From tenaga to tindakan: sparking Malaysia's coal-to-clean transition

Using the Coal Asset Transition (TZ-CAT) tool

May 2025

Thu Vu

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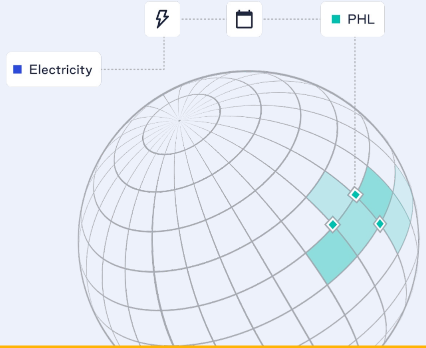

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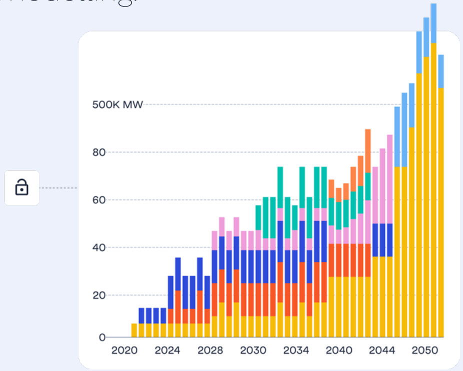

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Our analysts help decision-makers build the skills and knowledge they need to better understand energy transition risks and opportunities.

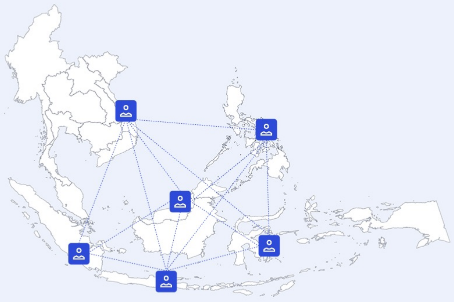


Table of Contents

About TZ-CAT

A background on the who, what, why and how of the Coal Asset Transition (TZ-CAT) tool

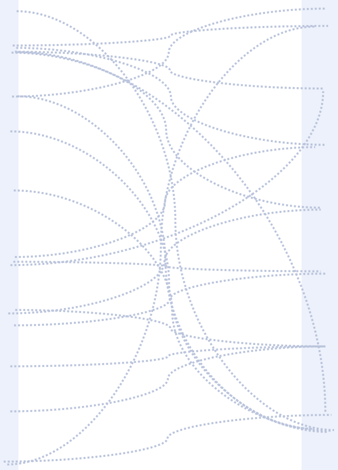
The Coal Asset Transition (TZ-CAT) tool provides foundational economic, financial, operational and environmental plant-level data to analyse the potential for system-level transition.

- Indonesia: released October 2022
- Philippines: released January 2024, to be updated in 2025
- Malaysia: released May 2025

Data in, data out: Understanding TZ-CAT metrics

CAT provides metrics based on the asset's technological specifications, cash flows, operations, and environmental performance.

Metrics	Inputs	Outputs
Technological Specifications	Boiler Type	Cost of abatement (USD/tCO2)
Operational	Age	Buy-out cost (USD/year)
Cash Flows	Installed capacity	Net present value (USD)
Environmental	Coal type & source	Retirement year
	Thermal efficiency	Estimated PPA tariff (USD/MWh)
	Average Generation or Unit sales	SR & LR profitability (USD/MWh)
	Revenue	Emissions savings (tCO2)
	Fuel cost	
	O&M cost	
	Emission intensity & factor	



Use cases

TZ-CAT is a foundational dataset that can support a range of use cases

High-level screening to identify regions to prioritise for phase-out based on various screening metrics

The development of insights and policy recommendations for GFANZ's Managed Phaseout of Coal in Asia-Pacific report.

Asset-level deep dives into financial metrics, operating costs, and environmental externalities

Bankers and investors have used TZ-CAT data as the starting point for discounted cash flow analysis and retirement structures, including the World Economic Forum.

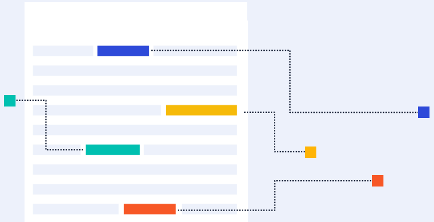
Identifying candidates for coal phase-out at the asset level based on criteria most important to the end user

Carbon Trust's Supporting a rapid, just and equitable transition away from coal report, analysing eligible coal assets in the province of Odisha, India.

Output formats

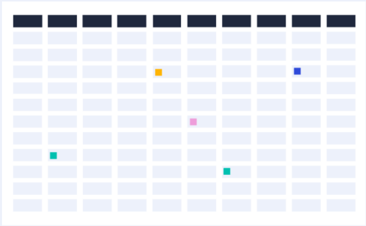
Learn more about TZ-CAT and explore the data in its different forms and functions

Technical annex detailing the sources, assumptions and methods used for each metric and asset



[DOWNLOAD HERE](#)

Dataset download (Excel sheet) with data points by plant



[DOWNLOAD HERE](#)

Analyst slide deck and blogs providing findings, insights and use cases for the dataset

TL;DR

Key takeaways from TZ-CAT Malaysia

Energy transition insights from TZ-CAT [1]

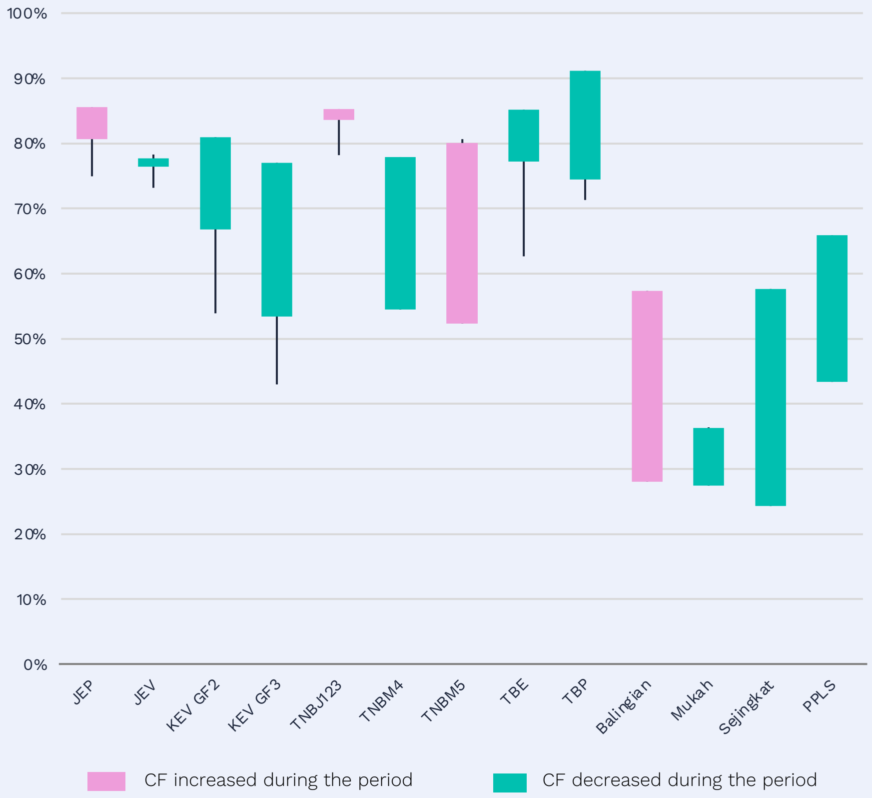
What the data tells us

1. **Malaysia manages its baseload coal fleet with notable flexibility, suggesting transition opportunities.** Our analysis finds that coal plants in Peninsular Malaysia – home to 91% of the country's coal fleet – operate at exceptionally high capacity factors, averaging 74% over the observed period. However, recent fluctuations in annual utilisation, driven by subdued demand, volatile fuel costs and plant outages, suggest that the system has a degree of built-in flexibility. This adaptability will be critical as the system evolves, particularly with the integration of more renewable energy, including the upcoming wave of utility-scale solar projects.

2. **Reliability issues on Malaysia's coal plants have direct consequences on tariffs and profitability.** Technical malfunctions are common, often resulting in missed performance targets under power purchase agreement terms. This typically leads to financial penalties, such as deductions in capacity and energy payments, translating into reduced revenues and average tariff rates.

Malaysia's baseload, yet flexible, coal fleet

Annual capacity factor by plant between 2020-2023 (%)



Source: TransitionZero (2025)

Energy transition insights from TZ-CAT [2]

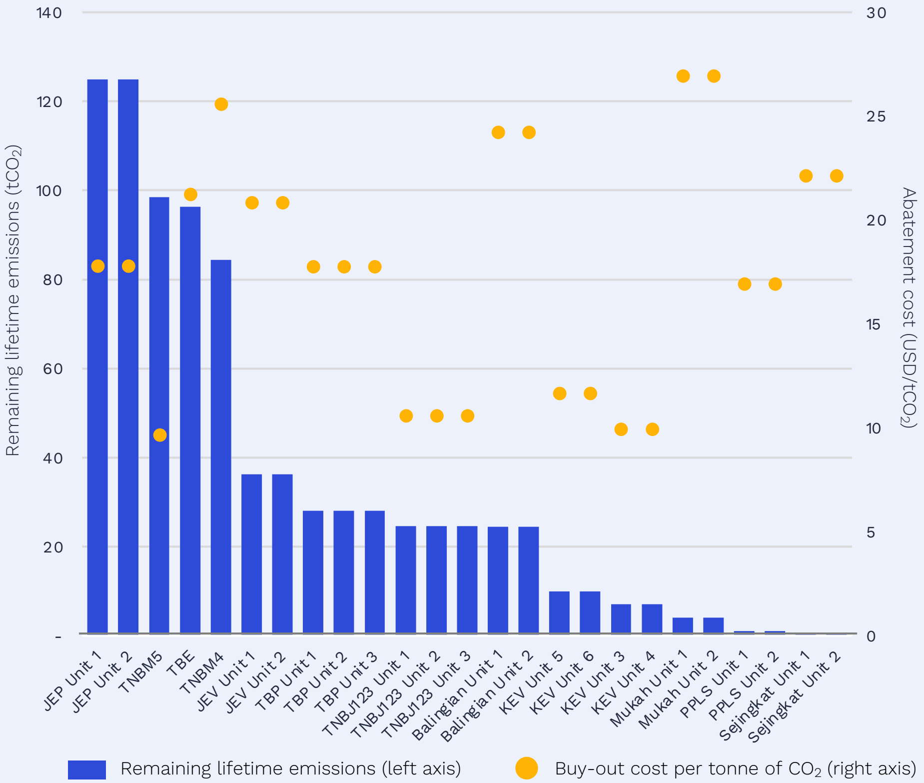
What the data tells us

3. **Greatest emissions reduction potential lies with the youngest and largest assets, but tailored transition strategies will be needed.** Five power units – Tuanku Muhriz (JEP) Units 1 and 2, Manjung Five (TNBM5), Tanjung Bin Energy (TBE), and TNB Janamanjung Generating Facility 2 (TNBM4) – are projected to account for 62% of coal fleet emissions through 2044, due to their size, existing utilisation rates, and remaining lifespans. These assets offer the greatest potential for both immediate and long-term emissions reductions; however, appropriate intervention strategies will vary by asset. Abatement costs average USD 18/tCO_2, ranging from USD 10/tCO_2 to USD 26/tCO_2, offer a benchmark for identifying cost-effective targets.

4. **A 2040 phase-out scenario would cost USD 1.43 billion, in exchange for avoiding 80 million tonnes of CO_2.** This would involve the pre-term closure and buy-out of four coal units in Peninsular Malaysia and two in Sarawak. The manageable scale and 2040 timeframe suggest that an orderly phase-out could be achieved without compromising system stability or imposing excessive financial burdens. Realization of this scenario will hinge on a clear and consistent policy signal from the government.

Top 5 prospective emitters

Remaining lifetime emissions and abatement cost by plant unit



Source: TransitionZero (2025)

Energy transition insights from TZ-CAT [3]

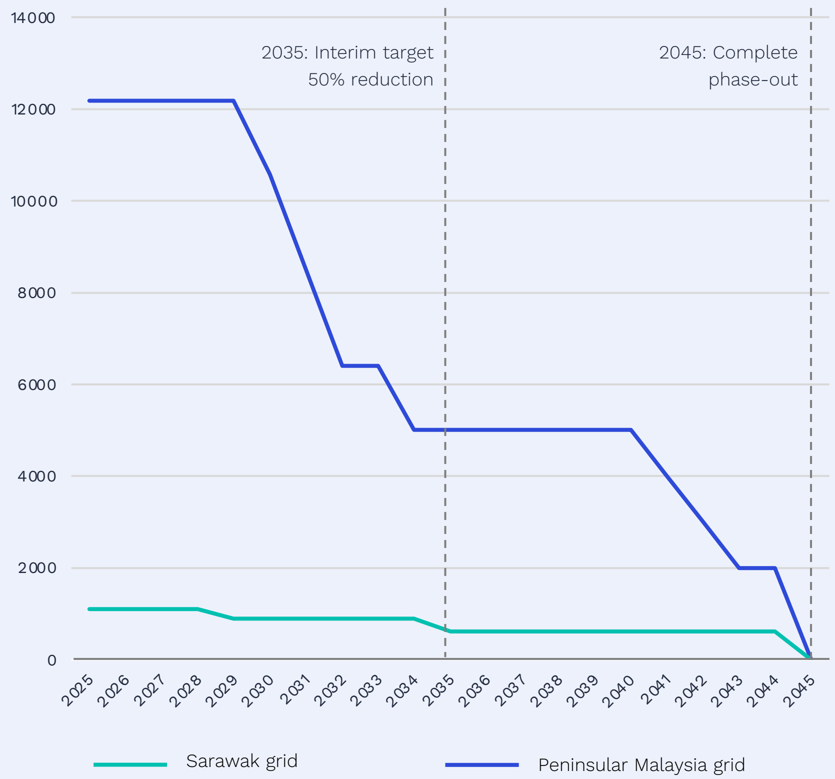
What the data tells us

5. **Coal phase-out is ultimately a system-level challenge.** Asset-level transition strategies cannot be treated in isolation; a system-level lens is critical for shaping effective transition strategies and deal structures. Malaysia is currently testing a mix of approaches, from coal-to-clean replacement, retrofit solutions to coal-to-gas switching. The trajectory of Malaysia's energy transition will depend on the ability of these pilot projects to deliver in terms of cost and feasibility, and how they compare with the pace and scalability of renewable energy solutions.

   As both the largest coal asset owner and system operator, Tenaga Nasional Berhad (TNB) is uniquely positioned to spearhead asset-level transition initiatives.

Malaysia's five-year window to 2030 to scale clean alternatives

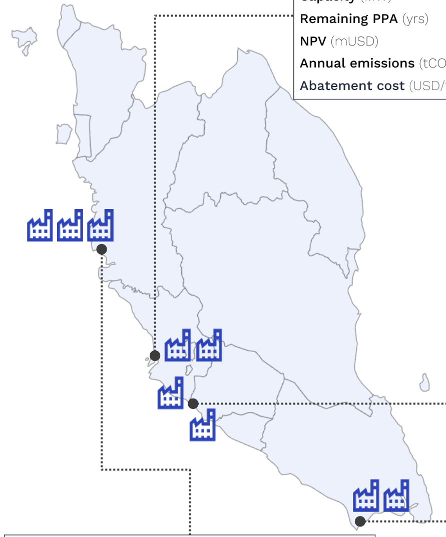
Coal phase-out roadmap based on PPA expiry dates by grid (MW)



Source: TransitionZero (2025)

TransitionZero

TZ-CAT: Asset-level data on 100% coal power stations in Malaysia



SULTAN AZIZ

POWER STATION	KEV GF2	KEV GF3
Capacity (MW)	600	1,000
Remaining PPA (yrs)	4	4
NPV (mUSD)	140	233
Annual emissions (tCO_2)	4	5
Abatement cost (USD/t)	10	12

JIMAH

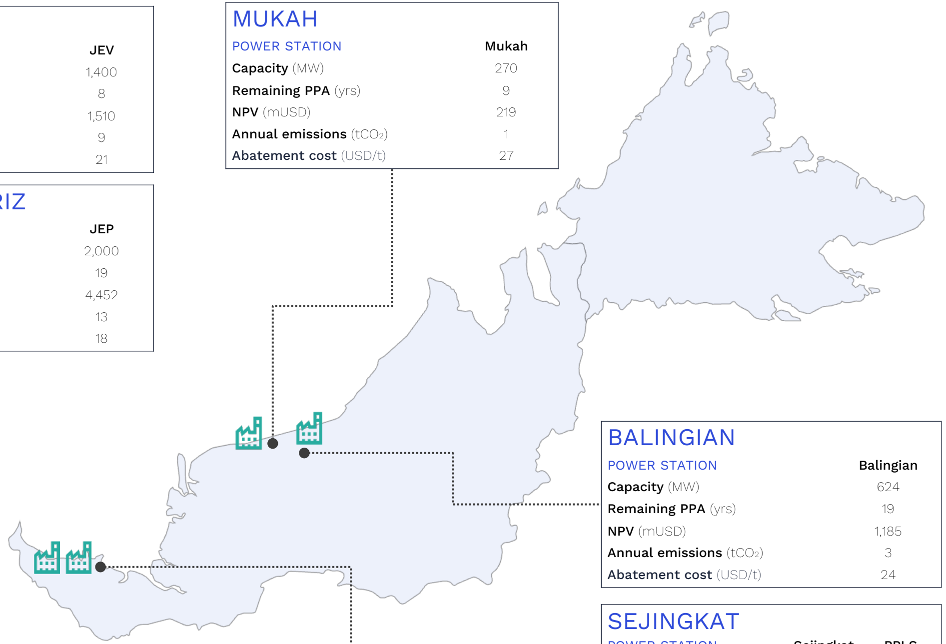
POWER STATION	JEV
Capacity (MW)	1,400
Remaining PPA (yrs)	8
NPV (mUSD)	1,510
Annual emissions (tCO_2)	9
Abatement cost (USD/t)	21

TUANKU MUHRIZ

POWER STATION	JEP
Capacity (MW)	2,000
Remaining PPA (yrs)	19
NPV (mUSD)	4,452
Annual emissions (tCO_2)	13
Abatement cost (USD/t)	18

MUKAH

POWER STATION	Mukah
Capacity (MW)	270
Remaining PPA (yrs)	9
NPV (mUSD)	219
Annual emissions (tCO_2)	1
Abatement cost (USD/t)	27



TANJUNG BIN

POWER STATION	TBP
Capacity (MW)	2,100
Remaining PPA (yrs)	6
NPV (mUSD)	1,596
Annual emissions (tCO_2)	14
Abatement cost (USD/t)	18

BALINGIAN

POWER STATION	Balingian
Capacity (MW)	624
Remaining PPA (yrs)	19
NPV (mUSD)	1,185
Annual emissions (tCO_2)	3
Abatement cost (USD/t)	24

MANJUNG

POWER STATION	TNBJ123	TNBM4	TNBM5
Capacity (MW)	2070	1010	1000
Remaining PPA (yrs)	7	15	17
NPV (mUSD)	782	2,162	953
Annual emissions (tCO_2)	15	6	6
Abatement cost (USD/t)	11	26	10

TANJUNG BIN ENERGY

POWER STATION	TBE
Capacity (MW)	1,000
Remaining PPA (yrs)	16
NPV (mUSD)	2,048
Annual emissions (tCO_2)	6
Abatement cost (USD/t)	21

SEJINGKAT

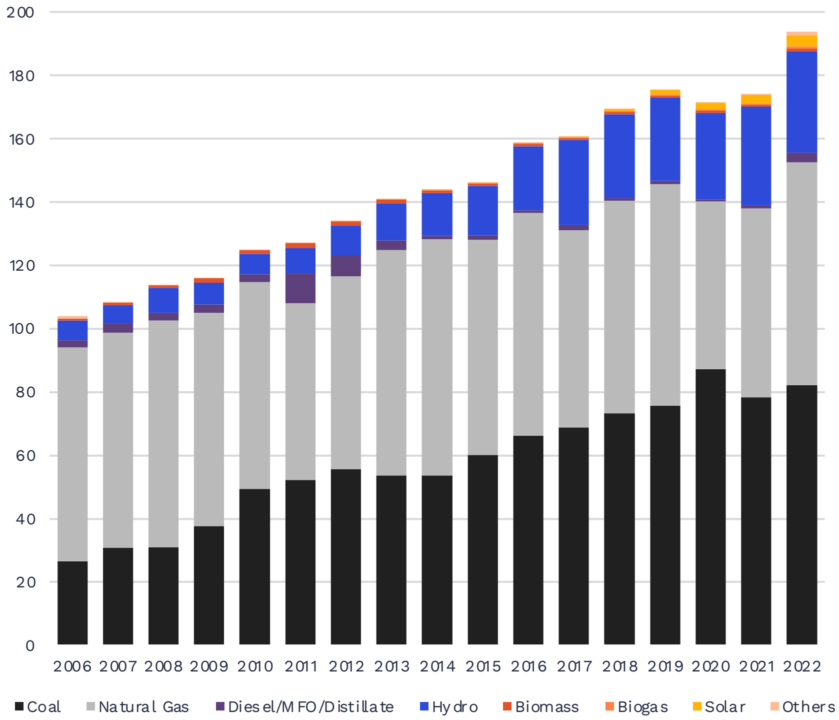
POWER STATION	Sejingkat	PPLS
Capacity (MW)	100	110
Remaining PPA (yrs)	3	3
NPV (mUSD)	30	33
Annual emissions (tCO_2)	0.5	0.6
Abatement cost (USD/t)	22	17

Brief overview of Malaysia's power sector

Market features, key regulatory players and coal transition policies

Malaysia power system, a snapshot

Malaysia electricity generation by technology, 2006-2022 (TWh)



40GW

In total installed capacity, the fourth largest power system in Southeast Asia

79%

Fossil fuels penetration ratio by generation output

<1%

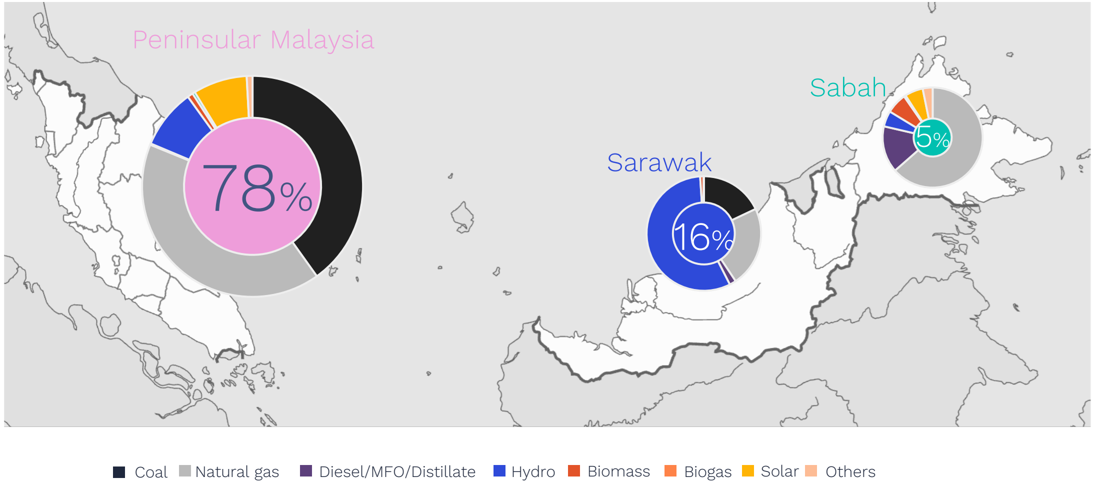
of solar energy technical potential exploited

- Malaysia's power system initially developed around its natural gas reserves, which served as a major energy source. Over time, as energy demand grew and the supply strategy shifted, coal was added to the mix.
- System development in the past two decades has been driven by an expanding coal power fleet, most of which run on imported coal. Fossil fuels currently dominate the power system, with gas and coal power accounting for 75% of total installed capacity and 79% of annual generation.
- Malaysia is endowed with renewable energy resources such as hydropower (particularly in the Sarawak region) and solar energy. Policy incentives for solar power were introduced in the early 2010s, however, uptake has been slow. Malaysia's solar capacity currently stands at around 2.4GW, just less than 1% of its estimated technical potential.

Source: Malaysia Energy Commission (2025)

Three grid systems reflecting each region's resource endowments

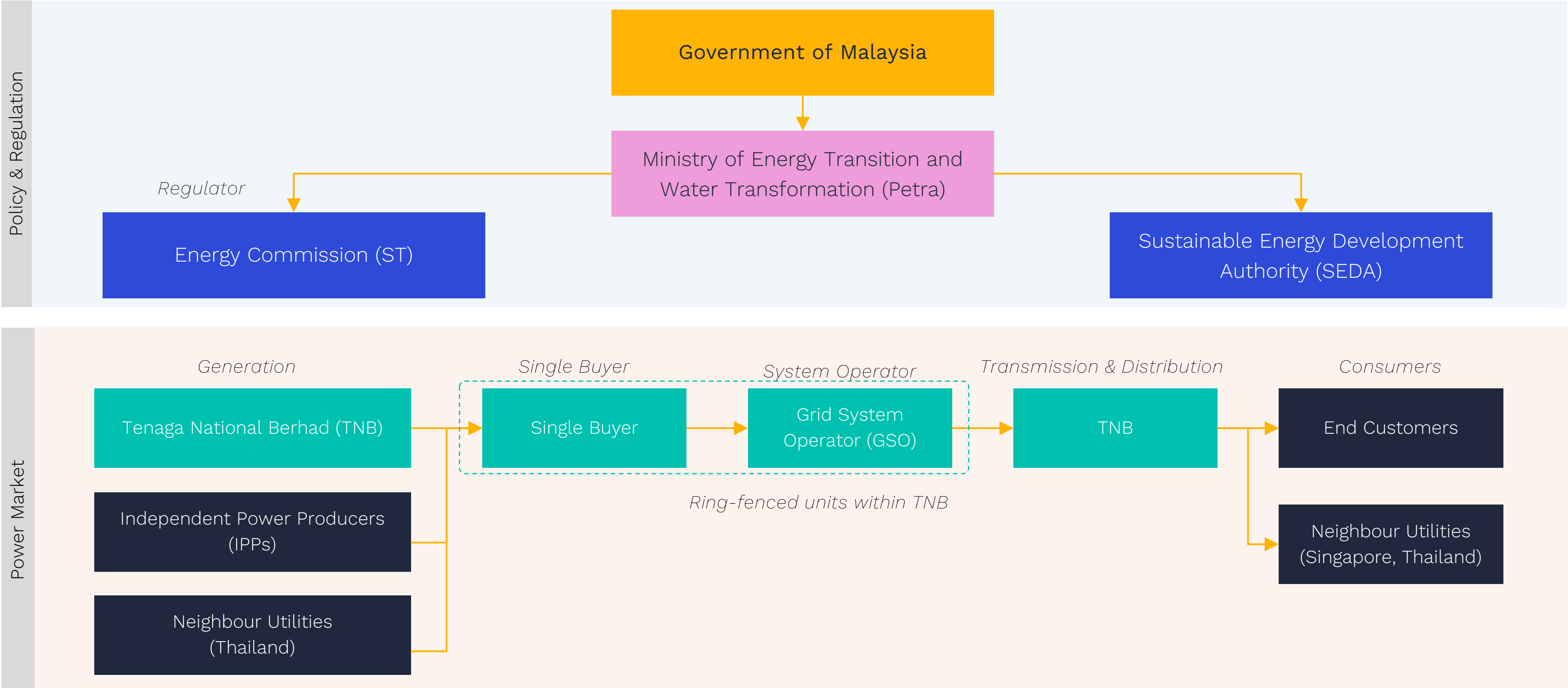
Generation mix by grid and share of installed capacity in Malaysia's total, 2022



Source: *Malaysia Energy Commission (2025)*

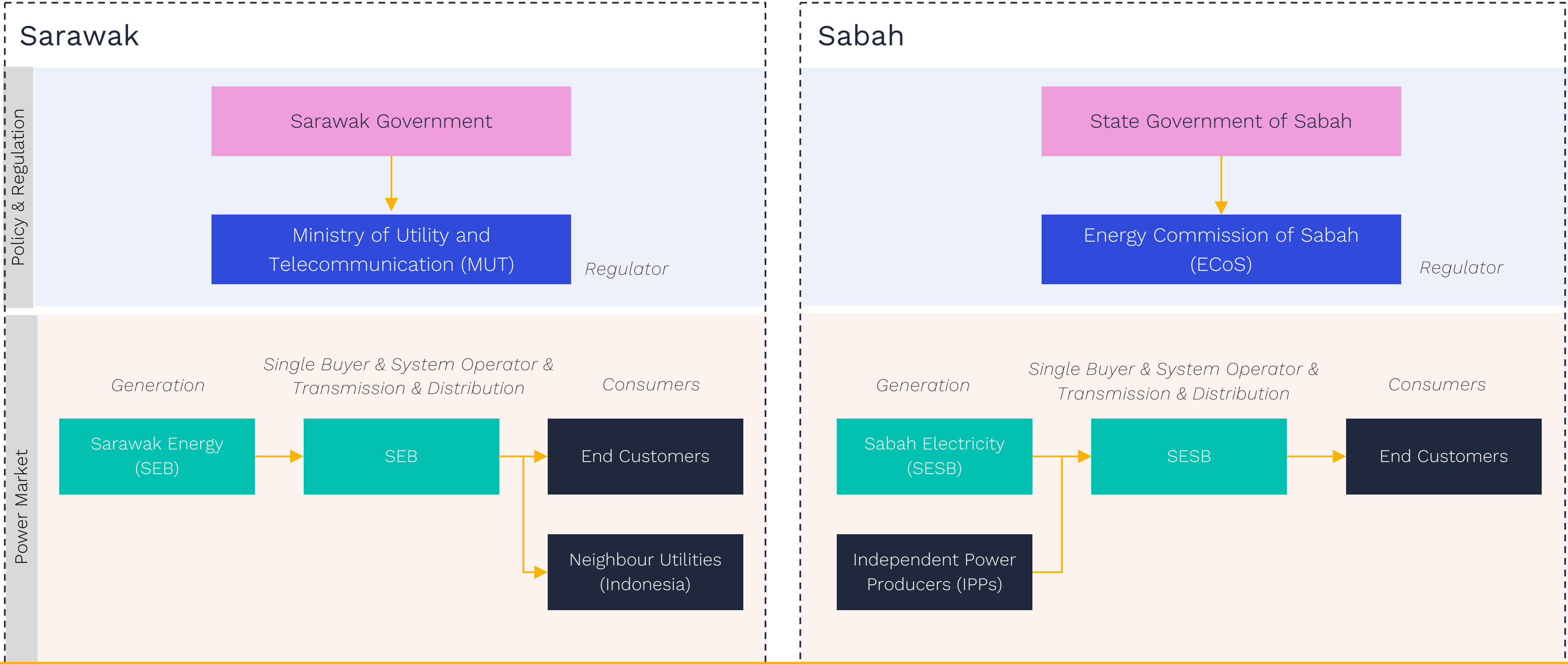
- Malaysia's power system reflects its distinct geography, with the country divided by the South China Sea. It consists of three separate grid regions: one covering Peninsular Malaysia, and the other two, Sarawak and Sabah, supplying electricity to East Malaysia.
- Peninsular Malaysia has the largest power system and the main load centre.
- At present, the three power systems operate independently from one another. There are cross-border interconnections with Thailand and Singapore (from Peninsular Malaysia), and with Indonesia's Kalimantan region (from Sarawak). However, annual electricity trade has been negligible.
- The Sarawak-Sabah grid connection is expected to be energised in late 2025, creating export opportunities for Sarawak, initially to the sibling state and potentially to the Philippines further on, supporting the ASEAN Power Grid initiative.
- Malaysia's electricity market is highly regulated, with the dominance of three vertically-integrated state-owned utilities Tenaga Nasional Berhad (TNB), Sarawak Energy Berhad (SEB), and Sabah Electricity (SESB), each servicing one grid.

Peninsular Malaysia's regulatory and market structures



Source: TransitionZero (2025)

Sarawak and Sabah have regulatory autonomy over their power sectors



Source: TransitionZero (2025)

Malaysia was an early mover on the energy transition

Foundational pro-renewables legislations began in 2011, focus renewed in recent years

1990

Electricity Supply Act

… is the key legislation governing the electricity supply industry in Malaysia, ensuring that it is safe, efficient, and reliable.

The law establishes the Energy Commission (ST) as the regulatory body of the electricity and gas sectors. It also lays the groundwork for private sector participation in electricity generation via independent power producers (IPPs).

2011

Renewable Energy Act

… introduces a feed-in-tariff (FIT) system to promote electricity generation from renewable sources.

Sustainable Energy Development Authority Act

… establishes the Sustainable Energy Development Authority (SEDA), an independent regulatory body that is responsible for promoting and regulating the renewable energy sector.

2016

Ratification of the Paris Agreement and submission of the country's first Nationally Determined Contribution (NDC), committing to reduce the emissions intensity of GDP by 45% by 2030, compared to 2005 level.

2021

Announcement of net-zero emissions target by 2050 at the United Nations Climate Change Conference (COP26) in Glasgow.

2022

National Energy Policy 2022-2040

… sets the overarching strategic policy direction for Malaysia's energy sector over the next two decades, focusing on the transition to a low-carbon, sustainable, and secure energy system.

2023

National Energy Transition Roadmap (NETR)

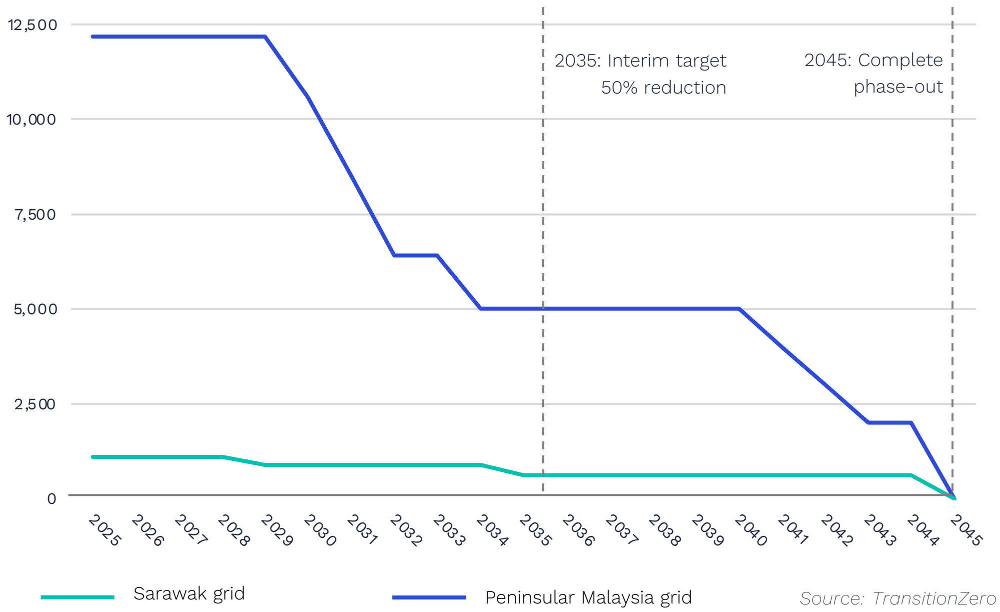
… details the blueprint for Malaysia's energy transition, which is underpinned by six levers and five cross-cutting enablers.

With renewable energy as a lever, NETR targets an **RE penetration rate at 40% of installed capacity by 2040** and increasing to **70% by 2050**. This is supported by a **complete phase-out of coal power by 2045**.

The roadmap also positions gas as a lower-carbon dominant source of baseload power for Malaysia in the long run.

Malaysia aims to halve its coal fleet by 2035, and a complete phase-out by 2045

Malaysia coal power capacity outlook based on PPA expiry dates (MW)



Source: TransitionZero (2025)

- With 13.3GW in installed capacity, Malaysia currently has the third largest coal power fleet in Southeast Asia, after Indonesia and Vietnam. Its newest coal power plant was commissioned in 2019; there are no additional plants under development.
- Following up to its 2050 net-zero emissions pledge at COP26, the Malaysia government released the **NETR** in 2023, instating an official ban on new coal power development and a complete phase-out deadline by 2045. This was later reinforced by an interim target to halve the coal fleet by 2035, suggesting that power purchase agreements (PPAs) of coal plants will not be renewed after expiry.
- To replace the retired coal capacity and meet future electricity demand, Malaysia plans to scale up solar power development (targeting 40% penetration by 2040, and 70% by 2050), expand gas generation, and facilitate cross-border renewable energy trade. To realize this, between 2024-2025, the authorities have launched competitive auctions targeting 4GW of new utility-scale solar by 2027. Renewables exports to Singapore commenced in 2024.

Unpacking TZ-CAT Malaysia

Our thought process, how we built it, what we used, and where the gaps remain

Coal in Malaysia: An overview of the what, who, and how

Size & Distribution

13.3GW

... of installed capacity, which feeds into the grids of Peninsular Malaysia and Sarawak. There are no coal power stations in Sabah.

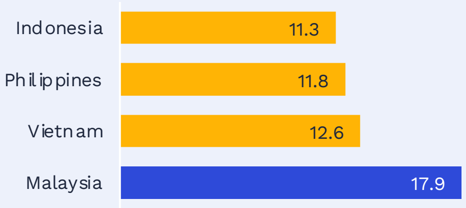
Coal power stations in Peninsular Malaysia use imported coal while Sarawak plants source from local coal mines, resulting in diverging generation costs.

Average plant age

(as of 2025)

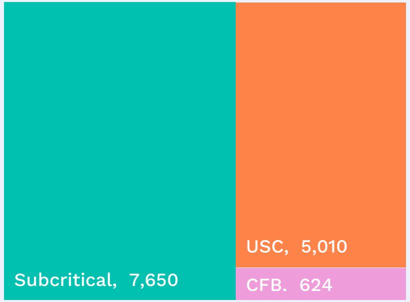
17.9 YEARS

Youngest plant commissioned in 2019, most senior one operational since 1988. Fleet relatively older than regional peers.



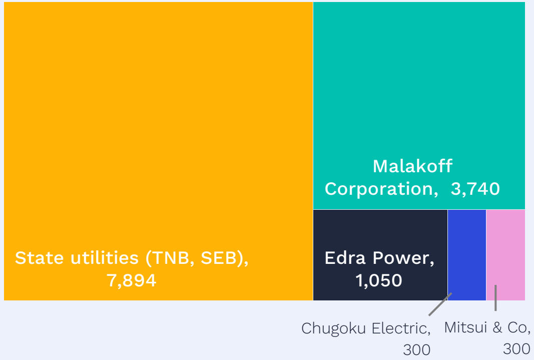
Boiler technology

Fleet reasonably balanced between old (subcritical, circulating fluidized bed) and more advanced (ultra-supercritical) combustion technologies.



Ownership

High concentration of ownership in state utilities TNB and SEB, operating through wholly-owned subsidiaries. Private sector participation remains limited, with the most prominent one being Malakoff Corporation, a domestic group.

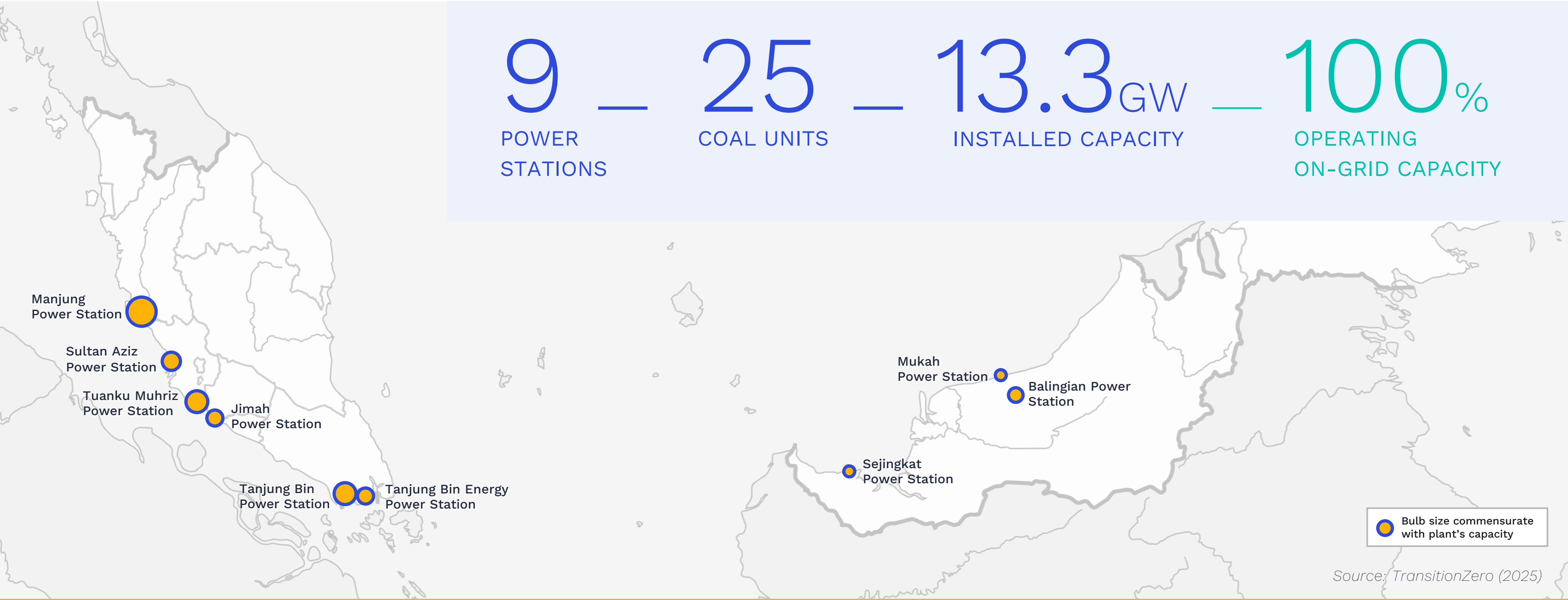


Source: TransitionZero (2025)

CAT Malaysia dataset coverage

First-of-its-kind deep-dive into asset-level performance

9 POWER STATIONS — **25** COAL UNITS — **13.3GW** INSTALLED CAPACITY — **100%** OPERATING ON-GRID CAPACITY



Source: TransitionZero (2025)

Coal PPAs in Malaysia

The standard project financing playbook in single-buyer markets

As in other regulated, single-buyer electricity markets such as Indonesia, Vietnam and Thailand, all coal power plants in Malaysia operate under long-term power purchase agreements (**PPAs**) with the monopoly utilities. Irrespective of their ownership, all coal plants are classified as IPPs, with PPAs being the single source of revenue for the plants.

Coal PPAs in Malaysia follow the standard international template for project financing. They guarantee plant owners with a steady revenue stream to cover initial capital expenditures, fixed annual maintenance costs, debt service, and a reasonable return. The contracts are structured to shield plant owners from demand and fuel cost volatility risks, both of which are borne by the offtaker.

Select features of a PPA

PPA tenor: 25 years, extendable

Fuel supply: Guaranteed by long-term coal supply agreements - in Peninsular Malaysia, with TNB Fuel Services Sdn Bhd, a TNB subsidiary; and in Sarawak, with Sarawak Coal Resources Sdn Bhd.

Fuel cost pass-through: If the plant meets specified heat rate requirements, it can pass fuel costs through to TNB or SEB. In Peninsular Malaysia, an applicable coal price (ACP) is set monthly by the Energy Commission and used as benchmark reference for the monthly Energy Payments. A variance between the ACP and the actual coal cost might result in negative or positive fuel margins for the plant.

Monthly revenue: Mainly includes two components, Capacity Payment (CP) and Energy Payment (EP).

Monthly revenue = Capacity payment + Energy payment

Capacity payment (CP) includes:

i. a capacity rate financial (CRF) to cover debt service and a certain rate of return; and

ii. a fixed operating rate (FOR) to cover fixed operations and maintenance costs.

CPs are paid in full if the plant meets availability targets and operates within unplanned outage limits (UOLs), regardless of the amount of electricity dispatched.

Energy payment (EP): mainly includes fuel payment and variable operating rate (VOR), which vary by the volume of electricity generated. These costs can be fully absorbed by the offtaker if the plant operates within the allowed heat rates.

Data availability

PPA transparency outperforming regional peers

PPA terms, annual operational statistics, and cash flows of coal power plants in Malaysia are generally more accessible than those in other regulated electricity markets in Southeast Asia.

For plants in Peninsular Malaysia, data is available via disclosures by the special-purpose vehicle (SPV) companies that own the assets. As local companies typically serve as the main sponsors, project financing and refinancing strategies often involve domestic bond issuances, which requires regular reporting of the plant's operational and financial performance.

As a result, our TZ-CAT Malaysia dataset was largely underpinned by reported plant statistics from 2020 to 2023, particularly key metrics such as annual CPs, EPs, generation, and tariffs – crucial indicators for assessing a plant's net value and transition prospects.

The primary data sources used were:

- For **Peninsular Malaysia plants**: company reports, TNB reports, corporate bond prospectuses, credit rating reports
- For **Sarawak plants**: SEB reports, corporate bond prospectus (available for only one plant)

In cases of data gaps – which still happens for certain plants and/or plant metrics – estimates were computed using data from comparable plants. For full details on the methodology, please refer to the Technical Annex.

TZ-CAT Malaysia uses best available data, and an in-house approach to fill in gaps

Plant metrics	Peninsular Malaysia	Sarawak
Annual generation and/or unit sales	Company reports	SEB reports
Annual revenue (CPs and EPs)	Company reports	TZ estimates
PPA tariff (USD/MWh)	Derived from reported annual generation or unit sales, and revenue data	TZ estimates
Thermal efficiency rate	Company reports, TZ estimates	SEB reports
Annual emissions	TZ estimates	SEB reports
Fuel consumption	TZ estimates	SEB reports

Contextualizing the TZ-CAT tool for Malaysia

TZ-CAT supports a nuanced coal transition discussion

The Malaysian government aims to phase-out coal power by 2045, in line with the natural expiry of existing PPAs with no extension allowed. This timeline lags a few years behind the International Energy Agency's recommendation that developing countries end coal-fired generation by 2040 to meet the Paris Agreement goals.

We acknowledge that coal phase-out is a complex undertaking that requires balancing multiple social, economic, environmental, and technical factors.

In Malaysia, coal currently serves as the primary source of baseload power supply. Plants in Peninsular Malaysia operate at 74% capacity factor on average. With reported reserve margins in the Peninsular and Sarawak grids below 30%, grid stability could be compromised unless cleaner alternatives are deployed rapidly to replace the phased-out coal capacity.

The country is considering several pathways to manage its coal transition:

- → Retrofitting plants for continued operations at lower emissions, such as co-firing with biomass/ammonia or installing carbon capture and storage (CCS) technology
- → Closing the assets by a select number of years ahead of the end of their current contracts
- → "Repowering", or replacing, coal plants with new hydrogen-ready gas power plants on the same site

With this iteration of the TZ-CAT tool, we offer users the flexibility to assess alternative options for system- and asset-level transition strategies. We do so by providing foundational metrics that evaluate the current role and financial value of each plant, which can be used for targeted interventions. Key metrics include:

- → **Average capacity factor** to understand how heavily in use the plant currently is, and its role in the power system
- → **Emissions intensity** to assess and compare the emissions profile of the plants
- → **Net present value** which captures all future revenue streams of the plant pursuant to the PPA terms.
- → **Cost of early retirement per year** which provides the cost of buy-out per year of early retirement, enabling users to estimate total buy-out costs by a chosen number of years.
- → **Abatement cost** per tonne of CO_2 which represents the cost incurred to prevent the emissions of one tonne of CO_2.

System-level impact analyses of shutting down or repurposing coal power plants are outside the scope of the TZ-CAT tool.

The Malaysia advantage on data transparency

Real data supports asset valuation and retirement cost estimates

A major contribution of the TZ-CAT dataset is in providing a benchmark valuation of plants and the cost of early retirement, which provides a starting point for assessing the feasibility and structure of potential transition deals.

Owing to corporate disclosures on PPAs revenue structure — particularly data on CPs and EPs — the financial valuation of coal-fired power plants in Malaysia can be carried out with relative confidence. This differs from previous TZ-CAT datasets, which estimated the valuation and buy-out costs based on annual generation, revenue, PPA tariffs minus fuel costs. However, the core valuation principle remains unchanged, the buy-out cost should cover CAPEX, OPEX, and a reasonable rate of return — all elements of CPs — but excludes fuel costs and related earnings.

For the TZ-CAT Malaysia dataset, we estimate the financial value of the plant based on the annual CP, multiplied by the remaining years of the PPA. We believe that this approach provides a fair value for initial assessment or screening of assets.

By extension, the cost of buying out a plant by one year ahead of the scheduled expiry of its PPA would equate to one year of CP.

Formula for estimating a plant's financial value:

Net present value =

Remaining PPA years x Annual Capacity Payment

Formula for estimating buy-out cost:

Cost of buy-out per year = Annual Capacity Payment

Capacity payment (CP) = Four-year average CPs received by the plant, based on data between 2020 and 2023

Remaining PPA year = Remaining lifetime of plant between 2025 and PPA expiry year

Data gaps and limitations

Boundaries in the methodology and approach

→ **Accounting for the 2020-2022 coal price swings**

This iteration of TZ-CAT Malaysia covers the abnormal period of 2020-2022 which saw depressed energy demand and significant volatility in coal prices. We recognize that these factors may have contributed to irregular plant performance, such as above-normal tariffs and plant under-utilization compared to typical conditions. To account for these anomalies, we have extended the coverage of market and plant statistics to four years (2020-2023), rather than the usual three years.

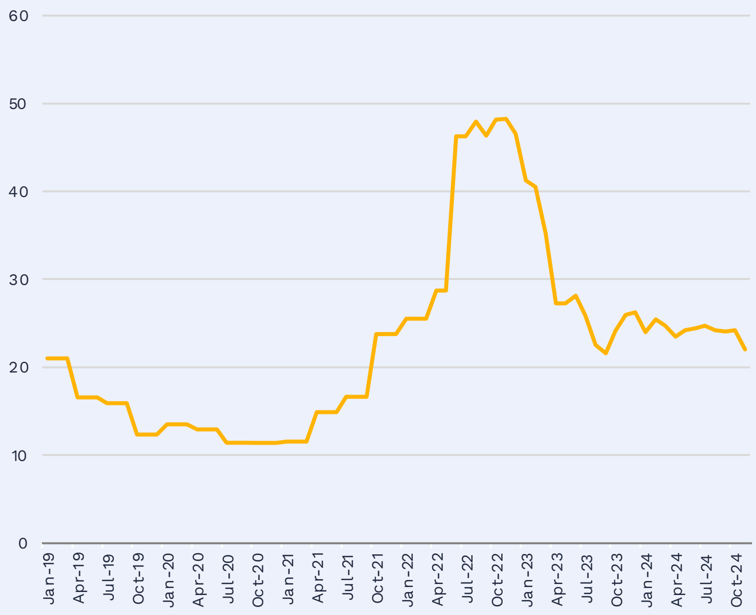
→ **Limitations with the valuation methodology**

Our methodology utilizes historical CPs to estimate the remaining asset value and buy-out cost. One limitation of this approach is that it may over-estimate the buy-out value, as it does not factor in potential risks such as future technical malfunctions and associated penalities, both of which are real concerns for coal plants in Peninsular Malaysia.

At the same time, our methodology assumes a constant buy-out cost per year through the remaining lifespan of the plant. In practice however, standard PPA terms allow for CP escalation every four years. Additionally, buying out a plant in its later years would likely be more expensive and challenging, as the asset is fully amortised and becomes a "cash cow" for its owners, thus disincentivizing early shutdowns.

Abnormal coal price swings causing atypical dispatch

Monthly benchmark coal price for power generation in Peninsular Malaysia (MYR/mmBtu)



Source: Malaysia Energy Commission (2025)

Highlights and findings

Deep-dive analysis of the TZ-CAT Malaysia dataset

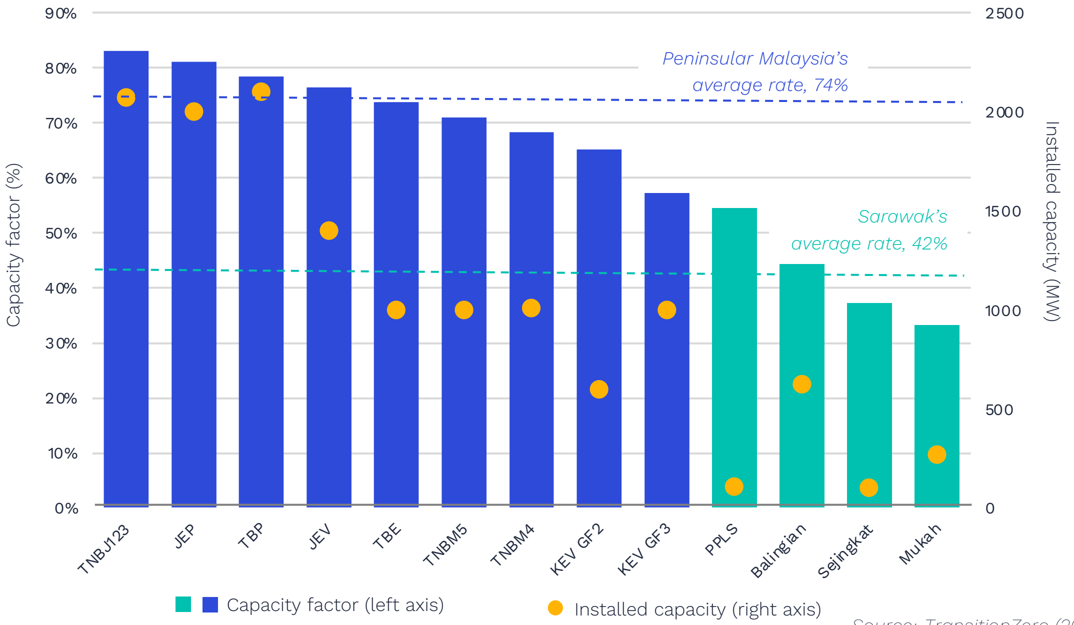
Key plant metrics in the TZ-CAT tool

Plant name	Shorthand	No. of units	Total capacity (MW)	Remaining PPA (years)	Capacity factor (%)	Average tariff (USD/MWh)	Net present value (USD million)
Tuanku Muhriz Power Station	JEP	2	2,000	19	81	64	4,452
Jimah Power Station	JEV	2	1,400	8	76	84	1,510
Sultan Aziz Power Station – Generating Facility 2	KEV GF2	2	600	4	65	83	140
Sultan Aziz Power Station – Generating Facility 3	KEV GF3	2	1,000	4	57	83	233
TNB Janamanjung – Generating Facility 1	TNBJ123	3	2,070	5	83	82	782
TNB Janamanjung – Generating Facility 2	TNBM4	1	1,010	15	68	68	2,162
TNB Manjung Five	TNBM5	1	1,000	17	71	52	953
Tanjung Bin Energy Power Station	TBE	1	1,000	16	74	63	2,048
Tanjung Bin Power Station	TBP	3	2,100	6	78	82	1,496
Balingian Power Station	Balingian	2	624	19	45	25	1,185
Mukah Power Station	Mukah	2	270	9	33	43	219
Sejingkat Power Station	Sejingkat	2	100	3	37	62	30
Sejingkat Power Station (PPLS)	PPLS	2	110	3	55	53	33

Baseload duty

Malaysia's coal fleet is in heavy use

Average capacity factor by plant and grid (%), and plant installed capacity (MW)



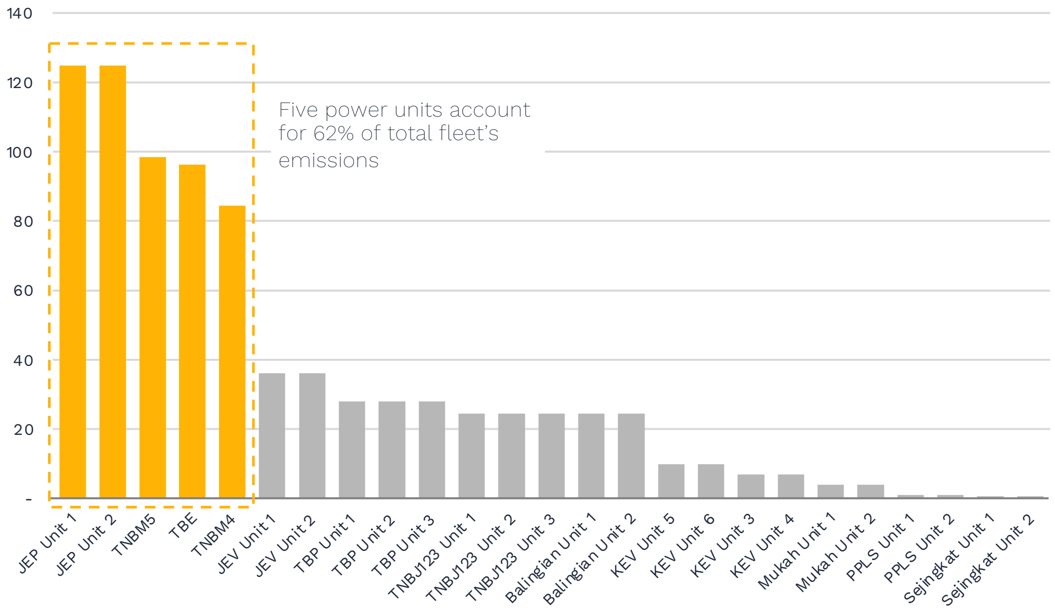
Source: *TransitionZero (2025)*

- Coal plants in Peninsular Malaysia operate at exceptionally high capacity factors, averaging 74% between 2020 and 2023. By comparison, coal-dependent countries such as the Philippines and Vietnam only report averages in the 50-60% range .
- Analysis shows that coal generation declined in 2021 and 2022, owing first to weaker demand during the pandemic and then to record-high coal prices. Generation recovered in 2023 as fuel costs stabilised and electricity demand rebounded.
- These figures underscore the cost-competitiveness of coal in the Peninsular system's merit order. However, they also indicate that the system has operational flexibility to reduce emissions as it evolves and integrates more renewables.
- In Sarawak, coal plays a less central role, with the state prioritising gas and hydropower expansion. Between 2020 and 2023, the system has increasingly prioritised dispatch from the newest and largest plant, Balingian (624MW), while consistently ramping down the old and more polluting stations such as Sejingkat (210MW) and Mukah (270MW).

Emissions reduction potential is significant [1/2]

Targeting the top contributors could go a long way

Remaining lifetime CO_2 emissions by plant unit under a BAU scenario (million tonnes)



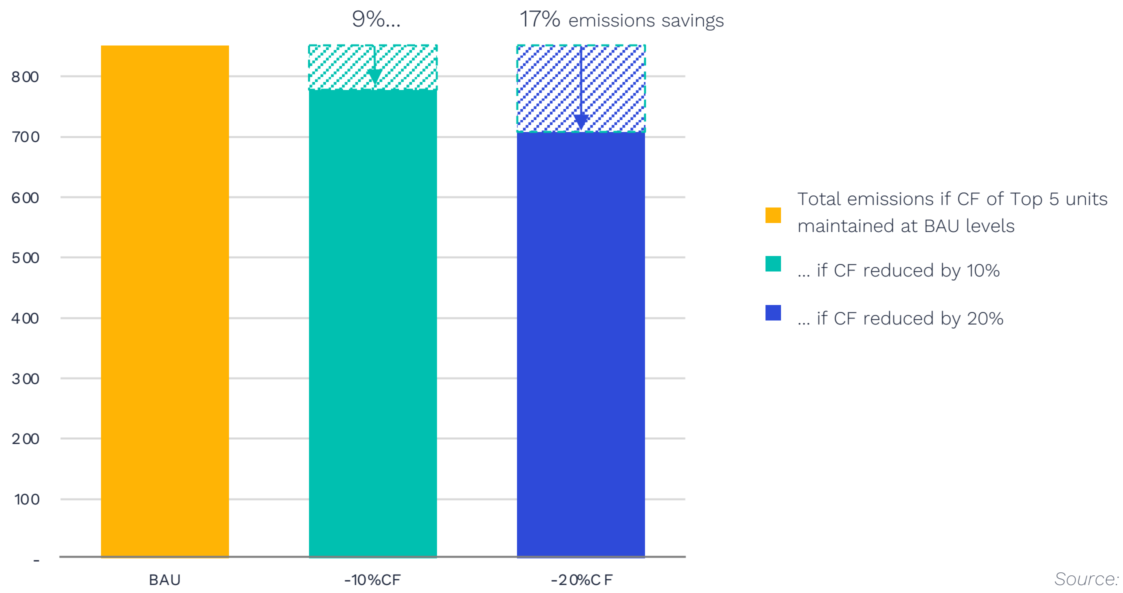
Source: TransitionZero (2025)

- Under a business-as-usual (BAU) scenario — where coal plants continue operating at the current rate until their PPAs expire, with the last units shutting down in 2044 — we estimate that Malaysia's coal fleet would emit up to 854 million tonnes of CO_2 between 2025 and 2044. This is equivalent to over three times the energy sector's emissions in 2019, the latest year with reported data.
- Five power units — **JEP Units 1 and 2, TNBM5, TBE and TNBM4** — are expected to account for nearly two-thirds of cumulative emissions from coal plants. These are large plants with the longest remaining lifetimes, ranging from 15 to 19 years.
- Given their current role as baseload and the absence of abatement measures, these assets could be targeted by stakeholders focused on emissions reduction strategies.

Emissions reduction potential is significant [2/2]

Targeting the top contributors could go a long way

Remaining lifetime CO_2 emissions of the coal fleet by scenario (million tonnes)



Source: TransitionZero (2025)

- High-level estimates suggest that reducing the annual CFs of these top five units by 10% from the current levels could cut total emissions by 9% compared to the BAU scenario. Meanwhile, a 20% reduction would bring down the total fleet's emissions by 17%.
- We note that such proposals need to be assessed with power systems modelling to test for supply adequacy and grid resilience.

Anni horribiles

Volatile coal prices inflated system costs and subsidies

The 2022 global coal price shock had a significant impact on coal power generation costs, and by extension, on overall system costs in Peninsular Malaysia, which relies entirely on imported coal from Indonesia, South Africa, and Russia.

Average tariff rates paid by TNB to local coal plants swelled by 1.5x to 2.7x in 2022 compared to the previous years' levels. According to TNB, the price of imported coal nearly quadrupled between 2020 and 2022, reaching USD 213 per tonne. Though coal prices stabilized in 2023, they continued to remain above pre-2022 levels; a trend that was mirrored in coal power tariffs.

Our TZ-CAT data shows that elevated tariffs were registered across the board, however, the cost swing was more excessive in some cases. Plants such as Malakoff-owned KEV and TBP; and TNB-owned TNBJ123 and JEV charged tariffs ranging between USD 124 and USD 138 per MWh over the course of 2022, eroding the cost-competitiveness of coal power.

It is worth noting that fluctuations in fuel costs, and by extension coal power tariffs, are generally absorbed by TNB, which may or may not fully pass them on to Malaysian consumers via the country's Imbalance Cost Pass-Through (ICPT) mechanism. In 2022, in response to fuel cost pressures, TNB increased retail electricity tariffs for non-domestic consumers, but kept them unchanged for residential customers for most of the year with government funding.

Coal price shock pushed tariffs up

Average tariff rates for select plants (USD/MWh), coal prices (USD/t) in Peninsular Malaysia

Source: TransitionZero (2025)

Reliability issues... [1/2]

Malaysian coal plants struggle to meet performance standards

Coal-fired power plants in Peninsular Malaysia have reliability issues.

According to company reports, it is common for plants to forgo a portion of the CPs provided under the PPAs. This is because the payments are availability-based, but many units regularly fail to meet unplanned outage limits (UOLs) and contracted average availability targets (CAATs) — both key conditions stipulated in the PPAs. Similarly, full pass-through of EPs is only possible when heat rate requirements are met, which is often compromised by poor coal quality.

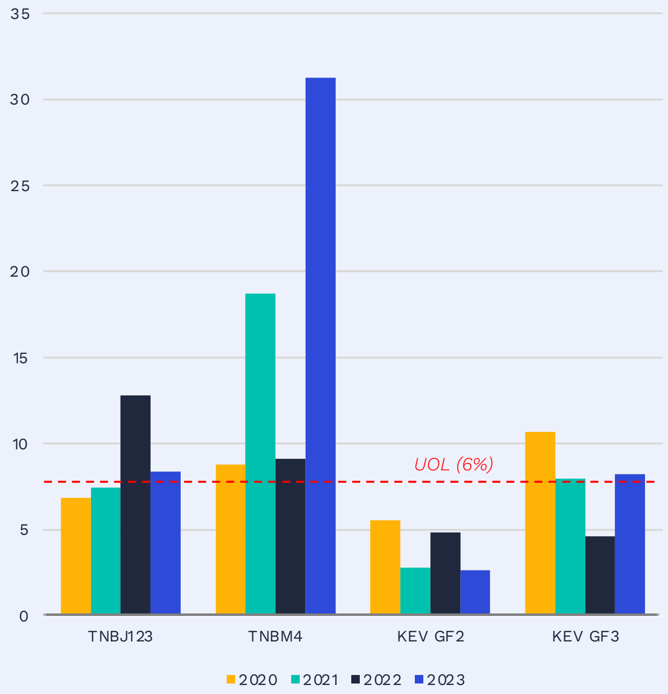
For example, the 1010MW TNBM4 plant, commissioned in 2015, exceeded the prescribed UOL of 6% every year between 2020-2023. As a result, its CAAT stood at just 88%, below the required CAAT of 91% set for the period.

Even though plants would be penalized financially for such underperformance, the trend shows that coal power generation might not be as dependable and dispatchable as commonly expected.

One implication of this pattern is that the TZ-CAT methodology may over-estimate a plant's financial value, as it relies mainly on historical CPs without accounting for future technical failure risks and associated penalties.

Over the line

Rolling average unplanned outage rates of select plants (%)



Source: Company data cited in RAM, MARC credit rating reports

… lead to financial penalties [2/2]

Tariffs reflect PPA terms but also technical performance

Plant underperformance typically results in financial penalties, with reduced CPs and EPs translating into lower revenue. Moreover, EPs can also be impacted by negative fuel margins, which occurs when the plant's coal procurement cost is higher than ST's monthly benchmark price due to time lagging effect, thus preventing a full cost pass-through. In 2023, all plants with reported financials registered pre-tax losses which were mainly attributed to negative fuel variance. This trend will reverse itself in a rising coal price environment.

Due to these factors, the different effective tariff rates charged by plants — as estimated in TZ-CAT using annual revenues and unit sales — may be a result of performance issues that cause reduced revenues and may not necessarily reflect the relative competitiveness of each plant's PPA rates, or of coal power in general.

Despite favourable PPA structures that shield owners from key risks such as demand and fuel cost fluctuations, coal plants in Peninsular Malaysia may still incur operating losses.

Tariffs dampened by technical shortcomings

Effective tariff rates of TNBM5 plant by scenario (USD/MWh)

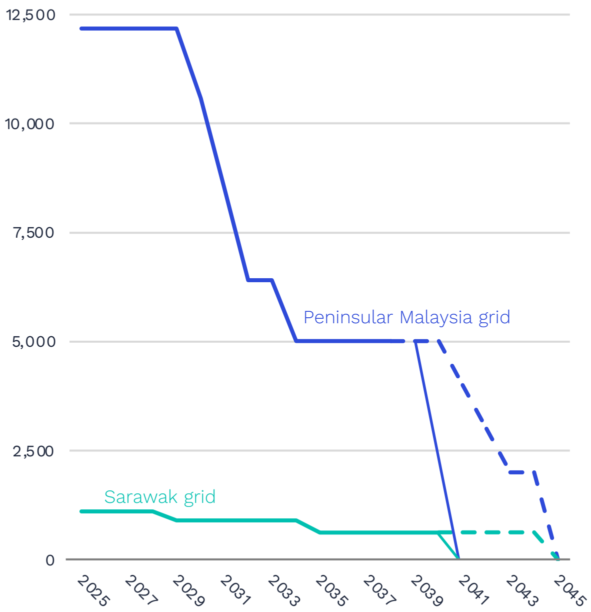
Note: Due to data constraints, EPs were included as actual paid amounts in both scenarios. Per company disclosures, the plant was unable to fully pass through fuel costs in 2022-2023, meaning that tariff rates could have been higher in those years if PPA conditions for EPs were met.

Source: Company data cited in MARC credit rating report

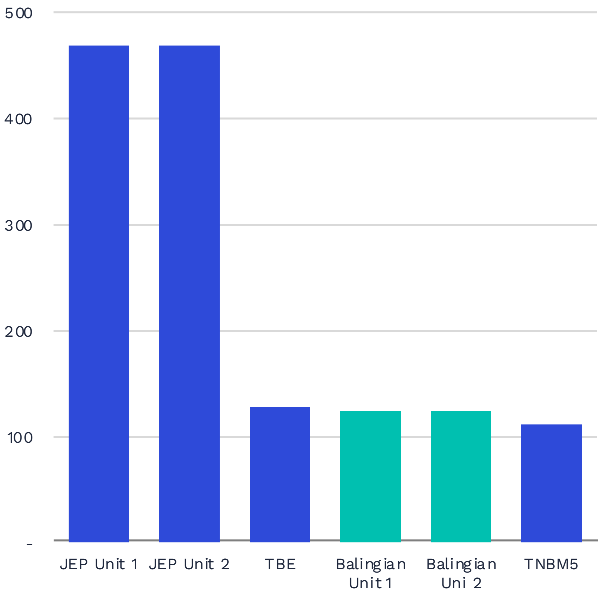
Ambition within reach

A 2040 phase-out scenario estimated at USD 1.43 billion

Total installed capacity of coal by grid and year (MW)



Cost of early retirement in 2040 by plant (USD million)



Source: TransitionZero (2025)

- The IEA-recommended scenario of coal phase-out by 2040 would require the early closure of four coal units in Peninsular Malaysia and two coal units in Sarawak, all of which have PPAs extending past 2040.
- The estimated total buy-out cost is USD 1.43 billion, in exchange for avoiding 80 million tonnes of CO_2. Replacement and grid costs are not yet included.
- This scenario could potentially be technically feasible, economically sound:
  - The capacity involved would be relatively small to the system by 2040 – at 5,010MW in Peninsular Malaysia, and 624MW in Sarawak
  - The 2040 timeline means that there is sufficient time for both grids to scale up clean energy alternatives
  - Plants in question would be taken offline just four years earlier (at most) than the intended schedule.

Phase-out case studies

Showcasing TZ-CAT data for screening and shortlisting potential assets for a coal transition strategy

Potential criteria for plant selection

The TZ-CAT tool allows users to screen assets by equipping them with an initial set of financial and operational metrics that are important for deal design and negotiations

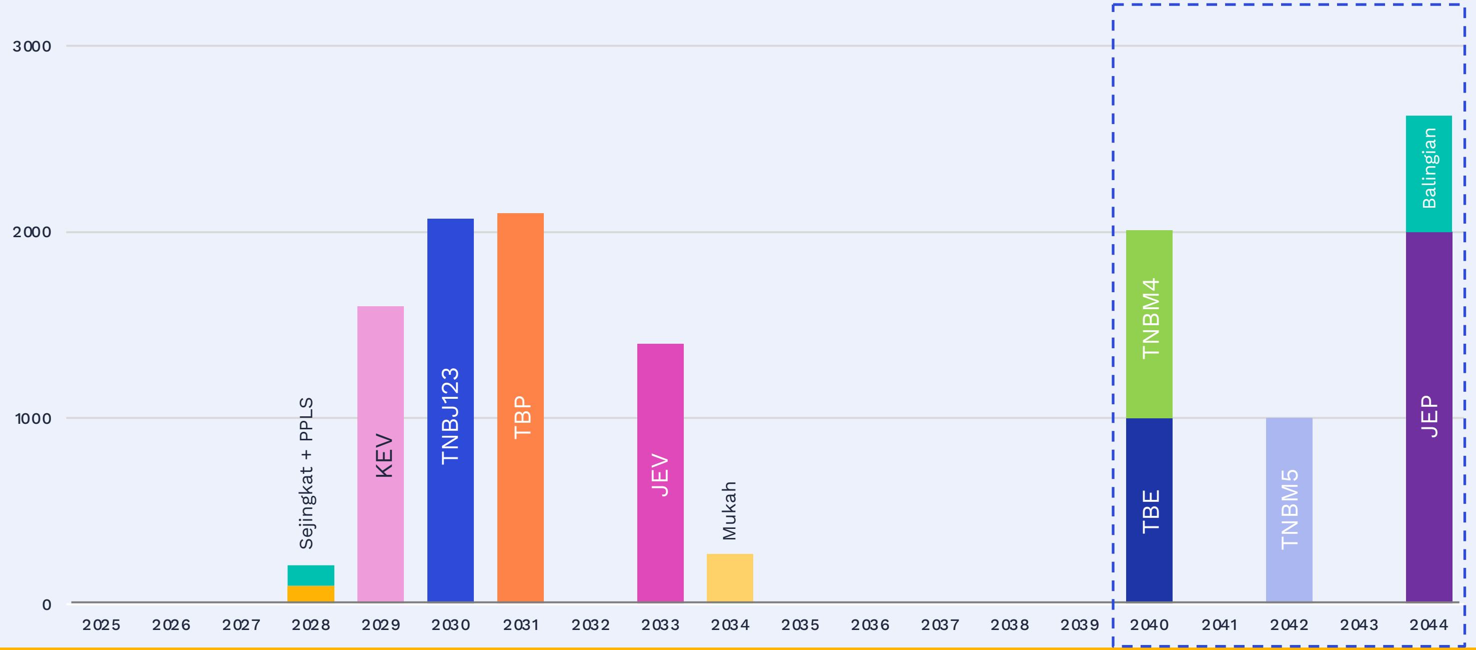
The suitability of assets for different transition options depends on the motivation behind the deal.

Criteria	Description	Considerations	Short-list of plants
Plants with longest remaining lifetimes	Plants with the most distant PPA expiry dates would have the largest potential emissions footprint but also offer the widest range of mitigation options.	Plants with PPA expiry after 2030	JEP, TBE, TNBM4, TNBM5
Highest capacity factor	Plants currently operating at high capacity factors could be ramped down, reducing emissions while remaining available to provide system services.	Age of plant, location, availability of cleaner alternatives to make up for reduced supply	JEP, JEV
Lowest abatement cost	Plants with the smallest USD value for a ton of CO_2 emissions avoided	Plant buy-out cost, capacity factor, emissions intensity	TNBM5

Filtering assets by PPA expiry

Prioritising intervention on largest prospective emitters

Retired capacity by plant and year (MW)



Plants with the largest potential emissions footprint due to size and longest remaining operational life

Source: TransitionZero (2025)

Tuanku Muhriz Power Station (JEP)

A big emitter that needs to be reined in

Tuanku Muhriz Power Station (JEP) will be the last and largest coal plant to shut down in Malaysia. Given its size, strong dispatch records (capacity factors between 75%-86% from 2020 to 2023), and remaining operational life, JEP's cumulative emissions budget through its scheduled retirement in 2044 could reach to 250 $mtCO_2$, potentially making it the largest emitter under a BAU scenario.

With TNB as JEP's majority shareholder and key implementer of national energy transition plans, JEP is already a target for emissions reduction measures. The plant is currently undergoing pilot studies for ammonia co-firing and carbon capture and storage (CCS) integration, the feasibility and cost implications of which remain to be seen.

Our TZ-CAT data indicates that there is merit in exploring other options, provided more detailed plant-level technical and grid-level reliability analyses be conducted. Specifically:

- → In the near term, gradually reducing the dispatch of the plant, or its units, could result in incremental emissions savings while enabling more RE integration
- → In the longer term, closing the plant a few years ahead of schedule; there is *at least* a 6-year window between JEP's debt maturity in 2038 and PPA expiry in 2044.

However, proposals should also consider the financial (dis)incentives for the relevant parties when evaluating these options. For instance, JEP has registered pre-tax profits every year since its commissioning, except for 2023 (due mainly to negative fuel variance). This suggests potential reluctance from its Japanese co-sponsors to agree to PPA renegotiations. Additionally, JEP's annual tariff rates are competitive relative to its peers. In the absence of a carbon tax, TNB as the cost-driven grid operator may be less inclined to reduce the plant's generation.

Basic plant information

Technical specifications	1000 x 2 units (MW) Sub-bituminous, bituminous imported coal Ultra-supercritical boiler
Location and grid region	Negeri Sembilan, Peninsular Malaysia
Owners	TNB (70%), Mitsui & Co (15%), Chugoku Electric Power (15%)
Age and lifetime	Both units operational since 2019 Current age: 6 years PPA expiry: May 2044

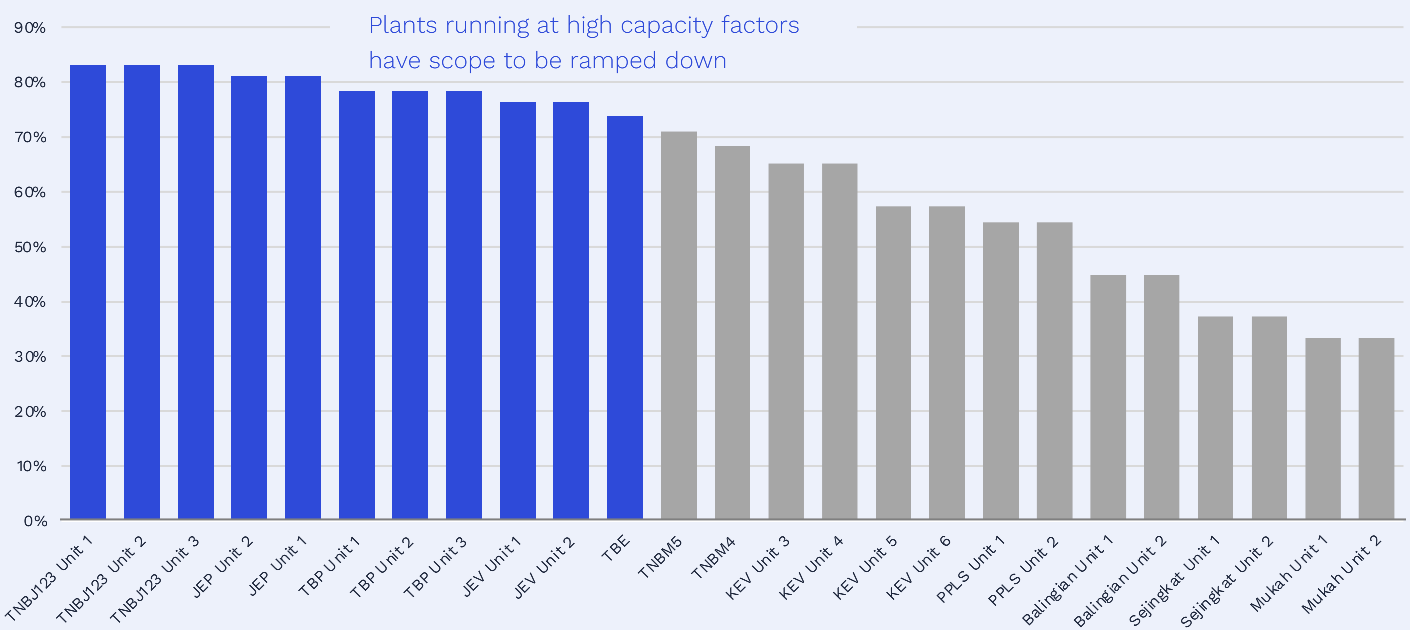
Key metrics from the CAT tool

Net present value	USD 4,451 million
Cost of early buy out	USD 234 million per year
Annual emissions	13 mtCO2 per year
Capacity factor	81%
Average tariff	USD 64 per MWh

Filtering assets by utilization rate

Targeting candidates with near-term emissions savings potential

Capacity factor by unit (%)



Source: TransitionZero (2025)

Jimah Power Station (JEV)

A pricey, baseload generator that could be ramped down?

Jimah Power Station (JEV) is a 1,400MW coal power plant located adjacent to JEP. It is majority owned by Edra Power, a leading IPP in Malaysia, with ultimate shareholders including China General Nuclear Power Corporation and China Southern Power Grid.

Although an aging plant, JEV performs relatively well in terms of availability, as evidenced by its qualification for full CPs every year since 2018, except for 2023, when a minor 0.4% deduction was incurred.

Assuming the plant will retire upon its PPA expiry in 2033 to align with the government's target of halving coal capacity by 2035, the transition options for JEV are somewhat limited. CAPEX-heavy and experimental retrofit solutions might not be economically viable.

However, our TZ-CAT data suggests there may be value in reducing JEV's dispatch. The two units currently operate at high capacity factors, ranging from 73% to 78% annually between 2020 and 2023. Given its size, any reduction in utilisation would result in notable emissions savings.

Furthermore, there could be system cost savings. JEV charges some of the highest tariffs among the coal fleet, primarily due to its use of higher-quality coal, which translates into higher fuel costs.

A key consideration is, the size of JEV and its location — in Pork Dickson and servicing the Greater Kuala Lumpur load centre — may raise concerns around system reliability if the plant is ramped down. To test these concerns, it would be worthwhile to conduct system-level analyses to evaluate the plant's flexibility potential.

Basic plant information

Technical specifications	700 x 2 units (MW) Bituminous imported coal Subcritical boiler
Location and grid region	Negeri Sembilan, Peninsular Malaysia
Owners	Edra Power (75%), TNB (25%)
Age and lifetime	Both units operational since 2009 Current age: 16 years PPA expiry: December 2033

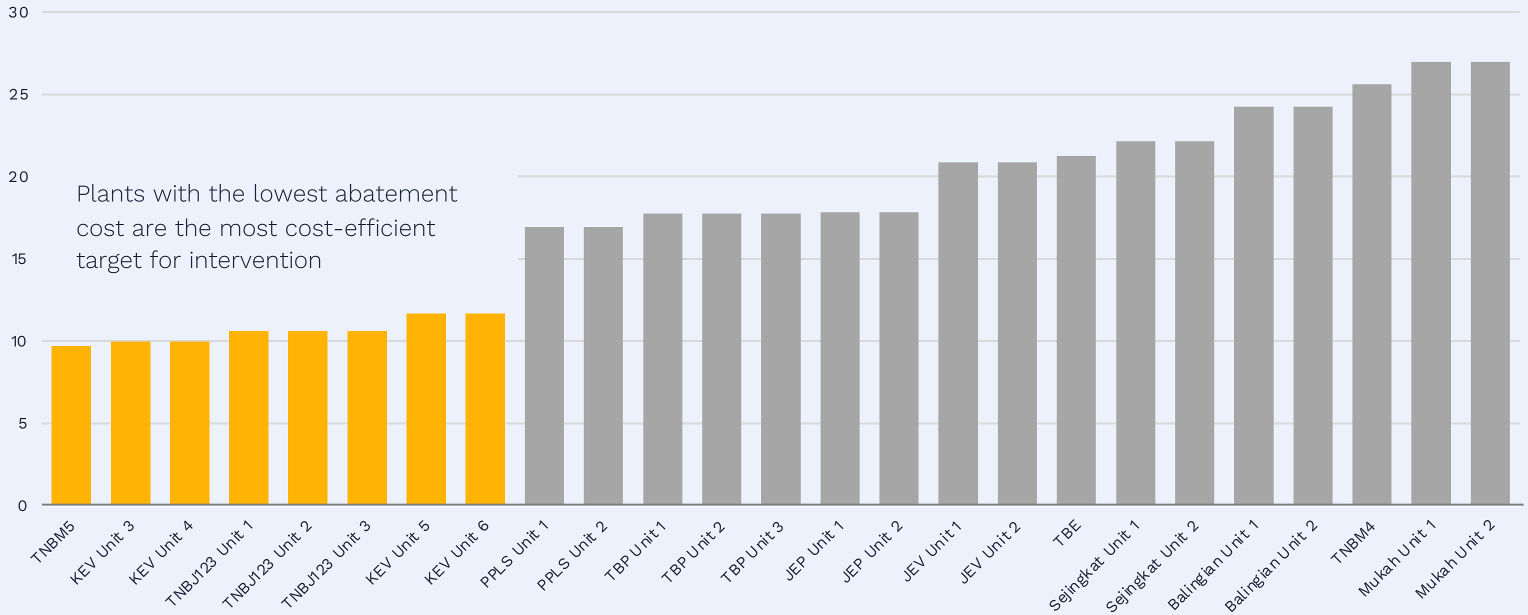
Key metrics from the CAT tool

Net present value	USD 1,510 million
Cost of early buy out	USD 188 million per year
Annual emissions	9 mtCO2 per year
Capacity factor	76%
Average tariff	USD 84 per MWh

Filtering assets by abatement cost

Prioritising candidates with best value for money

Abatement cost by unit (USD/tonne of CO_2 avoided)



Source: TransitionZero (2025)

Manjung Five Power Station (TNBM5)

Best bang for your climate buck

Manjung Five Power Station (TNBM5) is scheduled to be the second-last coal power plant to shut down in Peninsular Malaysia, in 2042. Given its size, strong dispatch record, and remaining operational life, TNBM5 is on track to be the second largest emitter of the fleet, after JEP, making it a strong candidate for emissions reduction measures.

Despite its relatively young age and USC boiler, TNBM5 has had difficulties meeting performance standards. Its annual CPs since 2019 have consistently stood below budgeted amounts, with the most significant underperformance occurring in 2020 (48% deduction) and 2021 (23% deduction).

As a result, according to our TZ-CAT data — which estimates buy-out costs based on historical CP receipts — TNBM5 has the most competitive abatement cost in Peninsular Malaysia, at just USD 9.7 per tonne. This means that compared to other plants, TNBM5 would require the lowest compensation for each tonne of CO_2 emissions avoided.

However, any transition option for this plant would be a dilemma for TNB, who is both the sole owner of the plant and the grid operator. In the latter capacity, the financial consideration for TNB is the currently very competitive tariffs offered by TNBM5. Annual tariffs only reached USD 67 per MWh even at the height of coal prices.

Basic plant information

Technical specifications	1000 x 1 unit (MW) Sub-bituminous imported coal Ultra-supercritical boiler
Location and grid region	Perak, Peninsular Malaysia
Owners	TNB (100%)
Age and lifetime	Operational since 2017 Current age: 8 years PPA expiry: September 2042

Key metrics from the CAT tool

Net present value	USD 953 million
Cost of early buy out	USD 56 million per year
Annual emissions	6 mtCO2 per year
Capacity factor	71%
Average tariff	USD 52 per MWh

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Conclusion & User guidance

Leveraging TZ-CAT Malaysia for energy transition planning

Malaysia's coal phase-out is a balancing act

Considerations for moving forward with coal transition

01

Malaysia's orderly transition away from coal will depend on the rapid expansion of cleaner energy sources and supporting infrastructure

With coal playing a major role in the country's baseload power supply, Malaysia faces a critical five-year window between now and 2030 to aggressively scale up renewable energy capacity and upgrade its grid to meet the interim target of retiring 7.7GW of coal capacity by 2035.

Watch for progress on ST's solar initiatives, such as the Large-Scale Solar auction rounds, and rooftop leasing scheme, as well as TNB's grid investment plans.

02

There is merit in exploring a mix of asset-level transition strategies—the earlier the better

There is significant potential for both near- and long-term emissions reductions within the existing coal fleet. Depending on the asset, intervention measures might vary. Early action through voluntary initiatives should be encouraged to maximise impact.

As both the largest coal asset owner and system operator, TNB is uniquely positioned to spearhead transition initiatives.

03

Coal phase-out is ultimately a system-level challenge

Coal phase-out measures will only succeed if they support – not undermine – Malaysia's broader energy transition objectives. As such, asset-level transition strategies cannot be treated in isolation. System-level analysis will be essential to guiding deal negotiations.

Additionally, it is important for Malaysia to signal a clear and sustained commitment to its coal phase-out roadmap, keeping it on course despite competing economic priorities.

Building on the TZ-CAT dataset

Users of TZ-CAT data layer other datasets and analysis to answer key transition questions

Target coal plants in high RE resource areas to optimize existing transmission lines

Layer geospatial data on RE potential and grid access with coal plant coordinates to identify coal plants and sites with a high potential for redevelopment as well as existing connection to the grid.

The rights for redevelopment per site will also be relevant to consider.

Layer TZ-CAT data with load centres, both existing and upcoming, to aid in targeted engagement and prioritisation

The grid location of the asset and near-term demand outlook of the area that it is servicing will inform different transition options.

Model by a target coal phase-out year

Total emissions reduction and cost of buy-out will depend on the country's schedule for coal phase-out. Potential scenarios to model and schedule retirements can assume a specific phase-out target date in line with system requirements and considerations.

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