular reactors): Nuclear generation offers the highest firm capacity at the lowest fuel input but remains at the feasibility stage. With a PETRA decision point set for 2031, it is a long-term option rather than a near-term diversification measure.

Part 3 concludes with recommendations for Malaysian policymakers to embed diversification as part of the NETR agenda and enact policies that support this agenda. To develop Malaysia's power system to meet future needs, Malaysian policymakers should:

- **Operationalize diversification under NETR:** conduct an interim NETR review and adopt a system-value framework alongside headline capacity targets.
- **Clarify regulatory pathways:** establish licensing, resource ownership, permitting, and grid access frameworks for non-solar firm resources, starting with a national geothermal policy.
- **Reform procurement pathways and incentives:** publish the methodology behind the System Access Charge (SAC), which determines grid access fees under the Corporate Renewable Energy Supply Scheme (CRESS). Set the charge according to how each of its six customary cost components applies to a given technology. Malaysia should also consider a Feed-in Premium (FiP) and update Feed-in Tariff (FiT) categories.

Glossary

AGS	Advanced geothermal systems
BESS	Battery energy storage system
Brown Energy	Electricity or fuel generated from non-renewable fossil sources
CRESS	Corporate Renewable Energy Supply Scheme
DNV	Det Norske Veritas
e-FiT	Electronic Feed-in Tariff application system
ECoS	Energy Commission of Sabah
EIB	European Investment Bank
FiP	Feed-in premium
FiT / FIT	Feed-in tariff
IAEA	International Atomic Energy Agency
JMG	Mineral and Geosciences Department (Jabatan Mineral dan Geosains)
LCEGP	Low Carbon Energy Generation Programme
LDES	Long-duration energy storage
LSS	Large Scale Solar
LSS6	Sixth round of the Large Scale Solar program
MTN	National Energy Council (Majlis Tenaga Negara)
MyBeST	Malaysia Battery Energy Storage System program
MyRER	Malaysia Renewable Energy Roadmap
NEDA	New Enhanced Dispatch Arrangement
NEM	Net Energy Metering
NEPIO	Nuclear Energy Programme Implementing Organization
NETR	National Energy Transition Roadmap
PETRA	Ministry of Energy Transition and Water Transformation (Peralihan Tenaga Dan Transformasi Air)
PTG	Lands and Mines Department (Pejabat Tanah dan Galian)
PV	Photovoltaic
SAC	System Access Charge
SEDA	Sustainable Energy Development Authority
SELCO	Self-Consumption
SMR / SMRs	Small modular reactor / reactors
TNB	Tenaga Nasional Berhad

Methodology

This study draws on desk research and stakeholder interviews to assess the energy landscape in Peninsular Malaysia. The desk research reviewed publicly available policy documents, government roadmaps and strategies, industry reports and articles, and academic literature. The Institute analyzed the information and data gathered to assess the potential of alternative energy technologies, identify constraints and opportunities, and develop policy recommendations.

The research also included interviews with representatives from relevant government departments, renewable energy developers, and academia. These interviews provided perspectives on policy implementation, technology readiness, and practical barriers to deployment. Interview findings informed the analysis alongside the desk research, with stakeholder perspectives presented without identifying individual interviewees.

Part 1: The Case for Renewable Energy Diversification

1.1 From feed-in tariffs to LSS6: the development of a solar-centric framework, 2011–2026

1.1.1 The feed-in tariff era, 2011–2015

Malaysia formally integrated renewable energy into national macroeconomic planning through the Tenth Malaysia Plan (2011–2015), the creation of the Sustainable Energy Development Authority (SEDA) and the Renewable Energy Act 2011. SEDA's first major operational mandate was the implementation of the Feed-in Tariff (FiT) scheme in 2011, which was designed to catalyze the deployment of renewable energy connected to the grid across Peninsular Malaysia, Sabah, and Labuan.

The FiT legally obliged energy distributors, principally Tenaga Nasional Berhad (TNB), Sabah Electricity Sdn. Bhd. (SESB), and NUR Power, to purchase clean electricity at long-term fixed premium rates. This obligation established predictable rates for renewable energy (RE) developers, which helped unlock private-sector infrastructure capital.

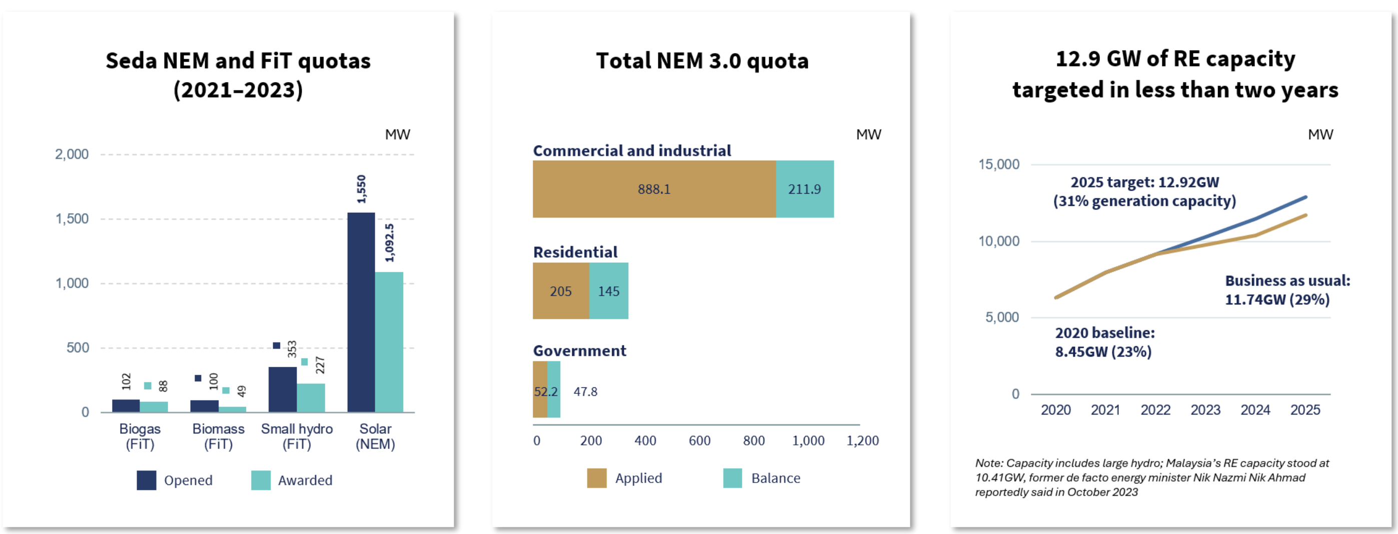

Figure 1: Growth of renewable energy projects under the FiT framework. Source: The Edge Malaysia.

RE developers used the FiT to scale solar, which was the most price-competitive RE technology at the time, converting a bankable, long-term offtake guarantee into deployed capacity. Installed renewable capacity under the scheme reached 2.8 GW by December 2020, the majority of which comprised solar.[6]

[6] Malaysia Renewable Energy Roadmap: Pathway Towards Low Carbon Energy System, SEDA. Available at: https://www.seda.gov.my/reportal/wp-content/uploads/2022/01/MyRER_webVer2.pdf

Prior to the FiT, renewable installations were broadly capital-intensive utility assets. SEDA made RE generation more accessible by launching a transparent, first-come, first-served e-FiT online application portal,[7] which enabled individual homeowners and small domestic commercial enterprises to secure rooftop solar photovoltaic (PV) quotas.

Contract durations matched the investment payback periods of different technologies, providing 21 years of revenue security for solar PV and small hydropower installations, and 16 years for biomass and biogas facilities.[8] This was the only distinction the FiT made in terms of technologies. The scheme did not differentiate between firm and non-firm generation, opting instead to focus on de-risking capital.

The lack of distinction between firm and non-firm technologies did not account for the difference in capital risk and generation characteristics. Unlike modular solar PV systems that operate with highly predictable overheads, firm technologies are more capital-intensive and require regulatory support throughout their development. For example, biomass projects face volatile feedstock supply dynamics, while next-generation geothermal applications require significant investment in exploratory drilling without guaranteed return.

The FiT set premium prices for RE, which absorbed risk for all developers. Without this, RE generation in Malaysia would not have developed at the pace that it did. However, the premium absorbed proportionally more risk for solar projects given the technology's relatively lower capital requirements. This made solar development more attractive as an investment compared to firm RE solutions.

1.1.2 Competitive bidding and the disincentivization of firm technologies, 2016–2023

The Eleventh Malaysia Plan solidified the FiT's unintended bias toward solar investment. The plan introduced competitive bidding for national procurement, supporting an increase in RE capacity through the Large Scale Solar (LSS), Net Energy Metering (NEM), and Self-Consumption (SELCO) programs.[9]

The Ministry of Energy Transition and Water Transformation (PETRA) – at the time known as the Ministry of Energy, Green Technology and Water – awarded LSS projects based on the lowest price per kilowatt-hour while NEM and SELCO extended uncapped incentives outside any competitive bidding process. Across all three programs, developers built modular, non-firm solar without battery energy storage systems (BESS) or other storage mandates. While the programs met their interim RE capacity milestones, PETRA never intended for the programs to displace brown energy, instead seeking modest gains in RE output to strengthen industry sentiment and bankability.[10] At the time, the constant, round-the-clock industrial load profiles that now shape system preferences for firm technologies were not yet present in the market.

Concurrently, SEDA faced execution hurdles when scaling frontier firm technologies. Agricultural biomass and biogas assets scaled steadily by securing residues from oil palm byproducts, but geothermal did not. In 2016, Tawau Green Energy secured a 21-year FiT contract to deliver a 37 MW geothermal plant at Apas Kiri, Tawau, drawing on Sabah's hydrothermal resources. Drilling delays and capital overruns stalled the project, and SEDA terminated the permit and redistributed its unused quota in late 2018.

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7 Feed-in-tariff rush seen, The Star. Available at: https://dev.seda.gov.my/seda_dev/?y=45&s=1129

8 Malaysia's Renewable Energy Journey: The Evolution of FiT Mechanism (December 22, 2025), The Edge Malaysia. Available at: https://theedgemalaysia.com/content/advertise/malaysias-renewable-energy-journey-the-evolution-of-fit-mechanism

9 Malaysia Renewable Energy Roadmap, SEDA. Available at: https://www.seda.gov.my/reportal/wp-content/uploads/2022/01/MyRER_webVer2.pdf

10 Large Scale Solar (LSS), SEDA. Available at: https://www.seda.gov.my/reportal/large-scale-solar/

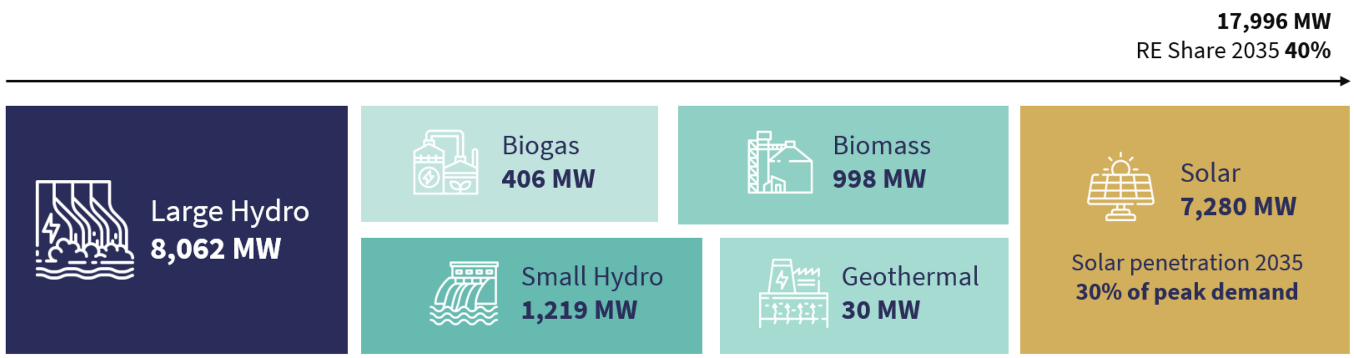

Figure 2: New Capacity Targets under MyRER. Source: SEDA, Malaysia Renewable Energy Roadmap (MyRER).

The scale-up of global solar PV manufacturing drove a 90% reduction in module and cell costs over 15 years. This coincided with an increase in natural gas generation costs.[11] Research from the Global Development Policy Center finds that local project developers bypassed domestic hardware to scale capacity by purchasing cheaper imports.[12] Reduced equipment costs mirrored dynamics in middle-income peers like Thailand, Vietnam, and India, where solar approached grid parity with brown energy ahead of domestic regulatory reforms that incentivized firm RE growth.

Malaysia's energy authorities consider a reliance on solar equipment imports as preferable to further expansion of natural gas capacity given price volatility. However, a preference for solar generation does not solve broader questions of diversity and energy security. Even when paired with BESS, solar cannot replicate the dispatchability gas currently provides.[13]

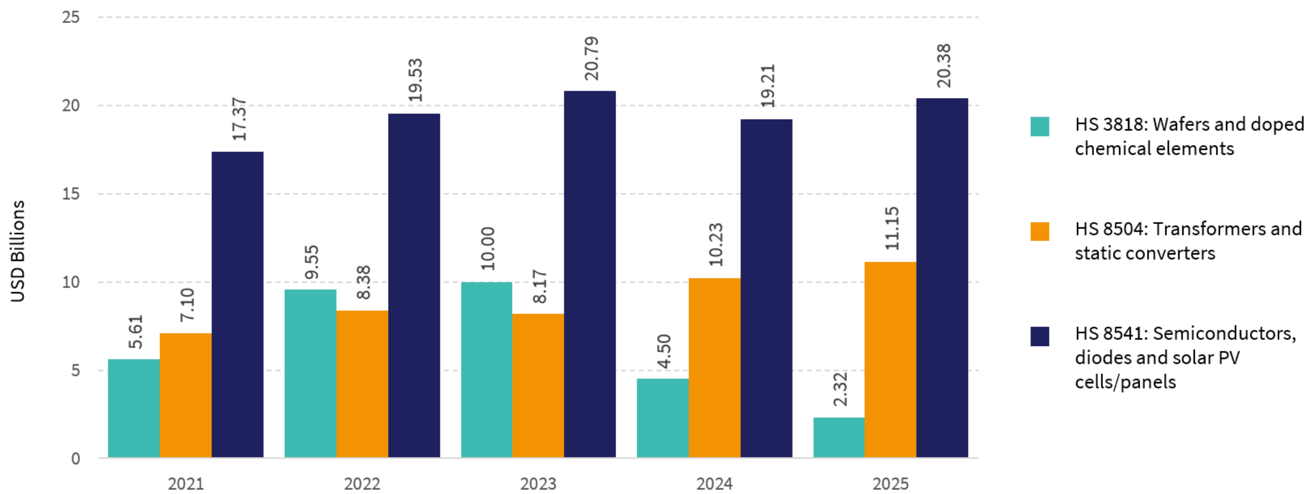

Figure 3: Malaysia's annual imports of solar equipment. Source: MyMETS, Department of Statistics Malaysia

11 How massive subsidies helped drive a 90% collapse in solar costs (June 22, 2026), PV Magazine. Available at: https://www.pv-magazine.com/2026/06/22/the-worlds-magical-21-billion-investment/

12 Trade Offs: Developing Malaysia's Solar Industry Amid the US-China Trade War (August 18, 2023), Boston University Global Development Policy Center. Available at: https://www.bu.edu/gdp/2023/08/18/trade-offs-developing-malaysias-solar-industry-amid-the-us-china-trade-war/

13 An illustration of this mismatch is depicted in Figure 6.

Firm and non-firm: two senses of the term

In industry usage, firm capacity is generation that a system operator can rely on being available when called, at a stated output, for a stated duration. Firmness is a matter of degree: it depends on availability, forecast accuracy, and how long output can be sustained.

Under CRESS, *firm* and *non-firm* are contractual classifications applied to a project's contracted output profile, and the classification is binary.

This paper italicizes the CRESS classification and sets the industry-defined term in standard font. The distinction is important to flag for Part 3: two projects can both be *CRESS-firm* while differing substantially in firmness.

1.1.3 Rebalancing toward firm supply: CRESS, LSS6 and the storage mandate, 2024–2026

Corporate Renewable Energy Supply Scheme (CRESS)

By the end of 2025, Malaysia had advanced its National Energy Transition Roadmap (NETR) milestones, pushing its RE share to 32% of national installed capacity, just slight ahead of the near-term target of 31% (equivalent to 12.9 GW). The government has set capacity targets of 40% by 2035 and 70% by 2050. However, sustaining this trajectory will depend on maintaining the commercial viability of solar and establishing complementary RE solutions.

PETRA launched the Corporate Renewable Energy Supply Scheme (CRESS) in late 2024, enabling businesses to buy green electricity directly from developers via TNB's network. Revisions to the scheme have lowered the System Access Charge (SAC) and improved the economics for firm supply. The first guidelines set the SAC at 25 sen/kWh for *firm* supply and 45 sen/kWh for *non-firm* supply. Adjustments in 2025 cut the SAC to 20 sen/kWh for *firm* supply and 40 sen/kWh for *non-firm* supply.[14]

Currently, there is no distinction concerning the duration of *firm* supply. A solar project paired with BESS supplying four hours of power is contracted on the same terms (20 sen/kWh) as a geothermal plant supplying constant power, despite delivering materially different value to the system across an evening peak, overnight, or multi-day period. Section 3.3 sets out how the six components above apply to differentiate between the two energy sources.

[14] Energy Commission Issues The Third Edition Of CRESS Guidelines: A Shift Towards Commercial Workability And Risk Rebalancing (June 3, 2026), RDS Law. Available at: https://www.rdslawpartners.com/post/energy-commission-issues-the-third-edition-of-cress-guidelines-a-shift-towards-commercial-workabili

What is the System Access Charge (SAC)?

Wheeling charges, of which Malaysia's SAC is one, are customarily constructed from several cost components, including:

- **Network:** the capital cost of the transmission system
- **Reliability:** the cost of holding dispatchable capacity to maintain system reliability
- **Balancing:** the cost of balancing deviations between forecast and actual output
- **Operation:** system operation and maintenance
- **System losses:** energy lost in transmission due to heat, equipment failure, or other factors
- **Administration:** program administration

Commonly, network, operation, and administration costs are fixed: every generator connected to the system drives them regardless of performance. Reliability, balancing, and system losses vary with the generator's output profile. International counterparts often establish wheeling charges based on generator performance against the aforementioned criteria.[15]

Publishing the methodology allows a generator to identify which components increase charges and pursue offtake solutions that reduce them. It also gives the regulator a basis to differentiate charges by measured system impact rather than by classification under a binary.

Low Carbon Energy Generation Programme (LCEGP)

PETRA has established other programs to support firm RE procurement, though the scale of capacity being procured remains modest. The Low Carbon Energy Generation Programme (LCEGP) was introduced in January 2024 and is administered under the TNB-owned procurement entity Single Buyer. The program reserved a 400 MW quota specifically for firm RE generation including small hydro, biogas, biomass, and hydrogen and allocates capacity to developers on a first-come, first-served basis under the New Enhanced Dispatch Arrangement (NEDA).[16, 17]

While the program suggests that PETRA and Single Buyer view diversification as a necessity, its 400 MW allocation is small relative to Malaysia's total renewable energy procurement target of 18.3 GW by 2031. Notably, neither geothermal nor nuclear power technologies are eligible under the program, despite being firm, dispatchable solutions aligned with the program's procurement targets. Explicitly including geothermal and nuclear (once the feasibility study under the Thirteenth Malaysia Plan concludes) would enable the program to procure the kind of firm capacity that the market is not yet mobilizing.

[15] Transmission charges vary between markets, with different energy regulators electing to charge certain functions toward differing parties. Examples of this would be the UK's Transmission Network Use of System (TNUoS), Balancing Services Use of System (BSUoS), and Distribution Use of System (DUoS) charges. Available at: https://www.neso.energy/document/301206/download

[16] Single Buyer, "Understanding LCEGP," https://www.singlebuyer.com.my/market/market-operations/programs/lcegp

[17] Christopher & Lee Ong, "Low Carbon Energy Generation Programme," Client Update: Malaysia, March 2024, https://www.christopherleeong.com/wp-content/uploads/2024/10/2024-03_CLO-Low-Carbon-Energy-Generation-Programme-v2.pdf

Understanding LCEGP

On 26 January 2024, in conjunction with the International Day of Clean Energy, the Ministry of Energy Transition and Water Transformation (PETRA) announced the Low Carbon Energy Generation Programme for non-solar renewable resources under the New Enhanced Dispatch Arrangement (NEDA) mechanism.

Reflecting diversification in procurement

The NETR contains the language of diversification, but Malaysia's procurement record does not yet reflect it. The roadmap explicitly targets diversification of the fuel mix and the substitution of imported non-renewable energy, with a stated goal of raising domestic energy self-sufficiency to between 48% and 72%. The ten catalyst projects span six transition levers, including bioenergy and hydrogen alongside solar.[18]

Diversification itself, however, is not treated as a measurable objective with its own target(s). In practice, LSS and CRESS have channeled investment overwhelmingly into solar. Malaysia's next phase of RE procurement can build on the existing solar framework by adding firm and storage-backed capacity alongside it. Section 1.2 sets out the three constraints that the next phase will need to address.

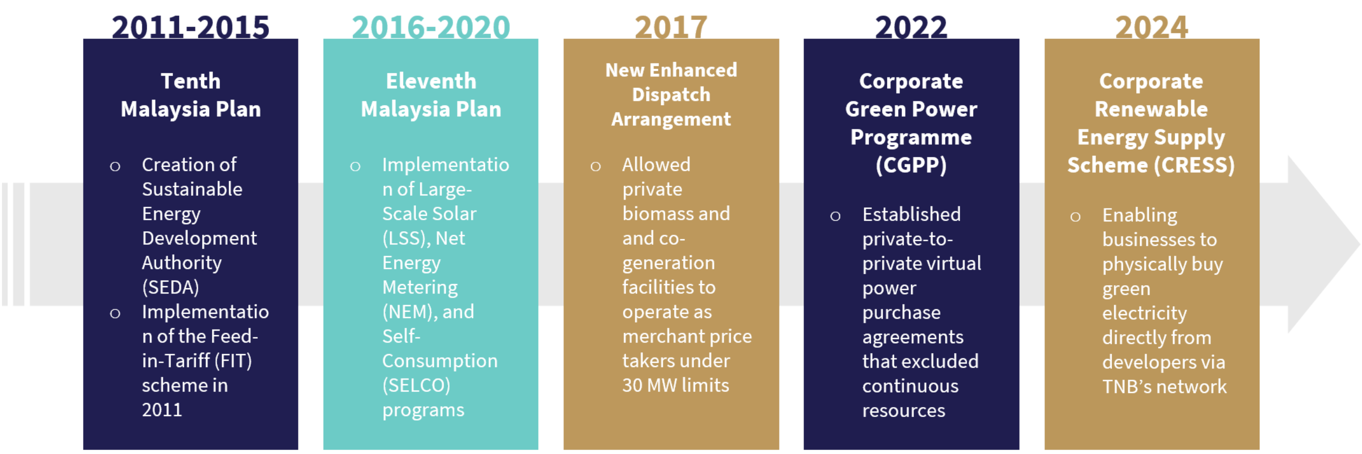

Figure 4: Timeline of Malaysia's renewable energy programs, 2011–2024.

[18] IRENA, "Socio-economic Impacts of the Renewable Energy Transition in Malaysia," December 2025, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2025/Dec/IRENA_SOC_Socio-economic_impacts_Malaysia_2025.pdf

1.2 Three structural constraints on a solar-heavy pathway

A renewable energy profile comprising a single non-firm solution raises three constraints, outlined below. The constraints accumulate: land scarcity raises the cost of the overbuilding that a storage-only response would require, and both compound with increased constant demand.

Constraint	Mechanism	Evidence	Implication for the mix
Land	Low power density of solar PV requires overbuilding of four to five times to replace thermal baseload, plus contiguous land for BESS, substations, and transmission rights-of-way	MyRER: approximately 210 GW of potential on 4,085 km² of unused suitable land, around 3.1% of peninsular land area; geothermal, nuclear, and gas fall in the smallest-footprint category	Electricity generated per unit of land becomes a selection criterion, favoring firm, compact resources
Storage	BESS deployment has lagged behind solar growth; storage adds at least 40% to project capital expenditure	Announced BESS projects and requests for proposals remain short of the reserve levels implied by forecast solar buildout; DNV places the comfortable ceiling for variable RE at roughly 20% in single-buyer markets	Storage mandates in BESS alone do not close the gap; firm complements or long-duration energy storage systems are required alongside them
Demand	Industrial load growth is constant and round-the-clock while firm thermal capacity retires	Data centers projected at 31% of Peninsular Malaysia's demand by 2035 (73,274 GWh); 7.2 GW of coal retiring by 2031	Without firm renewables, non-renewables like gas become the default backstop for retiring coal

Table 1: The three structural constraints on a solar-heavy pathway, summarized.

1.2.1 Land: replacing thermal baseload requires overbuilding solar four to five times

Fulfilling the NETR's 70% renewable capacity target by 2050 exclusively through solar would raise significant land-use, infrastructure, and financing challenges. Solar PV has a low power density and low capacity per square meter, meaning that replacing thermal plants requires overbuilding capacity: replacing a 100 MW coal power plant requires building 400–500 MW of solar capacity.[19]

Land-use challenges are particularly relevant in the Malaysian context. In Peninsular Malaysia, where developable land is heavily constrained by mountainous terrain, protected rainforests, and competing agricultural allocations (e.g., oil palm), dedicating large contiguous areas exclusively to solar arrays creates economic trade-offs.

SEDA's Malaysia Renewable Energy Roadmap (MyRER), the national roadmap that sets Malaysia's renewable capacity pathway to 2035, estimates approximately 210 GW of ground-mounted solar resource potential based on 4,085 km² of unused suitable

[19] The macro view of solar policy: The case for supporting utility-scale power, Solar Compass. Available at: https://www.sciencedirect.com/science/article/pii/S2772940024000304

land, equivalent to around 1.2% of Malaysia's total land area or 3.1% of Peninsular Malaysia's total land area.[20] This potential is substantial, but its realization would create material competition for land as renewable deployment scales.

Such a level of trade-off is unnecessary given the electricity requirements and the other options available. Applying technology-specific land-use intensities from Lovering et al. (2022) to Peninsular Malaysia's approximately 135 TWh annual electricity demand shows that ground-mounted solar would require around 270,000 hectares—2.05% of Peninsular Malaysia's total land area—to meet demand. Measured against MyRER's own estimate of 4,085 km^2 of unused suitable land, present demand alone would occupy roughly two-thirds of the identified resource, before accounting for demand growth.

By comparison, geothermal would require approximately 6,075 hectares, 0.05% of Peninsular Malaysia's land area, while nuclear would require around 959 hectares (0.01%). On an equivalent-generation basis, ground-mounted solar is therefore substantially more land-intensive than firm alternatives, requiring around 44 times more land than geothermal and 280 times more than nuclear.

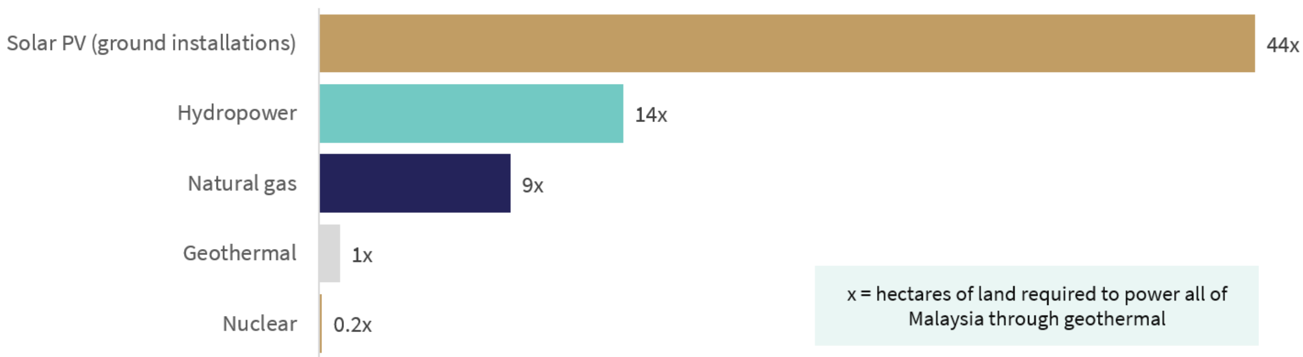

Figure 5: Estimated land required to meet Peninsular Malaysia's annual electricity demand, by generation technology. Source: SEAPPI calculations based on Lovering et al. (2022) and Peninsular Malaysia electricity demand data reported by InfoLink Consulting, citing TNB.

In practice, the total land area would be much larger in order to mitigate solar's daytime-only generation profile. Additional land would be required for BESS, substations, and wide transmission rights-of-way, to say nothing of land acquisition and connection costs. Relying solely on ground-mounted solar PV thus creates a land- and capital-intensive decarbonization pathway and strengthens the case for diversifying Malaysia's energy mix with space-efficient, firm alternatives.

1.2.2 Storage: BESS is necessary for solar integration but cannot substitute for firm generation

Increasing non-firm solar generation capacity is occurring alongside a transformation in Malaysia's electricity demand which projects greater constant load. MyRER illustrates the supply-side challenge through the "duck curve" (see Figure 6 below). As

[20] Malaysia Renewable Energy Roadmap (MyRER) (2021), Sustainable Energy Development Authority (SEDA) Malaysia, p. 38. Available at: https://www.seda.gov.my/reportal/wp-content/uploads/2022/01/MyRER_webVer2.pdf

solar penetration increases, particularly through distributed rooftop PV that is not visible to the grid system operator, midday generation pushes net system demand downward. Solar supply then falls toward sunset, as net system demand increases, requiring other generation to ramp up rapidly.[21] This supply profile is not well suited to a demand profile moving toward constant, round-the-clock consumption, which is addressed in Section 1.2.3. This section addresses what current storage solutions can do to meet the challenge of mismatched supply and demand.

Illustrative Solar Duck Curve and Round-the-Clock Data Centre Demand in Peninsular Malaysia

Impact of rising solar PV penetration on net load

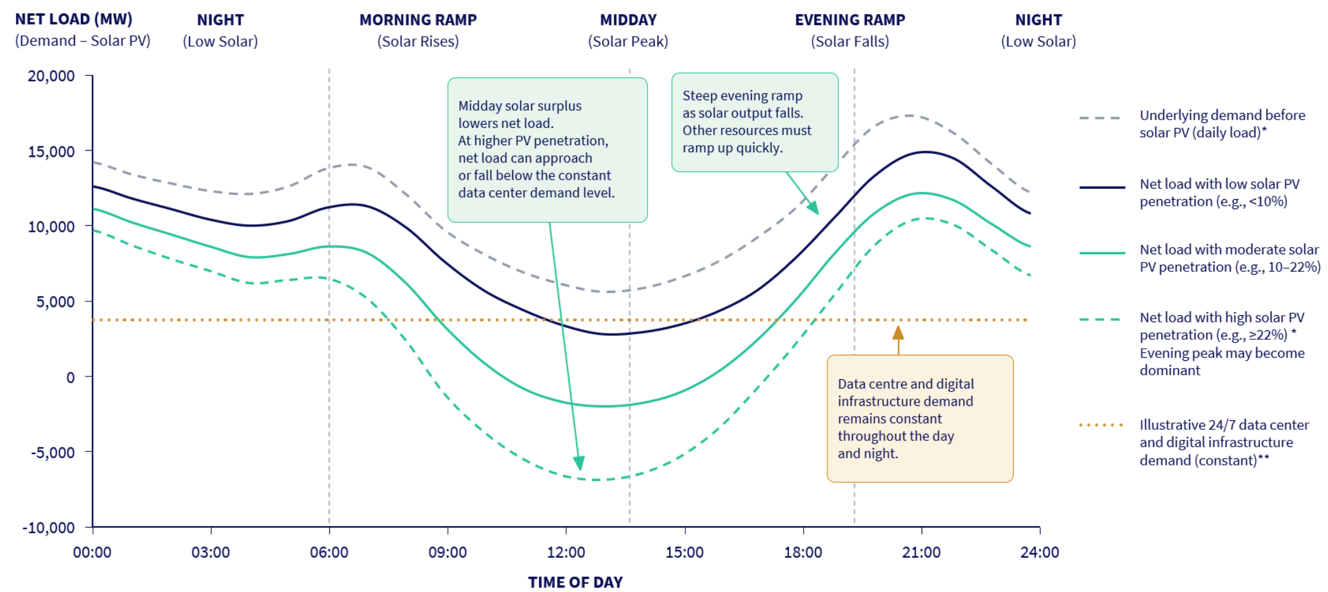

Figure 6: Illustrative solar duck curve and round-the-clock data center demand in Peninsular Malaysia. Adapted from SEDA Malaysia, Malaysia Renewable Energy Roadmap (MyRER), Figure 6-20, based on DNV-GL simulations.

BESS is essential to managing the mismatch described by the duck-curve, but its effectiveness is constrained by the duration for which it can discharge electricity. Batteries can absorb surplus solar generation during the day and release it during the evening ramp, reducing curtailment and the need for fast-ramping thermal generation. However, once discharged, a battery must be recharged before providing the same service again.

The Malaysia Battery Energy Storage System (MyBeST) program illustrates this distinction. Its 400 MW / 1,600 MWh configuration provides four hours of storage at rated output.[22] This is sufficient for intraday load shifting but not continuous overnight or multi-day supply in the case of poor irradiation. Short-duration BESS complements solar but cannot convert a non-firm source into an independently firm, round-the-clock electricity source. BESS has a clear role in renewable integration, but its limits

[21] Sustainable Energy Development Authority (SEDA) Malaysia, *Malaysia Renewable Energy Roadmap (MyRER)* (2021), p. 101. Available at: https://www.seda.gov.my/reportal/wp-content/uploads/2022/01/MyRER_webVer2.pdf

[22] Energy Commission (Suruhanjaya Tenaga), Request for Proposal for the Battery Energy Storage System with the Total Capacity of 400MW/1,600MWh for Peninsular Malaysia (MyBeST), December 19, 2025. Available at: https://www.st.gov.my/request-proposal-battery-energy-storage-system-total-capacity-400mw1600mwh-peninsular-malaysia

demonstrate that operating conditions, auxiliary infrastructure, and lifecycle management matter more than MW and MWh capacity alone.

To augment BESS capacity, the Energy Commission (ST) is now integrating storage directly into utility-scale procurement. The sixth Large Scale Solar round (LSS6) couples 2,650 MW of new solar capacity with 1,250 MW / 5,000 MWh of mandatory BESS, alongside the separate 400 MW / 1,600 MWh MyBeST program.[23] This treats storage as part of the infrastructure required to integrate additional solar rather than as an optional addition.

Suruhanjaya Tenaga
Energy Commission

NOTIS MAKLUMAN
PENGAPUNGAN DOKUMEN REQUEST FOR PROPOSAL BAGI PROGRAM BIDAAN TERBUKA LARGE SCALE SOLAR

Kementerian Peralihan Tenaga dan Transformasi Air melalui Suruhanjaya Tenaga akan melaksanakan program bidaan terbuka Large Scale Solar Pusingan Keenam (LSS6) di Semenanjung Malaysia dengan jumlah penawaran kuota sebanyak 2,650 MW solar dan 1,250MW/5,000MWh sistem bateri penyimpanan tenaga (BESS). Program LSS6 ini akan dilaksanakan secara tiga (3) pakej seperti berikut:

i. LSS6 – Hibrid Pakej 1: Pelaksanaan LSS + BESS tender terbuka kepada semua pemaju dengan kapasiti 2,200MW solar dan 1,100MW BESS;
ii. LSS6 – Hibrid Pakej 2: Pelaksanaan LSS + BESS tender terbuka kepada Bumiputera dengan kapasiti 300MW solar dan 150MW BESS; dan
iii. LSS6 – Solar Pakej 3: Pelaksanaan Solar Bumiputera tanpa BESS dengan kapasiti sebanyak 150MW solar.

Figure 7: LSS6 request for proposals, including mandated BESS capacity of 1,250 MW / 5,000 MWh. Source: Energy Commission.

While additional BESS capacity is timely, Malaysia is approaching the technical ceiling for absorbing non-firm generation capacity. Analysis of single-buyer electricity markets (such as Malaysia's) by Det Norske Veritas (DNV), a Norwegian risk management firm, identifies roughly 20% solar and wind penetration as the optimal ceiling for maintaining affordability and reliability without major system redesign.[24] Separate analysis of Malaysia by Ember finds that while the system can absorb penetration levels of up to 30%, costs rise noticeably beyond the 30–40% band, and scheduled curtailment becomes necessary above 40%.[25]

[23] Energy Commission, LSS6 Request for Proposals; *New Straits Times*, "Malaysia to mandate battery storage for all LSS6 solar projects, Fadillah says," June 3, 2026; Energy Commission, *Request for Proposal for the Battery Energy Storage System with the Total Capacity of 400MW/1,600MWh for Peninsular Malaysia (MyBeST)*, December 19, 2025.

[24] Det Norske Veritas (DNV), "Renewable Energy Integration and Balancing in Single Buyer Electricity Markets," https://www.dnv.com/publications/renewable-energy-integration-in-single-buyer-electricity-markets-231850/

[25] Ember, "Solar and Grid Flexibility Critical for Malaysia," August 2024, https://ember-energy.org/latest-insights/solar-and-grid-flexibility-critical-for-malaysia/

At its current buildout pace, Malaysia's solar capacity is approaching thresholds at which further expansion without complementary firm generation will require increasingly costly system interventions. This means either additional mandatory battery storage as introduced for LSS6, active curtailment of existing generation capacity, or firm RE alternatives to cover the shortfall.

1.2.3 Demand: round-the-clock industrial load is growing as firm capacity retires

Increasingly, power demand in Peninsular Malaysia is constant and round-the-clock. This type of demand is structurally mismatched to the power generation profile of solar PV. Industrial expansion, electrification, and the push to become a leading AI and digital economy are introducing new sources of electricity demand, most visibly through the rapid growth of data centers, which PETRA estimates will account for 31% of national demand by 2035, or 73,274 GWh.[26]

Data center load, as illustrated in Figure 6 (the "duck curve"), is more constant throughout the day than traditional manufacturing.[27] Solar PV generation cannot serve that demand without complementary storage at scale or firm generation alongside it. Constant load is also arriving faster than the system was planned to absorb: reserve margins fell to 13% at their lowest in 2026 during outages at gas-fired plants, below the 15-20% range seen in comparable single-buyer systems.[28] This load is arriving as firm generation capacity in coal leaves the system, turning a demand problem into a reliability challenge. Peninsular Malaysia will retire 7.2 GW of legacy coal capacity by 2031 and achieve a complete coal phase-out by 2044, removing one of the major sources of firm power currently supporting industrial demand.

Without diversification, replacing baseload coal risks an overreliance on natural gas as the sole transition fuel to backstop non-firm renewables. Solar is one component of a balanced generation mix, alongside short-duration BESS for intraday shifting and LDES or firm generation for longer shortfalls. Building that balanced mix allows the power system to absorb round-the-clock industrial load for a diverse range of sectors as coal retires.

[26] Ministry of Energy Transition and Water Transformation (PETRA), parliamentary written reply, July 6, 2026. Available at: https://www.parlimen.gov.my/files/jindex/pdf/JDR06072026.pdf

[27] Data centre power demand in Peninsular Malaysia to surge to 31pct by 2035 (July 1, 2026), NST. Available at: https://www.nst.com.my/news/nation/2026/07/1477411/data-centre-power-demand-peninsular-malaysia-surge-31pct-2035

[28] Malaysia needs to hustle to maintain power grid buffer as data centres flourish (June 20, 2026), The Edge. Available at: https://theedgemalaysia.com/node/810541

Part 2: Technology Options for Diversification

Malaysia's current RE plan under MyRER identifies five key domestic energy resources, with solar representing the largest estimated potential capacity. However, this assessment may not fully capture emerging technologies that could complement the current portfolio and strengthen the power system.

For example, the geothermal potential reflected in MyRER focuses on conventional geothermal technologies and does not account for next-generation geothermal technologies. Nuclear energy, which is becoming an increasingly viable option, is not included.

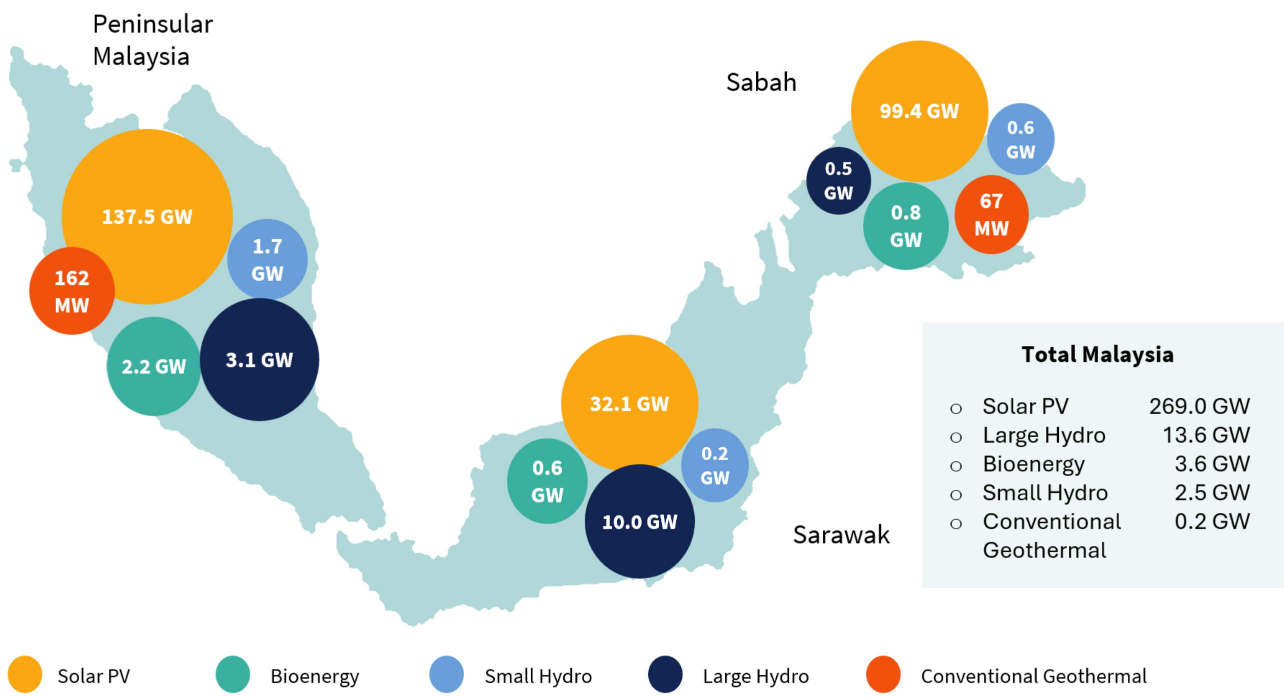

Figure 8: SEDA's current listed renewable energy potential by region and technology. Only conventional geothermal potential is listed under the figure. Source: SEDA, Malaysia Renewable Energy Roadmap (MyRER).

Each technology option below is assessed against three criteria, each of which addresses a specific shortfall in the current state of solar development described in Part 1 (Table 2 summarizes the results).

- The first criterion is whether Malaysia has a domestic resource base: this means primary inputs are available within Malaysia's own territory, so that generation is not contingent on imported fuel or feedstock and its cost base sits largely within the domestic economy.
- Second, whether the technology offers firm 24/7 output: this means power that can be called upon or modulated according to system demand regardless of weather conditions.
- Third, whether the technology can complement solar: namely the ability to fill the parts of the generation profile that solar cannot – the evening peak, overnight baseload, and multi-day supply security – while fitting Malaysia's competing land-use priorities across energy, agriculture, and industry.

Notably, this paper assesses geothermal at greatest length because it scores well on all three criteria yet remains the least developed in policy terms. LDES is discussed second, as a complementary option to solar without added generation capacity. Nuclear is discussed last, because it is a long-term baseload option rather than a near-term diversification measure.

The three options assessed exclude biomass and biogas, which are already in commercial use in Malaysia and can generate dispatchable power. The constraint for biomass and biogas is feedstock rather than technology, limiting how far the technologies can scale. The residues that would fuel biomass thermal plants are already committed to other uses such as mill fuel, mulch, soil nutrients, material inputs, or pellets for export. Volume diverted to power generation is therefore volume not used for more profitable ventures elsewhere. Besides creating resource competition, the byproducts are also low in energy density, carry high moisture content that reduces energy yield per ton, and are limited in the distance for economical collection and transport. This is why the National Biomass Action Plan proposes aggregation infrastructure rather than generation capacity.[29]

Current fuel inputs therefore support the 74.53 MW of biomass and 164.29 MW of biogas now operating, but fuel availability scales with agricultural output rather than with electricity demand. While biomass has a continuing role in Malaysia's mix, it does not offer a pathway to the multi-gigawatt firm capacity that replacing retiring coal-fired generation requires.

Technology	Native resource base	Firm 24/7 output	Complements solar	Stage in Malaysia
Next-generation geothermal	Yes – granite formations across Peninsular Malaysia suggest promising subsurface temperatures[30]	Yes – continuous baseload, small surface footprint	High – covers evening peak and overnight	Exploratory; no national framework; regulated only under Sabah's enactment
Long-duration energy storage	Yes – storage options sourced locally	No – shifts energy rather than generating it, but can deliver firm output for 10 hours to multiple days	High – addresses multi-day and overnight gaps	No dedicated power system-scale storage policy

[29] Pelan Tindakan Biojisim Negara (National Biomass Action Plan). Available at: https://www.mpic.gov.my/kpk/images/mpi_biomass/27032024-NBAP-BOOK-MALAY.pdf
[30] Radiogenic Heat Production in West Malaysian Granites and Implications for Geothermal Energy. Available at: https://www.researchgate.net/publication/392478152_Radiogenic_Heat_Production_in_West_Malaysian_Granites_and_Implications_for_Geothermal_Energy

Technology	Native resource base	Firm 24/7 output	Complements solar	Stage in Malaysia
Nuclear (SMR / Gen III+)	No – reactors, fuel, and services to be imported	Yes – highest firm capacity of the three assessed options	High, but not on the diversification timeline (decision by 2031, development unlikely before 2040)	Early feasibility and NEPIO stage under MyPOWER; no commercial nuclear power experience; long project development timelines
Biomass and biogas	Yes – oil palm residues and palm oil mill effluent (POME)	Yes – dispatchable, subject to feedstock supply	Low – dispatchable against demand, but low potential capacity and competing feedstock uses	Operating: 74.53 MW biomass and 164.29 MW biogas; further FiT 2.0 quotas planned

Table 2: Technology options assessed against the three diversification criteria.

2.1 Next-generation geothermal

2.1.1 Technology viability and current developments

Geothermal electricity generation began in Italy in 1904. Conventional geothermal harnesses naturally-occurring underground reservoirs of heat, water, and permeable or fractured rock. Its limitation is geological: it can only be built where those three conditions occur together, commonly along high-seismicity zones.

Indonesia, which holds an estimated 40% of the world's conventional geothermal resources,[31] relies on hydrothermal technology suited to its volcanic geology. The Philippines does the same, where developers such as the Energy Development Corporation operate wet-steam fields and flash-steam plants. Malaysia lies outside the Pacific Ring of Fire and lacks the geology required for conventional hydrothermal technology.

Next-generation geothermal removes that constraint. Advanced geothermal systems (AGS), also called closed-loop systems, circulate water or another working fluid through sealed underground wellbores to extract heat from hot, dry rock, without requiring a naturally occurring reservoir. This widens the range of geographies where geothermal can be developed at scale. Investment has followed: funding for next-generation geothermal rose from USD 22 million in 2018 to USD 2.2 billion in 2025.[32]

[31] Muhammad Nurdin Walid et al., A strategic analysis of geothermal energy for sustainable energy transition: Case study from Indonesia. Available at: https://www.sciencedirect.com/science/article/pii/S2590174525004350

[32] IEA, Investment in next-generation geothermal is surging. Policies are key to further growth, January 23, 2026, https://www.iea.org/commentaries/investment-in-next-generation-geothermal-is-surging-policies-are-key-to-further-growth

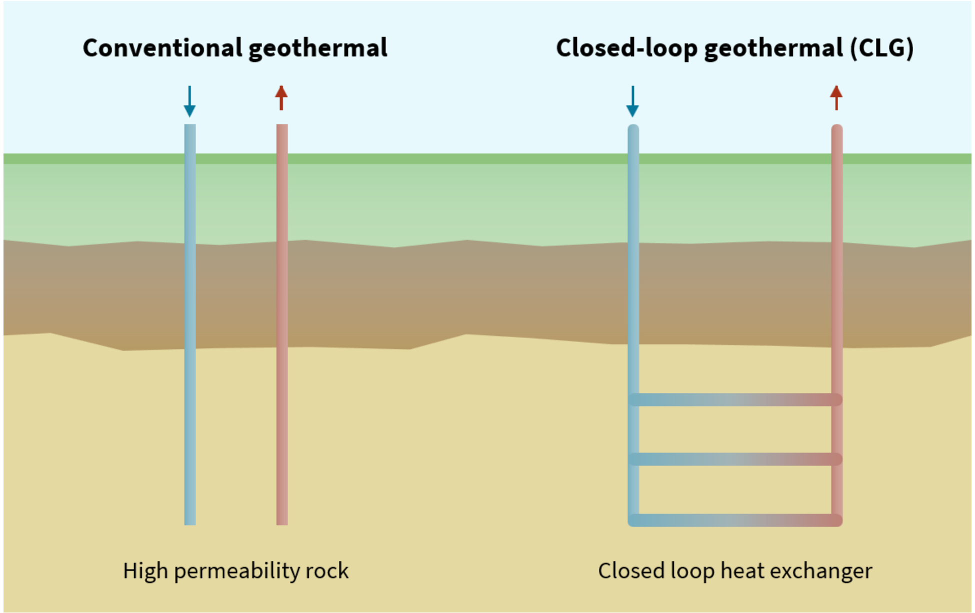

Figure 9: Geothermal power generation technologies. Source: International Energy Agency

Category	How it works	Key advantages	Key limitations
Conventional hydrothermal	Uses naturally occurring hot water or steam from a permeable underground reservoir and brings it to the surface for power generation	○ Commercially mature ○ High output is possible from productive reservoirs ○ Established operating experience	○ Geographically constrained ○ Depends on reservoir quality and requires brine/fluid management
Next-generation geothermal or closed-loop advanced geothermal systems (AGS)	Circulates a working fluid through sealed deep wellbores that function as an underground heat exchanger while the fluid does not need to flow through the surrounding rock	○ No requirement for hydraulic fracturing ○ Wider siting flexibility ○ Limited subsurface water interaction ○ Lower exposure to permeability and fluid-flow risk ○ Minimal to no seismicity concerns	○ Precise drilling ○ Performance depends on heat-transfer efficiency and drilling cost ○ Early-stage commercial deployment

Table 3: Comparison of geothermal technology pathways.

Drilling surveys for next-generation geothermal are already underway in comparable non-volcanic settings. Eavor Technologies' Geretsried project in Germany represents a major milestone for AGS.[33] The developer successfully demonstrated that closed-loop systems could reliably repeat the thermosiphon effect, which allows the system to operate without a pump to circulate fluid by leveraging temperature differences. Moreover, the system proved to be flexible, able to go back online after shut-down without an external power source. In Singapore, work led by Nanyang Technological University has identified high

[33] Eavor, Eavor reports first electricity generation at pioneering geothermal project in Geretsried, Germany, December 4, 2025. Available at: https://www.thinkgeoenergy.com/eavor-reports-first-electricity-generation-at-pioneering-geothermal-project-in-geretsried-germany/

heat-producing granites,[34] and in April 2026, Singapore's Energy Market Authority launched a feasibility study focused on next-generation geothermal systems.[35]

2.1.2 Applicability to Malaysia: industry readiness and regulatory framework

Next-generation geothermal development in Malaysia will strengthen energy security and resilience. As a domestic source of firm, round-the-clock power, it would reduce Malaysia's need for imported fuels for thermal generation.

Malaysia has no domestic industrial base focused on geothermal, conventional or next-generation. However, Malaysia does have drilling and management capabilities from the oil and gas sector. Petronas already operates advanced directional drilling systems, including bottom-hole assemblies (BHAs), intelligent circulation systems, and real-time measurement-while-drilling (MWD) tools, all transferable to AGS. Beyond drilling technologies, Petronas also has the human resources to conduct project evaluation, planning, and management, as well as the construction, operation, and maintenance of surface facilities.[36]

Oil and gas capability is the principal mechanism by which next-generation geothermal costs are expected to fall. The International Energy Agency (IEA) estimates that up to 80% of geothermal project investment draws on expertise and technology originating in the oil and gas sector, and global estimates by the IEA project that costs for next-generation geothermal could fall by around 80% by 2035, to roughly USD 50 per MWh, on the basis of policy support combined with oil and gas industry engagement. At that level it would rank among the cheapest dispatchable low-emissions sources.[37] The US National Renewable Energy Laboratory's Annual Technology Baseline applies learning rates of 18–35% to geothermal on the same basis.[38]

Building on the government's existing support for conventional geothermal exploration, Malaysia should facilitate next-generation pilot projects in partnership with private developers. Pilots will help establish drilling and operating benchmarks and test commercial viability, and lessons from the pilots will inform regulatory and commercial frameworks. As projects move toward commercialization, targeted mechanisms such as government-backed guarantees, fixed pricing, and streamlined approvals should be considered to support wider deployment.

Malaysia has no national regulatory framework for geothermal energy. Regulation is jurisdiction-specific and operates at the state level: only Sabah covers geothermal, under the Sabah Renewable Energy Enactment and the Feed-In Approval and Feed-In Tariff Rate Rules 2024.[39] A federal framework could draw on that state-level precedent. Alternatively, Malaysia can also draw on other markets. The United States' Geothermal Energy Advancement Bill, which has already passed the U.S. House of Representatives and is awaiting approval in the Senate, could offer one model for a national framework.[40]

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[34] NTU, Strong geothermal potential discovered in northern Singapore (July 4, 2025). Available at: https://www.ntu.edu.sg/news/detail/strong-geothermal-potential-discovered-in-northern-singapore

[35] EMA to Conduct Study on Feasibility of Deploying Geothermal Energy Systems. Available at: https://www.ema.gov.sg/news-events/news/media-releases/2026/EMA-to-conduct-study-on-feasibility-of-deploying-geothermal-energy-systems

[36] IEA, Overview of synergies between the oil and gas and geothermal industries. Available at: https://www.iea.org/reports/the-future-of-geothermal-energy/overview-of-synergies-between-the-oil-and-gas-and-geothermal-industries

[37] IEA, The Future of Geothermal Energy, December 13, 2024. Available at: https://www.iea.org/reports/the-future-of-geothermal-energy

[38] Geothermal, Annual Technology Baseline, NREL. Available at: https://atb.nrel.gov/electricity/2024/geothermal

[39] Sabah Renewable Energy (Feed-In Approval and Feed-In Tariff Rate) Rules 2024, Energy Commission of Sabah. Available at: https://ecos.gov.my/sites/default/files/uploads/para/attachments/2024-01/20.%20Sabah%20Renewable%20Energy%20%28Feed-In%20Approval%20and%20Feed-In%20Tariff%20Rate%29%20Rules%202024.pdf

[40] H.R.5631 — 119th Congress (2025-2026). Available at: https://www.congress.gov/bill/119th-congress/house-bill/5631

2.1.3 Technology limitations

The main constraints on geothermal development are high front-loaded capital costs, the risk of well failure, long development timelines, limited Malaysian operating experience, and the early stage of commercial deployment. Advances in drilling technology are the principal route through which those constraints ease. Insulated Drill Pipe (IDP), Active Magnetic Ranging (AMR), and Rock-Pipe sealant each improve drilling precision and efficiency while reducing project costs, as Eavor's experience at Geretsried shows: the company reported cutting drilling times and drill-bit replacement rates over two years of operation.[41]

Eavor's experience in Germany also demonstrates how targeted policy support can facilitate the commercialization of novel geothermal technologies. Eavor received a grant from the EU Innovation Fund and European Investment Bank (EIB) financing backed by an InvestEU guarantee,[42] as well as assurances that electricity output from the project would be eligible for long-term feed-in support under Germany's Renewable Energy Sources Act.[43]

2.2 Long-duration energy storage

2.2.1 Technology viability and current developments

LDES systems can provide round-the-clock and low-irradiation scenario backup for non-firm electricity generation and can also retain excess power generated during periods of peak production. Storage technologies can be divided into four categories: electrochemical, thermal, mechanical, and chemical.[44]

Category	How it works	Examples of actual technologies
Electrochemical	Stores energy through reversible chemical reactions inside a battery cell	○ Lithium-ion and alkaline batteries ○ Sodium-ion batteries ○ Iron-air batteries ○ Flow batteries (Vanadium, H2-iron, acid-based, etc.)
Thermal	Converts electrical energy into heat and stores it in insulated materials	○ Molten salt thermal storage ○ Latent heat storage ○ Sensible heat storage
Mechanical	Stores energy physically using potential or kinetic forces	○ Pumped Hydro Storage (PHS) ○ Compressed Air Energy Storage (CAES) ○ Liquid Air Energy Storage (LAES)
Chemical	Uses excess electricity to produce combustible or reactive chemical fuels	○ Ammonia ○ Hydrogen

Table 4: Energy storage technology categories.

41 Eavor, Eavor reports first electricity generation at pioneering geothermal project in Geretsried, Germany, December 4, 2025. Available at: https://www.thinkgeoenergy.com/eavor-reports-first-electricity-generation-at-pioneering-geothermal-project-in-geretsried-germany/

42 EIB, Germany: EIB and EU Innovation Fund support Eavor's innovative geothermal technology in Bavaria. Available at: https://www.eib.org/en/press/all/2024-168-eib-and-eu-innovation-fund-support-eavor-s-innovative-geothermal-technology-in-bavaria?

43 Eavor, Eavor Announces a Commercial Eavor-Loop Project to be built in Geretsried, Germany, May 1, 2022. Available at: https://eavor.com/press-releases/eavor-announces-a-commercial-eavor-loop-project-to-be-built-in-geretsried-germany/

44 LDES Council, Driving to Net Zero Industry Through Long Duration Energy Storage (November 2023). Available at: https://ldescouncil.com/wp-content/uploads/2025/05/LDESIndustrialDecarbonization_May2024.pdf

Malaysia is exploring several of these categories, though attention to-date has concentrated on two. PETRA has considered pumped hydro storage given the availability of suitable off-river sites, but the environmental impacts of conventional pumped hydro, including reservoir disruption and biogenic emissions, mean its development does not align with existing environmental impact goals. Electrochemical storage, like BESS, is already operating in Malaysia, but faces the aforementioned constraints. Thermal and chemical storage have yet to feature in Malaysian procurement, though both feature heavily in international LDES benchmarks.

2.2.2 Applicability to Malaysia

According to MyRER, Malaysia's commitment to achieve a 31% renewable energy target by 2025 was expected to be fulfilled largely by solar, with installed solar capacity reaching around 7,280 MW. As solar generation approaches 30% of peak demand, additional flexibility measures are required to maintain power system stability and manage variability.

MyRER identifies around 5.7 GWh of energy storage as part of the targeted system requirements to support higher levels of solar integration.[45] MyBeST and LSS6 both procure BESS, which is modular and deployable across a wide range of locations but discharges at rated power for only one to four hours. LDES, by comparison, delivers bulk power from 10 hours to multiple days.[46] The current pipeline is therefore configured for intraday flexibility rather than for the multi-day shortfalls that matter most to constant industrial demand.

Wider LDES implementation depends on an electricity market framework that values long-duration storage explicitly, through mechanisms such as regulatory caps or floors, or a market-based pricing model. Malaysia has begun to require storage in specific segments: since January 2026 the Energy Commission has required certain solar installations, including SELCO systems, to incorporate energy storage.[47] That requirement addresses short-duration storage, but Malaysia does not yet have a dedicated nationwide policy supporting grid-scale or long-duration storage integration.

Malaysia can draw lessons from countries such as Australia, which has built policy specifically for LDES. Under its Capacity Investment Scheme, Australia uses competitive tenders and revenue underwriting to provide a minimum financial safety net, helping close the financing gap for investors.[48] Australia also adopts a whole-of-system approach through its Integrated System Plan (ISP), which helps identify the required storage durations, transmission infrastructure needs, and capacity targets. This supports least-cost modeling to map power system needs. The approach could guide Malaysia in establishing a centralized national blueprint and a suitable financial model to support the deployment of LDES.

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[45] SEDA, Malaysia Renewable Energy Roadmap. Available at: https://www.seda.gov.my/reportal/wp-content/uploads/2021/12/MyRER_webVer-1.pdf
[46] Boostess Energy, How long can BESS store energy? (April 1, 2026). Available at: https://boostess.energy/blog/how-long-can-bess-store-energy/
[47] Baker McKenzie, Malaysia: 2026 Updates to Renewable Energy Schemes (January 28, 2026). Available at: https://www.bakermckenzie.com/en/insight/publications/2026/01/malaysia-2026-updates-to-renewable-energy-schemes
[48] Australian Government Department of Climate Change, Energy, the Environment and Water, Capacity Investment Scheme. Available at: https://www.dcceew.gov.au/energy/renewable/capacity-investment-scheme

2.2.3 Storage solutions for solar beyond BESS

As solar generation cannot easily match constant electricity demand, storage or other complementary technologies are needed. In Malaysia, cloud cover during the monsoon and haze seasons creates the multi-day periods of low-irradiation that short-duration BESS cannot fully cover. There is no one-size-fits-all LDES solution. Flow batteries are the most established option at scale: this form of electrochemical LDES is efficient and competitive for grid applications of 10 hours or longer.[49] Other options include iron-air batteries and thermal energy storage, both of which can accommodate for solar generation.

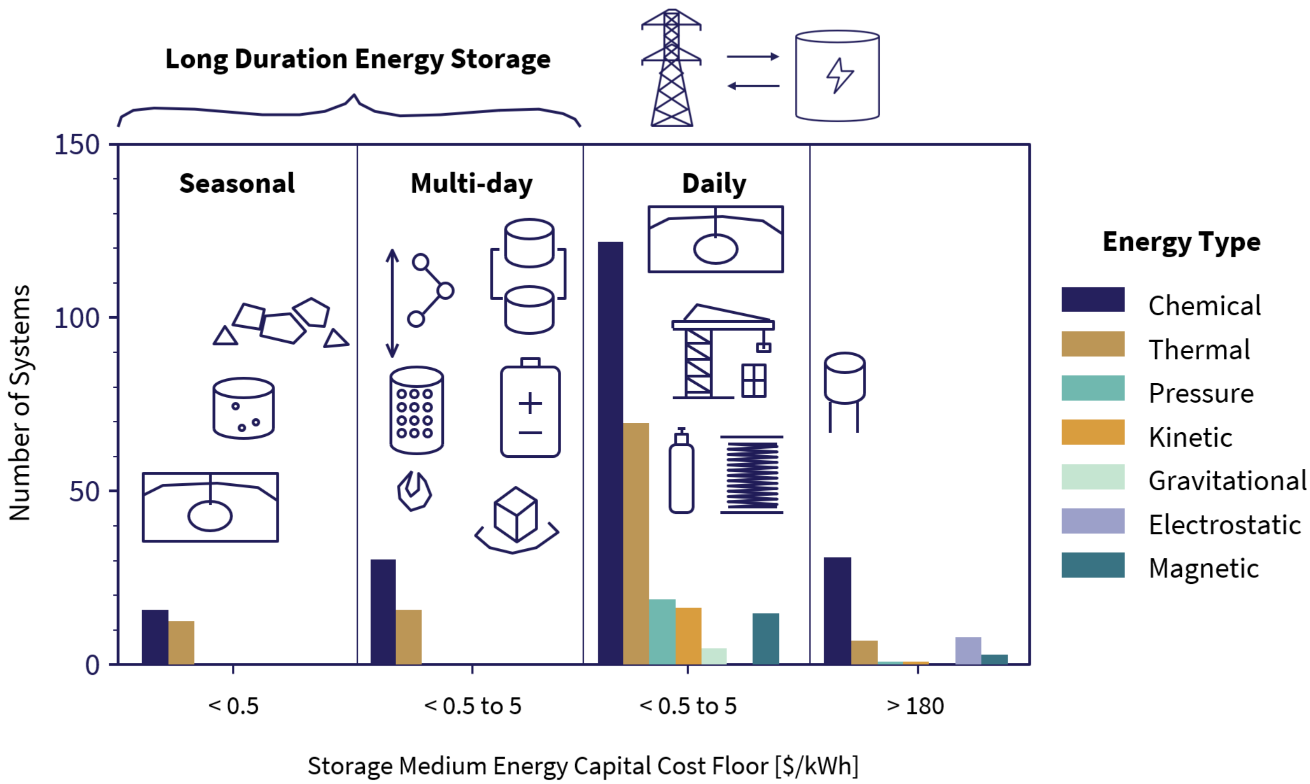

Figure 10: A techno-economic survey of energy storage media for long-duration energy storage applications. Source: Cell Reports Sustainability

[49] ZareAfifi et al., Path to future markets: Method for quantifying long-duration energy storage competitiveness. Available at: https://www.sciencedirect.com/science/article/pii/S2589004226011260

2.3 Nuclear

2.3.1 Technology viability and current developments

Nuclear remains at the program development and feasibility stage in Malaysia. Under the Thirteenth Malaysia Plan (2026–2030), the government reintroduced nuclear as a potential source of generation from 2031. An earlier program, launched in 2011 under the Malaysia Nuclear Power Corporation, was suspended in 2018 following the Fukushima disaster and a change of government.

In 2024, the government designated MyPOWER Corporation as the Nuclear Energy Programme Implementing Organization (NEPIO). The corporation completed pre-feasibility work the same year,[50] and began a detailed technical and legal feasibility assessment in August 2025,[51] working with the International Atomic Energy Agency (IAEA) on reactor technology and vendor evaluation.[52]

Malaysia has not yet selected a reactor technology. A key choice to be made is between commercial maturity and unit size. Small modular reactors (SMRs) offer lower upfront capital and smaller footprint requirements, as well as passive cooling, but remain at an earlier stage of commercial deployment globally. Generation III and III+ reactors carry higher capital outlays and longer timelines but benefit from an established operating track record and supply chains.

Category	How it works	Key advantages	Key limitations
Small modular reactors (SMR)	Factory-built reactor modules deployed in smaller unit sizes and added incrementally	Lower upfront capital per unit; smaller physical footprint; passive cooling designs that enhance safety	Earlier stage of commercial deployment globally; vendor, fuel, and service dependency; no domestic operating experience
Generation III / III+ reactors	Large conventional reactors constructed on site	Established operating experience and international supply chains; suited to the larger baseload requirement of Peninsular Malaysia's grid	Significantly higher upfront capital and longer development timelines; siting and public acceptance requirements

Table 5: Comparison of nuclear technology pathways under consideration.

2.3.2 Applicability to Malaysia: industry readiness and regulatory framework

Malaysia has operated a 1 MW research reactor since 1982, but the reactor is used for scientific research and isotope production. It provides a useful foundation for developing Malaysia's nuclear capabilities, but moving to a commercial plant would still require expertise in licensing, financing, construction, and plant operation. The Atomic Energy Licensing (Amendment) Act 2025 materially strengthens the legal framework by adding provisions on safety, security, safeguards, nuclear material accounting, facility life cycles, decommissioning, transport, and liability. A federal gazette brought most provisions into force on December 1, 2025, but some sections remain deferred. As a result, the full amended architecture is not yet operative.

[50] The Star, Nuclear on the horizon (November 8, 2025). Available at: https://www.tnb.com.my/assets/newsclip/08112025a.pdf

[51] WNN, Malaysia launches nuclear energy feasibility study (August 19, 2025). Available at: https://www.world-nuclear-news.org/articles/malaysia-launches-nuclear-energy-feasibility-study

[52] NST, Malaysia on solid footing to pursue nuclear power (June 14, 2026). Available at: https://www.nst.com.my/news/nation/2026/06/1462966/iaea-chief-malaysia-solid-footing-pursue-nuclear-power

Malaysia's international legal position also remains incomplete. The IAEA's February 2026 country factsheet shows that Malaysia is a party to the Early Notification and Assistance Conventions, but not a party to several key instruments.[53] These include the Convention on Nuclear Safety, the Joint Convention on spent fuel and radioactive waste, the Convention on the Physical Protection of Nuclear Material and its Amendment, and the principal liability conventions listed by the IAEA.

Current technical and regulatory gaps mean that nuclear energy, while promising, is at an early stage for Malaysia. Nuclear is therefore best treated as a long-term baseload solution rather than a near-term diversification measure. Moving from feasibility to deployment will require sustained political will and significant coordination across government agencies and stakeholders over multiple administrations.

2.3.3 Technology limitations

To develop nuclear power, Malaysia will need to import reactors, nuclear fuel or enrichment services, specialized components, software, and other services and equipment. Malaysia holds established ties with all current leaders in nuclear energy, including the United States, Russia, China, and France. Selecting long-term partners is therefore a political decision as much as a technology decision, and one that will have implications for Malaysia's foreign policy, which is officially non-aligned.

In terms of commercial maturity, there are only a small number of SMRs operating globally, and the technology has not yet been widely deployed. This is in comparison to other firm options such as next-generation geothermal, which offers clearer near-term opportunities for scalable deployment.

There are additional institutional and legal limitations for nuclear power development which will require the establishment of a fully capable and independent regulatory system and institutions. This system will need to manage appropriate arrangements for nuclear fuel and radioactive waste, secure long-term financing, and build a capable workforce to support the nuclear sector over the long term. This will require significant investment by the state, in addition to the capital costs for the technology itself.

[53] IAEA, Malaysia Membership Profile. Available at: https://ola.iaea.org/Applications/FactSheets/Country/Detail?code=MY

Part 3: Policy Recommendations

Recommendation 1: Operationalize RE Diversification Under NETR

Recommendation 1: Operationalize RE Diversification Under NETR		
Priority	**Target**	**Implementor**
Short-term	Upcoming review of the NETR under the Ministry of Economy	Ministry of Economy (Energy Division); Ministry of Energy Transition and Water Transformation (PETRA); Sustainable Energy Development Authority (SEDA); coordination via the National Energy Council (MTN) *Enablers: Tenaga Nasional Berhad (TNB), Single Buyer*
Overview Review and update the NETR to set RE source diversification targets based on factors such as energy security, firmness, and projected baseload requirements.		
Tools and Mechanism ○ Conduct an interim review of the NETR to make RE diversification a national, cross-agency mandate and priority ○ Leverage the MTN to coordinate across multiple ministries and government-linked bodies to achieve diversification goals		
Expected Outcomes ○ Government agencies to adopt a whole-of-system approach to energy transition beyond broad capacity targets, with improved inter-agency coordination to facilitate diversification projects		

Rationale

Malaysia should embed renewable energy diversification as an explicit policy objective within the NETR. The NETR's 70% renewable energy installed capacity target has been an effective tool to mobilize investment and accelerate deployment. But building capacity does not address broader challenges faced by the energy system, such as energy security, system reliability, and retiring baseload, especially as it faces increased constant demand. The next phase of Malaysia's renewable energy policy should therefore focus on the value that additional capacity contributes to the power system, above adding capacity overall.

Recommended action

PETRA, the Energy Commission, SEDA, Single Buyer, and industry stakeholders should develop a system-value framework alongside existing NETR targets. This framework can track indicators such as dispatchable renewable capacity, non-solar renewable generation, storage duration, domestic resource utilization, and land-use intensity. These indicators should complement, rather than replace, headline renewable energy targets by providing greater visibility into the composition and resilience of Malaysia's future generation mix.

Implementation Priorities

A system-value approach enables policymakers to assess different technologies against common strategic objectives without presupposing specific technology outcomes. Next-generation geothermal, LDES, nuclear, and other emerging technologies can be evaluated according to their contribution to system reliability, dispatchability, domestic resource availability, and cost competitiveness. Such an approach would provide a more transparent basis for future procurement, incentive design, and infrastructure planning.

Adopting system-value metrics will improve policy coherence across ministries and agencies involved in energy planning. It will allow policymakers to distinguish between renewable energy investments that primarily contribute to capacity targets and those that address wider system needs, including firm generation requirements, ramping and reserve capability, and long-term energy security. This will provide a clearer framework for determining where technologies such as solar, battery storage, geothermal, and future low-carbon resources should sit within Malaysia's broader energy transition strategy through 2050.

Recommendation 2: Clarify Regulatory Pathways for Firm, Domestic, and Storage-Backed Resources

Recommendation 2: Clarify Regulatory Pathways for Firm, Domestic, and Storage-Backed Resources		
Priority	**Target**	**Implementor**
Short-term	Prospective investors and renewables developers	Ministry of Energy Transition and Water Transformation (PETRA), Energy Commission (ST), Sustainable Energy Development Authority (SEDA), Malaysian Investment Development Authority (MIDA) *Enablers: Regulatory bodies including, but not limited to, the Lands and Mines Department (PTG) and the Mineral and Geosciences Department (JMG)*
Overview Provide regulatory clarity for emerging non-solar technologies by establishing clear licensing, resource ownership, revenue- and royalty-sharing, permitting, and grid access frameworks, with priority given to technologies that can contribute to system reliability.		

Tools and Mechanism

- Develop a dedicated regulatory framework or policy blueprint for emerging technologies to clarify resource ownership, exploration rights, environmental impact assessment requirements, and grid interconnection processes
- Formalize agency roles and coordination spanning PETRA, ST, SEDA, PTG, JMG, and relevant state authorities

Expected Outcomes

- Reduced regulatory uncertainty and project development risks for investors
- Improved bankability of next-generation geothermal, LDES, and other emerging technologies

Rationale

Malaysia should establish clearer regulatory pathways for clean technologies that contribute to system resilience, reliability, and energy security. While solar deployment has benefited from established licensing, procurement, and grid access frameworks, non-solar RE developers engaged for this paper highlighted continued uncertainty regarding resource ownership, approval requirements, grid interconnection arrangements, and long-term eligibility under RE policies. Firm RE developers and researchers engaged in the preparation of this paper identified regulatory uncertainty and lack of commitment as the principal barriers to sourcing capital for non-solar firm technologies.

Recommended action

For emerging technologies, developers are unlikely to commit capital to geothermal, LDES, and other non-solar technologies if they remain uncertain about permitting requirements, resource rights, environmental approvals, market participation rules, or future policy treatment. Establishing transparent regulatory pathways will improve investor confidence and reduce development risk during the early stages of technology adoption. Next-generation geothermal provides the clearest example of this challenge. Geothermal researchers engaged for this paper highlighted the need for a national geothermal policy to provide regulatory certainty throughout the entire planning, geospatial mapping, commercial risk-sharing, and commissioning process.

Dedicated, technology-specific frameworks should clarify exploration and resource rights, royalty allocations, geological data and research access, environmental requirements, grid-connection procedures, and potential changes to commercial mechanisms. Resource ownership is the most consequential of these for geothermal. Onshore drilling implicates land categories that do not arise offshore, including Malay reserve land and state land, all of which are regulated by state-level authorities. A production-sharing arrangement of the kind Petronas operates offshore for oil and gas is therefore difficult to replicate onshore without a framework that resolves how exploration rights and royalties are allocated between federal and state parties.

Implementation Priorities

The regulatory environment for geothermal cuts across agencies including the Mineral and Geosciences Department (JMG), SEDA, local land authorities, and the Energy Commission. The termination of the Apas Kiri project, for instance, raises the need for a dedicated regulatory framework to address issues including licensing processes, agency responsibilities, and long-term policy treatment.

Case Study: Apas Kiri, Tawau

In 2016, Tawau Green Energy secured a 21-year FiT contract for a 37 MW conventional geothermal plant at Apas Kiri in Sabah, drawing on the state's hydrothermal resources. The project encountered subsurface drilling delays and capital overruns, and SEDA terminated the permit and redistributed the unused quota in late 2018.

The lack of a dedicated regulatory framework contributed to the failure of the project. There are three justifications for increased government involvement in future projects. First, there was no risk-sharing mechanism of the kind used in upstream oil and gas development, meaning that exploration risk was absorbed by the developer. Second, there was no accountability pathway, and responsibility was distributed across SEDA, JMG, state land authorities, and the Energy Commission. Third, there was no established procedure for handling geological data, resource rights, or quota when a project fails, so the exploration effort produced no redeemable public asset.

Sabah's subsequent transition into leading its own energy policy through the Energy Commission of Sabah (ECoS), and the Apas Kiri site's reintroduction under ECoS's Sabah Energy Roadmap and Master Plan 2040, suggest that local authorities plan to resume geothermal development in the state.[54]

The same principle should apply across other technologies. LDES should be recognized as an independent source of power system reliability. Nuclear should remain separate from near-term renewable procurement efforts, but Malaysia should continue developing a transparent readiness framework with clearly defined institutional, technical, regulatory, and public engagement milestones before any future deployment decision.

[54] Energy Commission of Sabah, Sabah Energy Roadmap and Master Plan 2040 (SE-RAMP 2040). Available at: https://ecos.gov.my/sites/default/files/uploads/downloads/2023-09/SABAH%20ENERGY%20ROADMAP%20AND%20MASTER%20PLAN%202040%20%28SE-RAMP%202040%29.pdf

Recommendation 3: Reform Procurement Mechanisms and Feed-in Incentives

Recommendation 3: Reform Procurement Mechanisms and Feed-in Incentives		
Priority	**Target**	**Implementor**
Medium-term	Renewable energy developers, corporate offtakers, utilities, and investors seeking to commercialize emerging renewable and storage technologies.	Ministry of Energy Transition and Water Transformation (PETRA), Energy Commission (ST), Sustainable Energy Development Authority (SEDA)
Overview Reform procurement and incentive frameworks to reward technologies for their contribution to system value, including firmness, reliability, flexibility, storage duration, and domestic energy security. The objective is to price the SAC according to its various cost components, and to improve the commercial viability of emerging technologies while minimizing fiscal exposure.		
Tools and Mechanism ○ Reform existing renewable energy procurement mechanisms, particularly the Corporate Renewable Energy Supply Scheme (CRESS), including through variable charges based on transparent SAC components ○ Expand coverage of feed-in mechanisms to establish a Feed-in Premium (FiP) ○ Amend the Renewable Energy Act 2011 and the Sustainable Energy Development Authority Act 2011 to update FiT rates and eligible technologies		
Expected Outcomes ○ Improve the commercial viability of next-generation geothermal, LDES, and other emerging technologies through a lower levelized cost of electricity (LCOE) and greater cost-forecasting confidence for RE developers ○ Leverage existing market mechanisms through hybrid market-based support mechanisms ○ Promote investment in technologies that provide grid reliability and energy security		

Rationale

The Malaysian government should consider reforming existing procurement mechanisms and fiscal incentives to better compensate technologies that contribute system value to the power system. Existing RE mechanisms have been successful in driving capacity growth and lowering generation costs, particularly for solar PV. The next phase can build on that success by extending the same commercial certainty to firm and storage-backed resources.

Future stages of the energy transition will require additional investment in technologies that contribute to firmness, scalability, storage duration, and energy security. Notably, Malaysia has already taken initial steps in this direction through the differentiation of *firm* and *non-firm* supply under CRESS, where the SAC recognizes the added value of reliability and dispatchability and charges a lower SAC for *firm* energy supply.

Recommended action

The most direct reform available is to price the SAC on cost causation: the principle that a generator should be charged for the network services it causes the system to provide. The six components set out in Section 1.1.3 provide a framework (see also Table 6 below). Three of the six are fixed: network, operation, and administration costs are driven by every generator connected to the system and should be recovered from all of them on the same basis. The remaining three vary with how a generator performs. A plant with constant generation that imposes minimal balancing cost, because its output does not deviate materially from forecast, and minimal reliability cost, because the system does not need to hold standby capacity against its absence. A non-firm generator imposes both in full. A non-firm generator paired with four-hour storage sits between the two: the storage covers an evening peak but not a multi-day shortfall, so the system must still hold capacity against the hours it does not cover.

SAC component	Continuously dispatchable (e.g., geothermal)	Solar + 4-hour BESS	Solar without storage
Network (transmission cost)	Full	Full	Full
Reliability (cost of holding dispatchable capacity)	Minimal: no standby capacity required	Partial: covered at the evening peak, but not overnight or multi-day	Full: standby capacity required whenever output is unavailable
Balancing (correcting deviations in forecast)	Minimal: output does not significantly deviate from forecast	Reduced: storage absorbs short-term deviation	Full: output varies with irradiation
Operation and maintenance	Full	Full	Full
System losses	Variable based on location	Variable based on dispatchability and location	Variable based on dispatchability and location
Administration	Full	Full	Full

Table 6: Proposed six SAC component applications across generation profiles.

Applied this way, the total charge is not binary, but rather sits somewhere on a range. Continuously dispatchable renewable generation would sit at the lower end, storage-backed non-firm generation in the middle, and non-firm output without storage at the upper end. The difference between the middle and the lower end reflects the reliability and balancing costs a partly firm resource imposes. The difference between the middle and the upper end remains substantial, which preserves the incentive to pair solar with storage that the current structure has successfully created.

Implementation Priorities

First, PETRA and the Energy Commission should publish the SAC methodology so that developers can model the charge across a project's life and identify which components their technology drives. Second, the charge should be set by reference to those components rather than by a binary classification, so that a resource that does not impose a given cost is not encumbered with it. Pricing on power system impact also removes the need for discretionary discounts or waivers.

Beyond CRESS reforms, Malaysia should consider the introduction of a Feed-in Premium (FiP) mechanism that complements market-based procurement channels. Under such a model, renewable energy developers could continue selling power directly to corporate offtakers through CRESS while receiving an additional premium linked to system-value attributes such as firm renewable output, storage capability, or domestic resource utilization. This dual-revenue structure would preserve market discipline by requiring projects to secure commercial offtakers, while providing targeted support for technologies whose broader grid and energy security benefits are not fully valued through bilateral electricity sales alone. Compared with traditional subsidy schemes, a FiP framework would allow government support to be directed toward specific policy objectives related to diversification, reliability, and resilience, while leaving private offtakers to drive the majority of project revenues. Jurisdictions including Japan, for instance, have transitioned from traditional feed-in tariff systems toward feed-in premium frameworks that encourage renewable developers to participate in competitive power markets while receiving supplemental support tied to policy objectives.[55]

Finally, SEDA should review and update existing FiT categories to reflect new technological developments since the enactment of the Renewable Energy Act 2011. Current tariff structures were designed around the technology landscape of the early 2010s and do not reflect the cost structures and risk profiles of emerging resources such as AGS, co-located generation and storage, or LDES. A review of FiT eligibility categories and tariff differentiation would represent a relatively low-cost and straightforward step to improve policy certainty for investors and would allow tariff structures to recognize system-value attributes alongside generation output.

[55] Corporate PPAs in Japan and Asia Pacific: Regulatory Changes and Market Growth, *Bird & Bird,* May 11, 2026. Available at: https://www.twobirds.com/en/insights/2026/corporate-ppas-in-japan-and-asia-pacific-regulatory-changes-and-market-growth