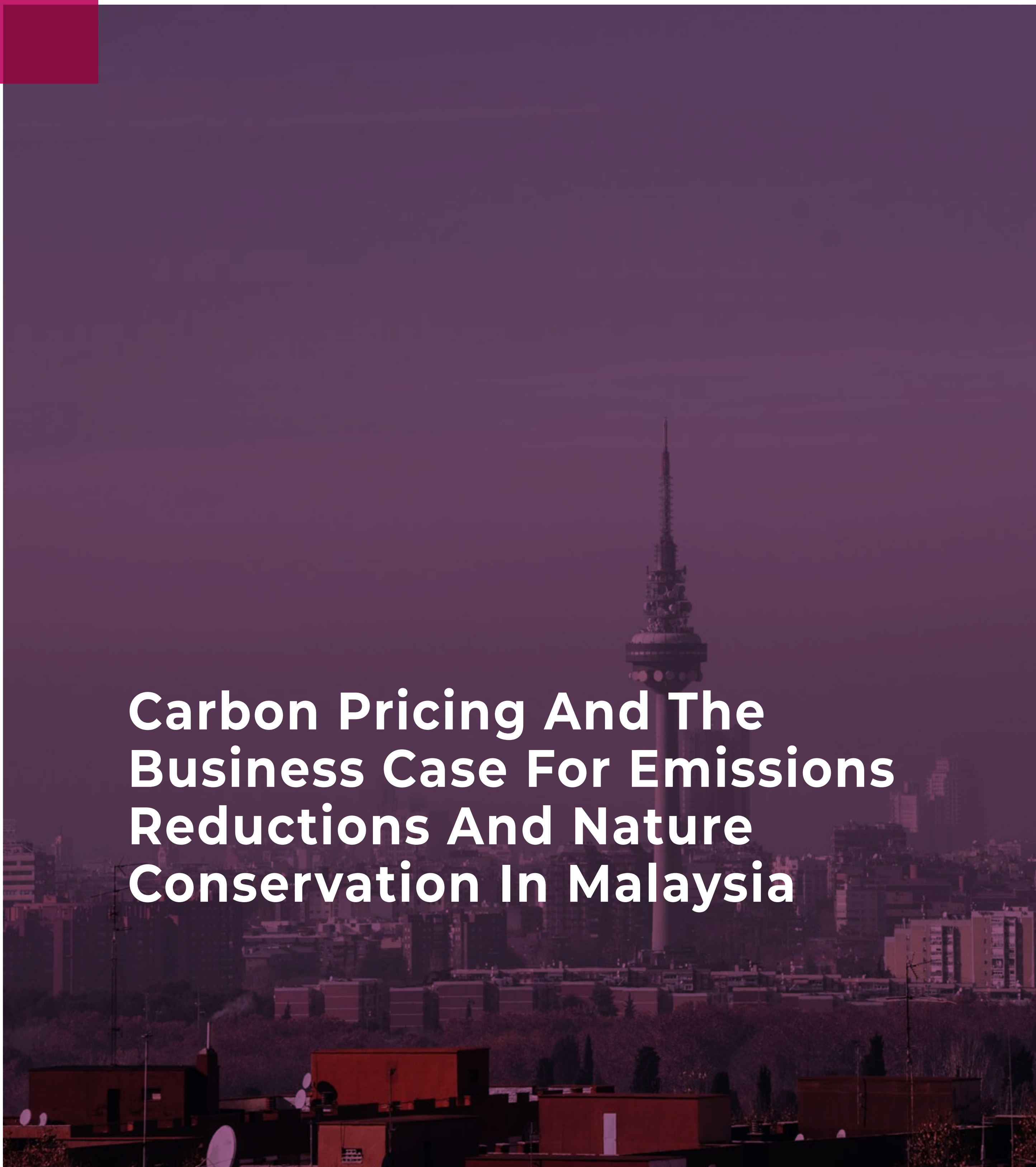
The Asia Foundation

Research Summary and Policy Recommendations



Carbon Pricing And The Business Case For Emissions Reductions And Nature Conservation In Malaysia

CARBON PRICING AND THE BUSINESS CASE FOR EMISSIONS REDUCTIONS AND NATURE CONSERVATION IN MALAYSIA

Research Summary and Policy Recommendations

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List of Commonly-used Acronyms

12MP	12th Malaysia Plan
CO_2(e)	Carbon-dioxide (equivalent)
BCA(s)	Border Carbon Adjustment(s)
CPI(s)	Carbon Pricing Instrument(s)
CBAM	Carbon Border Adjustment Mechanism (EU)
CT	Carbon Tax
(D)ETS	(Domestic) Emissions Trading Scheme
EFT(s)	Ecological Fiscal Transfer(s)
EPU	Economic Planning Unit
FiT	Feed-in Tariff
GHG(s)	Greenhouse Gas(es)
GTFS	Green Technology Financing Scheme
GWh	Gigawatt hours
IPCC	Intergovernmental Panel on Climate Change
IPP(s)	Independent Power Producer(s)
KASA	Ministry of Environment and Water
KeTSA	Ministry of Energy and Natural Resources
kWh	Kilowatt hours
LCOE	Levelized Cost of Electricity
LSS	Large-Scale Solar
MNRECC	Ministry of Natural Resources, Environment, and Climate Change
MOF	Ministry of Finance
MWh	Megawatt hours
MyRER	Malaysia Renewable Energy Roadmap
NDC(s)	Nationally-Determined Contribution(s)
NEM	Net Energy Metering
NEP	National Energy Policy
PEGT	Petronas Energy and Gas Trading
PES	Payments for Ecosystem Services
RE	Renewable Energy
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SCC	Social Cost of Carbon
SEDA	Sustainable Energy Development Authority
ST	Suruhanjaya Tenaga, or Energy Commission
TNB	Tenaga Nasional Berhad
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary Carbon Market

1. Carbon Pricing: Addressing the Market Failures of Climate Change

Addressing climate change is from an economic perspective an exercise in addressing a variety of market failures (The Guardian, 2012; Stern et al., 2021). The most prominent of these is the oversupply of negative externalities that arise from otherwise productive economic activity, such as electricity generation. These negative externalities, in the form of greenhouse gas (GHG) emissions, are driving the increase in global average surface temperatures and exacerbating climate change. A related market failure is the undersupply of positive externalities, in the form of underinvestment in the protection and conservation of natural capital, which amongst their many functions can also sequester carbon.

The failure to address these market failures plays an important role in the continued exacerbation of climate change. From this perspective, climate change is simply a manifestation of a lack of market-correcting interventionswhich incentivize emissions reductions andthe sustainable use of natural capital.

Carbon pricing, which forces an internalization of both the negative and positive carbon externalities, can be an impactful and efficient market-correcting regulatory intervention. By associating a direct cost with GHG emissions, carbon pricing instruments (CPIs) address the negative externality and transform energy markets by enhancing the economic case for investment in low-carbon energy ahead of fossil fuels (Fang, 2018). CPIs also strengthen incentives to conserve and rehabilitate natural capital, such as forests, by placing a tangible valuation on the economic benefits of carbon sequestration (Busch and Engelmann, 2017).

Pricing emissions doesn't necessarily mean a complete resolution of the market failures in question. The 68 CPIs implemented at national and subnational levels globally differ greatly in design, featuring a wide range of carbon prices and coverages. Prices range from roughly USD 1 per ton of CO_2e in Poland, Ukraine, and the city of Shenzen, China, to over USD 130/tCO_2e in some European countries and Uruguay (World Bank, 2022). Singapore's carbon tax rate is currently just under USD 4/tCO_2e, with plans for this tax to rise to over USD 35 by 2030. Indonesia plans to tax emissions from coal power plants at a rate of just over USD 2/tCO_2e. Only a fraction of implemented CPIs price carbon at levels either commensurate with scientific evidence (i.e., the social cost of carbon, or SCC) or consistent with the meeting of 1.5°C pathways as per the Paris Agreement or IPCC guidance (CPLC, 2017; US-IAWG, 2021; Wang et al., 2019). The reasons for this are manifold, chief amongst them that the pursuit of first-best policy solutions is often encumbered by economic and political realities.

Beyond national-level CPIs, attention is turning towards border carbon adjustments (BCAs). BCAs are simply carbon taxes imposed on imports into jurisdictions which already have national-level policies in place. They are aimed at equalizing the stringency of carbon regulation across imports and domestic production, with the cost of the tax based on carbon price differentials between the two jurisdictions in question. Within the host countries of BCAs, the rationale for their implementation centers around the preservation of domestic competitiveness and prevention of carbon

leakage. Externally, BCAs can serve to encourage other nations to adopt their own, ambitious carbon regulation (Campbell et al., 2021). For example, the EU announced in 2021 its intention to implement a carbon border adjustment mechanism (CBAM) that applies to energy, iron, steel, fertilizer, aluminum, and cement imports into the EU (Dumitru et al., 2021). Nations without CPIs have an incentive to match EU carbon regulations and collect revenues domestically, rather than concede potential income to the EU. For Malaysia, a fossil fuel-producing, trade-reliant nation deeply integrated in global value chains and a host destination for FDI, the EU CBAM and BCAs more broadly pose very real economic threats and issue a strong rationale for the development of domestic CPIs.

Against this backdrop and given the Malaysian government's intentions to introduce CPIs (EPU, 2021), it is important to consider how carbon pricing can be used to drive reductions in emissions and encourage conservation. This study focuses on the implications of carbon pricing across Malaysia's energy and forestry sectors. Action across both sectors, to reduce emissions and protect carbon sinks, is crucial in Malaysia's pursuit of its NDCs and long-term goals to decarbonize and achieve net-zero emissions by as early as 2050.

Finally, one important caveat to this study is that it considers the topics of carbon pricing and climate change from an economic perspective. This, however, is only one interpretation of the issue of climate change and the solutions to address it. Non-economic considerations and political mechanisms also play an important role in the broader climate response, including the development of a whole-of-society approach to climate change (e.g., bottom-up pressure, civil society participation, the protection of indigenous populations), the strengthening of enforcement of existing and broader environmental legislation (e.g., biodiversity), the concept of climate justice, and greater transparency and accountability on climate and environmental issues, but discussions on these – and yet other – perspectives are beyond the scope of this study.

2. Policy Background: Carbon Pricing in Malaysia

A. **The 12MP indicated for the first time the government's ambition to formulate a national carbon pricing policy and implement CPIs** (EPU, 2021). It was later established that the then-Ministry of Energy and Water (KASA), now merged with the Ministry of Energy and Natural Resources (KeTSA) into the Ministry of Natural Resources, Environment, and Climate Change (MNRECC), intends to launch a domestic emissions trading scheme (DETS), while the Ministry of Finance (MOF) is studying the feasibility of a carbon tax (CT) mechanism (Aziz, 2021). In parallel, Malaysia's capital market regulator, Bursa Malaysia, launched the domestic voluntary carbon market (VCM) in December 2022.

B. **The VCM enables firms to generate, purchase, and sell carbon credits to meet their climate commitments and targets.** With compliance market instruments still in development, the VCM has the potential to act as a preliminary, 'bottom-up' approach to carbon price discovery and a stepping stone towards DETS implementation. Nevertheless, with carbon prices determined by markets rather than scientific evidence of the externality costs of each ton of CO_2 emitted, nor the Paris target to limit global warming to less than 2°C, market failures remain imperfectly addressed.

C. **Carbon prices in voluntary markets are lower than those observed across many compliance market instruments, and significantly lower than scientific estimates of the costs of emissions.** The price of credits averaged roughly USD 3.82/tCO_2e in 2021 (World Bank, 2022).

A potential risk of low prices is that it would not incentivize the technology-switching and investment in abatement required to sustain a long-term low-carbon transition capable of limiting the rise in global average surface temperatures to under 2°C.

D. Compliance market instruments, i.e. the DETS and CT, can address market failures and incentivize investment in emissions reductions and conservation if designed and implemented well. Consideration must be given to how these instruments can co-exist effectively and efficiently, in terms of their respective sectoral coverage, in the presence of a hybrid CPI approach. Consistency is required in carbon prices across mechanisms to ensure consistent signaling, based on the best available evidence of the social costs of GHG emissions, while also taking into consideration political and socioeconomic constraints.

E. This study focuses on Malaysia's energy and forestry sectors, allowing for the assessment of two converse aspects of carbon pricing. The energy sector analysis, focusing on electricity generation, considers the impacts of carbon pricing on the economic incentives to reduce emissions across an activity that contributes most significantly to national emissions. The forestry sector analysis assesses how carbon pricing can address the undersupply of carbon sequestration and support the conservation of natural capital, and is equally important in the context of Malaysia's climate agenda: more carbon is sequestered in Malaysia's forests than is emitted by the energy sector annually.

3. Carbon Pricing and Emissions Reductions in the Energy Sector

3.1 Background

A. **Malaysia has enacted numerous sectoral policies aimed at increasing Malaysia's use of renewable energy and aiding its low-carbon energy transition.** This includes the Malaysia Renewable Energy Roadmap (MyRER) and National Energy Policy (NEP), launched in 2021 and 2022 respectively. The MyRER includes strategies to increase the installed RE capacity share to 31% by 2025 and 40% by 2035, while the NEP augments this by targeting a total installed RE capacity of 18,431MW and a reduction in the capacity share of coal to 18.6%, by 2040 (EPU, 2021; EPU, 2022; SEDA, 2021).

B. **The NEP demonstrates a clear and present commitment to decarbonization**. It aims to further liberalize the electricity sector and enable a more competitive landscape across the energy value chain. Reinforcing the need to reduce coal use, it aims to more than double current RE production. Carbon pricing is well placed to support these ambitions by raising the costs of carbon-intensive electricity and potentially providing additional revenue streams for investment in low-carbon development.

C. **Existing policy instruments to incentivize RE in Malaysia across the past decade include the feed-in tariff (FiT), net energy metering (NEM), direct procurement of large-scale solar (LSS), and a number of financial instruments designed to support low-carbon investment (e.g., GTFS, GITA, GITE).** None represent direct attempts to internalize the negative externality costs of GHG emissions and as such imperfectly address the market failures driving climate change. As complementary instruments to carbon pricing, however, their impacts can be amplified.

D. **Malaysia still relies heavily on coal and natural gas for electricity generation.** Fossil fuels accounted for 78% of total installed electricity generation capacity and 84% of actual electricity generation in 2019. Hydropower remains the most significant source of low-carbon electricity in Malaysia, accounting for 17% of installed capacity and 15% of all electricity generated. The contribution of other RE sources remains minimal: solar, biomass, and biogas facilities contribute 4.4% of total capacity, and just 1.1% of total electricity generation in 2019 (ST, 2022).

3.2 Carbon Pricing: Incentivizing Emissions Reductions

A. This analysis develops two electricity generation scenarios (G-1 and G-2) and three carbon pricing scenarios (C-1, C-2, and C-3). These scenarios are used to estimate electricity-sector GHG costs (or potential CPI revenues) and the carbon-adjusted levelized costs of electricity.

- Both electricity generation scenarios are based on projected targets for various fuel sources between 2021 and 2035 highlighted in the MyRER (SEDA, 2021), with projections for 2035–2050 based on several assumptions made for this study. These assumptions are expressed in greater detail in the Appendix. G-1 assumes a high penetration of low-carbon energy by 2050 and no coal in the energy mix beyond 2045. G-2 assumes moderate penetration of low-carbon energy by 2050, with coal continuing to be used beyond 2050. The compositions of electricity generation under these scenarios are outlined in Figure 1.

- The three carbon pricing scenarios, C-1, C-2, and C-3, are reflective of increasing degrees of climate 'ambition'. These scenarios share the assumption that carbon taxes are imposed from 2025 onwards, with rates adjusted upwards every two or three years. The carbon pricing schedules under each of these scenarios are detailed in Table 1.

Figure 1: Electricity Generation Scenarios: G-1 and G-2

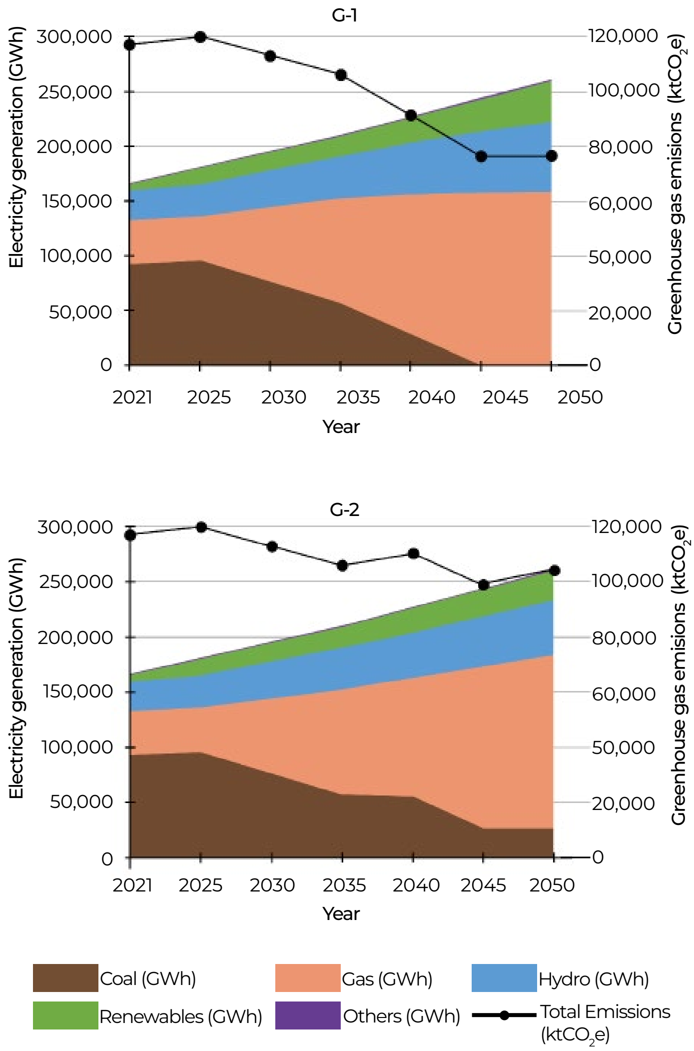


Table 1: Carbon Pricing Scenarios: C-1, C-2, and C-3

Scenario	Carbon Price (MYR/tCO$_2$e)						
	2020	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
C-1 (Conservative)	0	10	30	60	100	150	200
C-2 (Moderate)	0	35	75	150	250	350	500
C-3 (Ambitious)	0	15	80	200	400	600	900

B. These scenarios, and data on emissions intensities by fuel source based on electricity generation data for Malaysia (IPCC, 2006; KASA, 2020; ST, 2018; ST, 2019; ST, 2021; ST, 2022), are used to derive estimates for total electricity-sector GHG emissions and, subsequently, the cumulative cost of these GHG emissions, through to 2050. These GHG emissions costs also reflect potential annual CPI revenues, if all electricity sector emissions are perfectly captured. This data is presented in Figures 2 and 3 respectively.

Figure 2: Total GHG Emissions and Emissions Intensity of Electricity, Scenarios G-1 and G-2

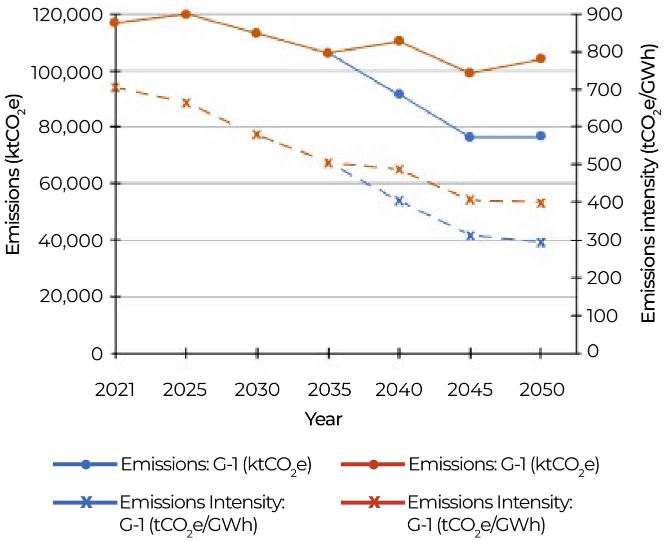
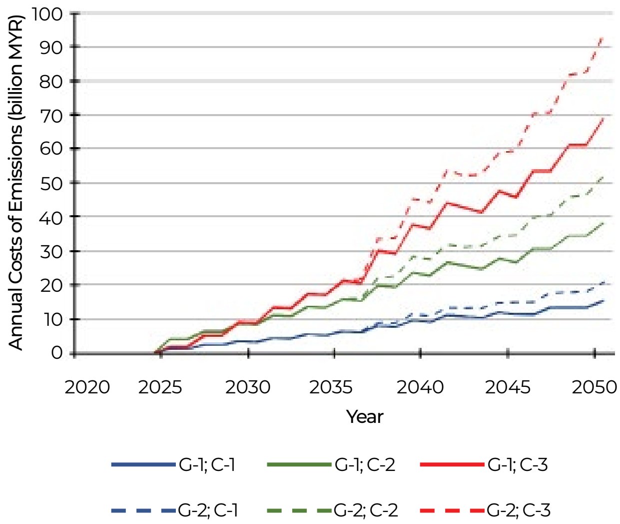


Figure 3: Annual Costs of GHG Emissions Across Generation and Carbon Pricing Scenarios



C. **Substantial emissions reductions can only be realized by eliminating coal from the electricity mix, while aggressively pursuing carbon-free generation sources in replacement.** Annual emissions are projected to reduce by 35% between 2021 and 2050 under Scenario G-1, but only by 11% for Scenario G-2.

D. **While the replacement of coal with natural gas reduces electricity sector emissions in the medium-term, a persistent reliance on gas causes a long-run upward trend in absolute emissions.** This is evidenced by projected increases in total emissions during periods where coal-fired generation is unchanged but gas-fired generation increases.

- Fossil-fuel technological advancements and other carbon-abatement technologies including carbon capture, utilization, and storage (CCUS) may partly alleviate these concerns, but effecting long-term emissions reductions beyond 2050 requires aggressively pursuing all low-carbon energy technologies to an even greater extent than projected by the more ambitious Scenario G-1.

E. **The emissions intensity of electricity generation is projected to reduce by 58% under Scenario G-1 and 43% under Scenario G-2 by 2050.** These reductions are however counteracted by projected growth in electricity demand of roughly 60% over the next 30 years. This enhances the importance of continuous efforts to improve energy efficiency and minimize electricity losses and wastage, in addition to expanding RE deployment.

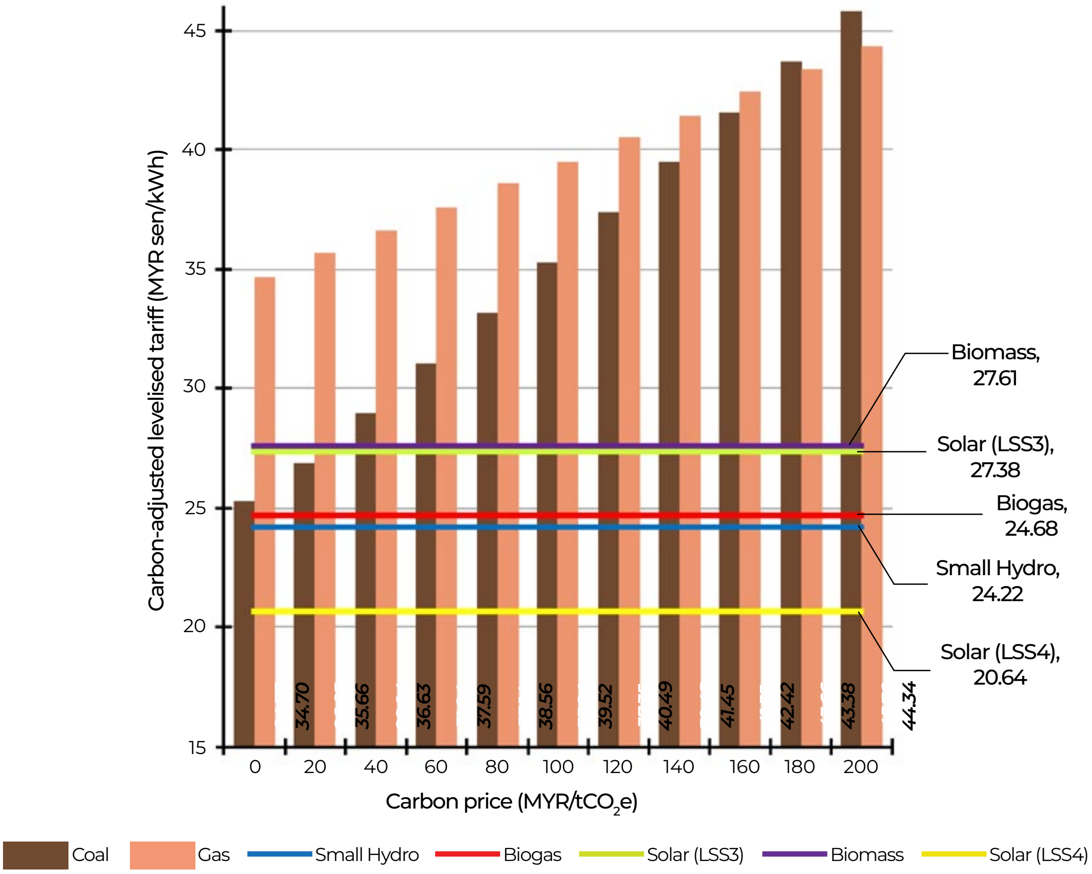
F. **Carbon pricing would recognize GHG emissions as substantial costs, and conversely, equally substantial potential revenues for the government.** Under the conservative CPI scenario, cumulative GHG costs amount to roughly MYR 203 billion under generation scenario G-1, and MYR 245 billion under generation scenario G-2, by 2050. Under the moderate CPI, this rises to between MYR 504 billion (G-1) and MYR 609 billion (G-2), and under the ambitious CPI, between MYR 790 billion (G-1) and almost MYR 1 trillion (G-2).

G. **Carbon pricing imposes additional electricity generation costs based on the emissions intensity of each unit of electricity generated.** This study treats the carbon cost per unit of electricity as a carbon-adjusted tariff premium (i.e. the social costs of emissions resulting from each unit of electricity produced) and adds this premium to published levelized tariffs (i.e. the price per unit of electricity produced) for coal and natural gas (ST, 2012; TNB, 2016). These carbon-adjusted tariff premiums and levelized tariffs are presented in Table 2. Figure 4 contrasts the carbon-adjusted levelized tariffs for coal and natural gas with the tariffs from competitive bidding exercises for electricity generated through low-carbon sources in Malaysia (SEDA, 2022; ST, 2019; ST, 2020).

Table 2: Impacts of Carbon Pricing on Levelized Tariffs for Fossil Fuels

	Carbon price (MYR/tCO_2e)	**0**	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**
Coal	Tariff premium *(MYR sen/ kWh)*	0.00	2.10	4.21	6.31	8.41	10.51	12.62	14.72	16.82	18.93	21.03
	Carbon-adjusted levelized tariff *(MYR sen/ kWh)*	24.73	26.83	28.94	31.04	33.14	35.24	37.35	39.45	41.55	43.66	45.76
Gas	Tariff premium *(MYR sen/ kWh)*	0.00	0.96	1.93	2.89	3.86	4.82	5.79	6.75	7.72	8.68	9.64
	Carbon-adjusted levelized tariff *(MYR sen/ kWh)*	34.70	35.66	36.63	37.59	38.56	39.52	40.49	41.45	42.45	43.38	44.34

Figure 4: Carbon-Adjusted Levelized Tariffs for Coal, Gas, and RE Sources



H. Levelized tariffs for gas are roughly 40% higher than coal in the absence of carbon pricing. Coal will remain a cheaper source of electricity than gas until carbon prices exceed 175 MYR/tCO_2e, assuming no other changes to fuel input prices. Even under our ambitious scenario, carbon prices only reach this level in 2035. The planned retirement of coal power plants in favor of natural gas in the coming decades can cause inflationary pressures on electricity prices, but this can be negated by continued growth in the deployment of low-cost, low-carbon electricity and other technical, efficiency-improving enhancements.

- The assumption that fuel input prices will remain unchanged is itself tenuous; both coal and gas prices have increased sharply in 2022 following the conflict between Russia and Ukraine, for instance, and further fossil fuel-price volatility over the coming decades is plausible. This also has implications for energy security and alongside climate change is a key driver of global momentum in favor of alternative fuels, including RE and other low-carbon energy sources such as nuclear.

I. Even before accounting for carbon prices, levelized tariffs for coal are already on par with small hydro and biogas, based on observed bid prices, and higher than those for solar during LSS4. Biomass and LSS3 reach parity with coal at a price of approximately 26 MYR/tCO_2e. Levelized tariffs for gas, on the other hand, are much higher than the bid prices of all low-carbon sources, even in the absence of carbon prices. Gas will likely face increased competition from RE until carbon prices reach a point where gas is more economically feasible than coal. This may not occur until the late-2030s – if not the 2040s – depending on the ambition of CPI design.

J. On average, bid prices under LSS4 are the lowest in the analysis at 20.64 sen per kWh, with individual bids reaching as low as 13.99 sen/kWh. Rising costs for solar panels, driven by increases in raw material and transport costs, challenge the present feasibility of such prices. This has necessitated amendments to agreements between ST and successful bidders. Steps to limit the adverse effects of such price shocks, such as the deployment of locally-produced technology, can counter these concerns moving forward.

3.3 Stakeholder Assessment: Carbon Pricing and Electricity

A. Carbon pricing will most significantly affect stakeholders operating in carbon-intensive industries and sectors. Fossil fuel combustion results in roughly 75% of national GHG emissions; electricity alone accounts for just under 31% of the total (KASA, 2020). The sector will be deeply implicated by carbon pricing and, importantly, represents an area of significant potential emissions reductions.

B. The electricity industry cuts across various economic actors and stakeholders, including policymakers, regulators, fuel suppliers, and power producers. Ministries and Agencies with direct responsibilities within the energy sector include the EPU and MNRECC (EPU, 2022). In Sabah and Sarawak, state-level EPUs play an important role formulating energy policies. The Ministry of Plantation and Commodities (MPC) is responsible for the supply of biofuels, while the Energy Commission (Suruhanjaya Tenaga, or ST) is the electricity sector regulator (Yatim et al., 2016). TNB and the various independent power producers (IPPs) are the power producers on the Peninsula, with Sabah Electricity Board (SESB) and Sarawak Energy Berhad (SEB) the state-level utility companies in East Malaysia. Finally, the Sustainable Energy Development Authority (SEDA) remains the focal point for RE promotion and deployment.

C. Malaysia's electricity sector has evolved in a more liberalized fashion following efforts to restructure the industry. Previously a vertically-integrated monopoly system with TNB the key industry player, reforms in 1993 introduced IPPs with the aims of enhancing electricity supply security and generation capacity. The Single Buyer was also introduced, tasked with the procurement of electricity from IPPs and TNB Generation, and management of generation scheduling based on the least-cost dispatch model (Kumar et al., 2021).

D. Affected stakeholders will depend greatly on CPI design. These may include stakeholders operating at the fuel supply, generation, and procurement levels, depending on the incidence of regulation. For fuel supply, implicated stakeholders would include TNB Fuel, which imports coal, and Petronas Energy and Gas Trading (PEGT), which supplies natural gas. At the generation level, implicated stakeholders would include TNB Generation and the IPPs. An upstream CPI, i.e. at the fuel supply level, for example, would implicate TNB Fuel and PEGT, while a downstream tax incidence would see TNB Generation and the IPPs face the costs of the GHG emissions produced at their facilities. Finally, should these added costs be passed through to end-users as base generation costs, customers will be amongst the most impacted. This can have broader macroeconomic consequences and steps must be taken to limit such cost pass-through.

4. Carbon Pricing and Natural Capital Conservation

4.1 Background

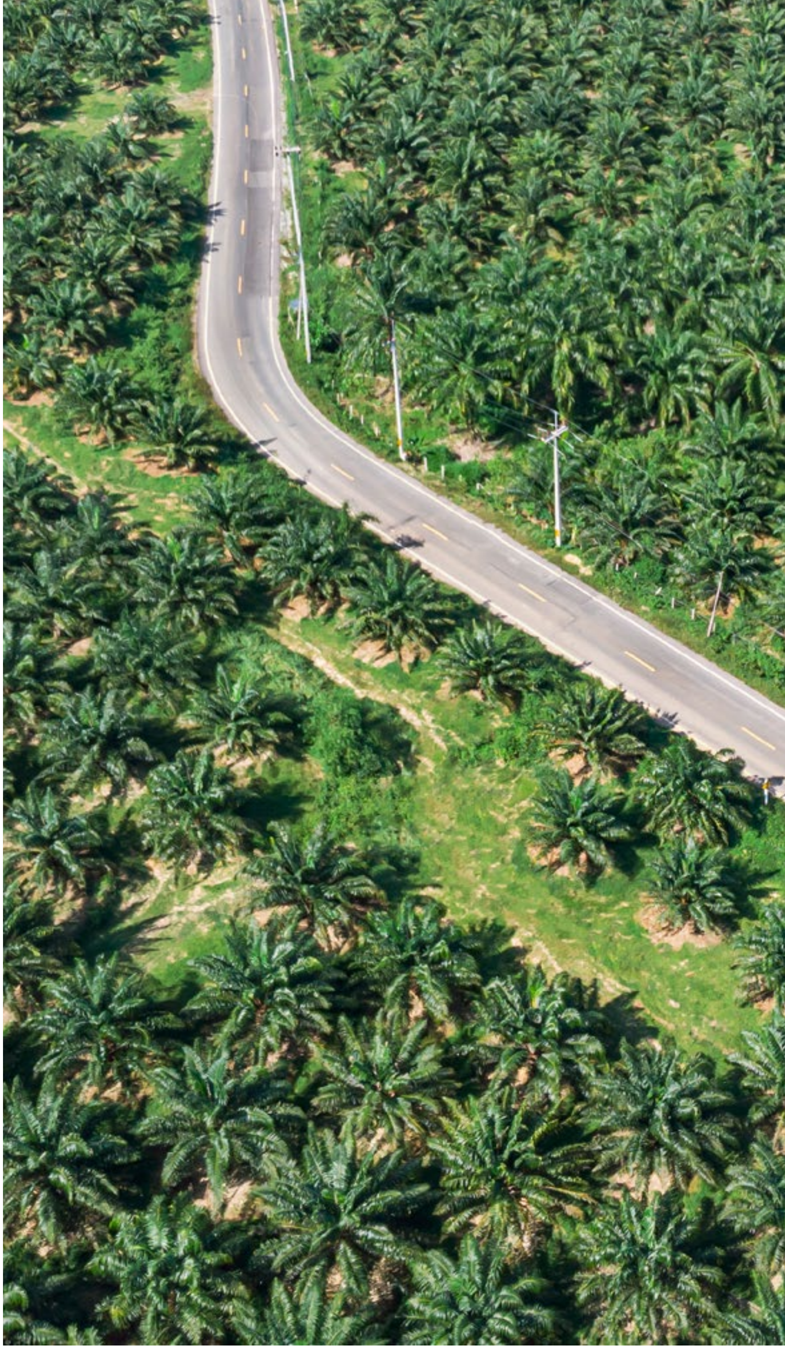
A. The recently revised Malaysian Forestry Policy recognizes the integral roles that forest resources play in aiding climate change mitigation and adaptation, including the role of forests as carbon sinks. Calls are made for their increased protection through legislative and economic instruments, but no specific targets have been set.

B. Instruments catered towards encouraging conservation and enhancing the contribution of the forestry sector towards climate change include the REDD+ financing scheme, payments for ecosystem services (PES), and ecological fiscal transfers (EFTs). These are largely in early or limited stages of implementation (EPU, 2021). Significant scope exists for expansion and complementarity with carbon pricing. For instance, placing a high price on carbon reduces the likelihood of forest degradation or conversion. Alongside PES, this can ensure that a broad range of forest ecosystem services are valued monetarily and can further deter forest exploitation. Carbon pricing revenues can also be used to further forest protection and REDD+ activities, as well as provide for an additional source of revenue for state governments.

C. The 12MP highlights the expansion of both EFT and PES to enhance conservation and support the role of natural capital in addressing climate change mitigation and adaptation (EPU, 2021). PES involves payments issued to landowners to ensure continued provision of ecosystem services and incentivizing projects supporting environmental goods. Expansions of PES and the introduction of CPIs need to be coordinated to ensure they do not contradict one another. For example, PES typically include payments to ensure the continued sequestration of carbon; if this practice is maintained for PES in Malaysia, there is little need for CPIs with overlapping functions. Cohesion between instruments will maximize their effectiveness in addressing the broad set of factors causing underinvestment in conservation. This also necessitates coordination across the government entities involved in their design.

D. As evidenced by the broad range of instruments needed to ensure forest conservation objectives are met, the business case for conserving natural capital goes well beyond just carbon. CPIs, for their part, are an avenue towards internalizing the positive externalities of carbon sequestration – but not the other positive externalities associated with the protection of biodiversity, forests, and other natural capital.

4.2 Carbon Pricing: Incentivizing Natural Capital Conservation



A. **The economics of conservation is dependent on opportunity costs**. A comprehensive understanding is needed of the monetary value of the benefits of natural capital conservation, including carbon sequestration and the various ecosystem services they provide. Acting against the benefits of conservation are the returns generated through exploitation. To that end, this section assesses some of these trade-offs, focusing on the exploitation of forests for oil palm, timber and limestone, as well as conserving forests to maintain and enhance investible carbon.

B. **Malaysia is the second-largest producer of oil palm globally, generating revenues of more than MYR 4,000 per ton of palm oil exported in 2021.** Due to variations in agroecological conditions, returns from oil palm vary substantially by state. Across Peninsular Malaysia, plantations generate annual revenues of between MYR 10,000 and MYR 19,000 per hectare. In Sarawak, returns average between MYR 6,400 and MYR 11,400 per hectare (MPOB, 2022). However, the proportion of these revenue that accrue to state governments is difficult to discern from available literature. This data is important to determine how CPIs can compensate for the opportunity costs of managing natural forests for carbon in lieu of converting them to oil palm plantations.

C. **While timber remains an important commodity in Malaysia, persistently high demand for timber products coupled with the dwindling supply of natural tree resources, high environmental costs, and falling employment and profits threaten the industry's long-term sustainability**. Without sufficient funding from the federal government to protect and conserve natural forests, states need to obtain revenue from forests in the form of premiums and cess from land, as well as royalties from timber and other forest-based products. Between 2007 and 2019, average forest-based revenues ranged from a low of MYR 52 per hectare in Negeri Sembilan to MYR 233 per hectare in Selangor (Law, 2021). As such, CPIs must ensure these opportunity costs are compensated for to ensure the business case for enhanced forest management in lieu of logging.

D. **Limestone karsts, which can sequester carbon and support biodiversity, is alongside granite, the most commonly-mined rock in Malaysia (primarily for use in cement production).** Limestone quarries account for 78 of the 368 quarries nationwide and are most numerous in Perak. Between 2014 and 2016, the state produced over 50 million tons of limestone. In comparison, Sarawak, the second-largest producer, accounted for only roughly 20 million tons over the same period. Between 2015 and 2020, annual per-ton limestone revenues averaged between MYR 9 (in 2019) and MYR 14 (2016) (JMG, 2022). However, the proportion of these revenue that accrue to state governments is difficult to discern from the available literature. Such data is important to determine how CPIs can compensate for the opportunity costs of managing limestone karsts as carbon sinks in lieu of converting them to oil palm plantations.

E. **In Malaysia, the top five states in terms of volume of investible carbon are, in decreasing order, Sabah, Sarawak, Pahang, Terengganu, and Johor.** Combined, these states possess investible carbon of just under 489,000 tons of CO_2e annually. This equates to an average of USD 20.6 million a year, assuming a carbon price of USD 5.80 over the first five years that appreciates by 5% annually over the subsequent 30 years, with a 10% risk-adjusted discount rate (Koh et al., 2021).

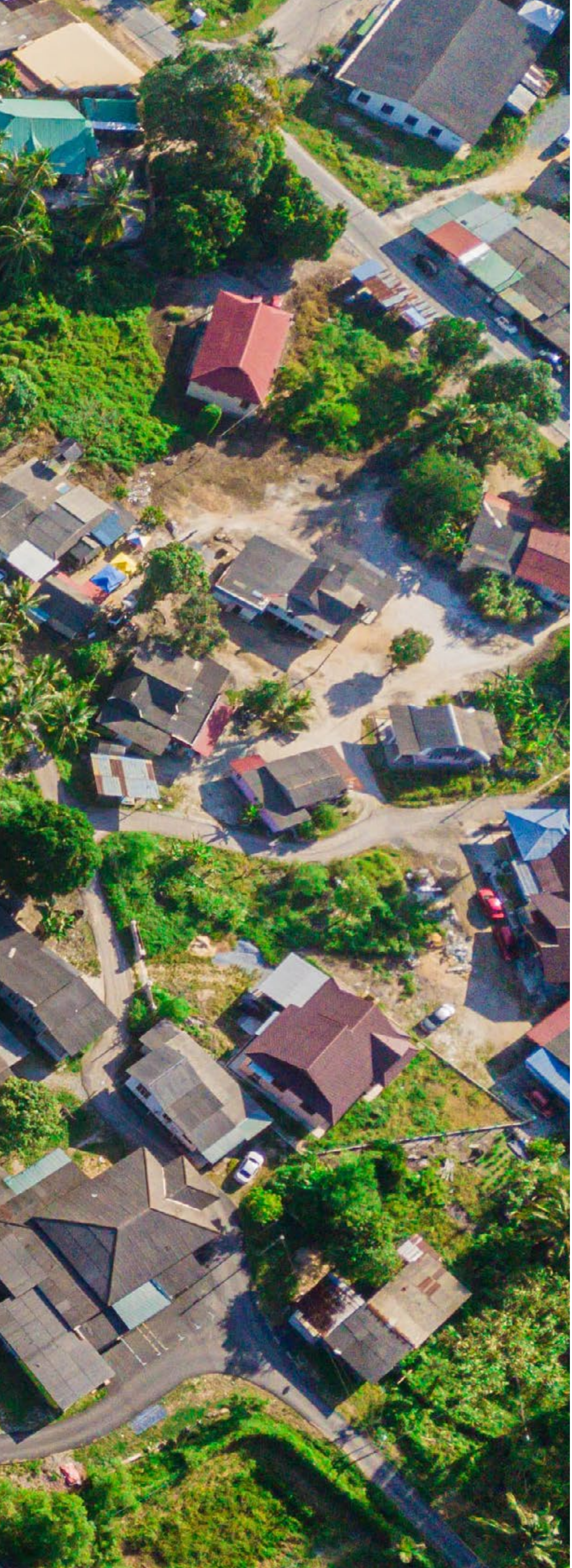
Table 3: Ranking of States in Malaysia by Volume of Investible Carbon

State	Investible carbon (tCO_2e/year)	Aggregated NPV of Annual and accumulated profits from forests with investible carbon (USD/year)
Sabah	207,997	10,148,384
Sarawak	195,605	6,483,760
Pahang	53,152	2,457,047
Terengganu	18,427	749,475
Johor	13,777	730,858
TOTAL	**488,958**	**20,569,524**

F. **Investible carbon is only the tip of the iceberg in the context of forest and natural capital conservation. Exploitation can disrupt ecosystem and environmental services and can engender a variety of economic damages.** This includes peat fires and haze, which can adversely affect agriculture, the environment, public health, and increase the risk of zoonotic spillovers. Some of these damages can be transboundary, meaning costs accrue outside the jurisdictions of origination. Beyond climate change, remains difficult to quantify in monetary terms, including the costs of life expectancy changes, premature deaths, social unrest, undiscovered mental health problems, threats to food and water security, and the next pandemic. Importantly, these costs only further reinforce financial incentives in favor of conservation.

G. **The quantification of biodiversity is another challenge towards developing a full accounting of the economic returns of conservation.** Over recent decades, various frameworks have been created to measure biodiversity. Still, there remain no simple ways to value biodiversity and other ecosystem services owing to their subjectivity and dependence on time, place, circumstances, and choice of base cases for comparison.

H. **Focusing solely on carbon stock accumulation can trigger unwanted consequences across other ecosystem services.** This approach can cause the neglect of highly biodiverse, low-carbon areas. Although co-benefits can be accurately detected with high-resolution data, existing mechanisms do not guarantee the protection of other ecosystem services in the presence of a focused emphasis on profit maximization through carbon stock accumulation.



4.3 Stakeholder Assessment: Carbon Pricing and Forestry

A. **As a megadiverse country, Malaysia's land-use, land-use change, and forestry (LULUCF) sector is a major determinant of carbon emissions and sequestration.** Malaysia's carbon sinks sequester more CO_2e than is emitted by energy use. The recent focus across both public and private sectors toward net-zero emissions has reinforced importance of a sustainable forestry sector to Malaysia's climate response. Indeed, meeting its NDCs and long-term net-zero plans will necessitate an acceleration of natural capital conservation.

B. In contrast to the complex stakeholder ecosystem within the electricity sector, the situation in the forestry sector is more straightforward, as the most influential stakeholders are easily identifiable. With land a state jurisdictional matter, state governments remain the key stakeholders.

C. **States rely on natural resources and land for a sizeable proportion of their revenues**. A key challenge that the forestry sector has long faced is the lack of an equitable revenue-sharing mechanism between federal and state governments to incentivize forest conservation and rehabilitation at the state-level. Attempts to raise conservation funds, such as through the National Conservation Trust Fund for Natural Resources (NCTF), as well as EFTs and PES, have in their current state proven insufficient in replacing income generated from exploitative activities such as logging, land sales, mining, or plantations.

D. **States vary significantly in terms of forest cover, geography, topography and economy, complicating any attempts towards developing a federal-state revenue-sharing model.** Establishing 'fair share contributions' for each state towards the achievement of national conservation targets can simplify this process. States will face varying degrees of impact from carbon pricing; those with higher quantities of forest cover would benefit from high carbon prices; states with lesser forest cover, less so. Carbon pricing will not equally impact states across the country; consequently, the incentives it creates for conservation will also vary across Malaysia.

5. Carbon Pricing, Energy, and Forestry: Policy Outlook and Recommendations

5.1 National Policy Outlook

A. **With the implementation of CPIs firmly on the 12MP agenda, MNRECC has announced its intentions to launch the DETS, and MOF is assessing the potential of a CT mechanism.** Bursa Malaysia, meanwhile, launched the VCM in December 2022. While details on the former two compliance mechanisms remains scarce owing to the nascence of policy and instrument development, evidence shows an increasing integration of climate and sectoral objectives. A cross-sectoral focus on CPIs can complement this approach by incentivizing all implicated industries to decarbonize.

B. **Low-carbon commitments within the energy sector have been reinforced by the recently-launched MyRER and NEP.** This includes more ambitious targets for installed RE capacity (40% by 2035); commitments to significantly reduce coal use; plans for further market liberalization; and investment in RE-enabling grid infrastructure upgrades and energy storage. This context points to a more competitive landscape across the energy value chain in the future. Carbon pricing is well placed to support these ambitions by raising the costs associated with carbon-intensive energy and providing additional revenue streams for investment in low-carbon development.

C. **There is evidence of an increasingly holistic approach to sustainable forest management in Malaysia through the recent emphasis on EFTs, PES, and REDD+.** The VCM can further these efforts by providing a platform for private-sector investment in conservation. Together, this represents a broad approach towards internalizing the positive externalities of nature-based services. It is important to ensure that the quantification of the monetary value of conservation reflects the value of the wide range of services rendered by nature. The development of protocols to enable states to generate revenue and support conservation through carbon trading will add further impetus to these efforts, especially across states with large tracts of investible carbon.

5.1 Policy Recommendations

Malaysia is likely to take a hybrid approach to the implementation of CPIs, evidenced by the focus of MNRECC on the DETS and MOF on CT. This situation adds a level of complexity to the process of designing effective CPIs, necessitating consideration of various aspects of their design and implementation. Beyond this, our analysis has shed light on other important factors in the context of electricity-sector emissions reductions and natural capital conservation. This context gives rise to the policy recommendations discussed below.

5.2.1. Policy Recommendations: CPI Design

A. Develop a long-term roadmap to price carbon at a level that reflects the marginal cost of GHG emissions, i.e. the social cost of carbon (SCC).

This enables the full internalization of the externality costs of GHGs. In practice, however, economic and political constraints tend to hinder this first-best approach, especially in carbon-intensive economies. The immediate imposition of high carbon prices or strict emissions caps in the absence of economically-feasible, low-carbon technologies can negatively affect industrial growth, which may outweigh the monetary value of environmental benefits (Carlin et al., 2022). Assessments of carbon pricing points or emissions reduction pathways that can best assist the achievement of Malaysia's emissions reductions targets (such as net-zero by 2050) can act as a starting point to determine prices best suited to support national climate ambitions in a balanced manner (Kaufman et al., 2020).

B. Establish estimates of the Malaysia-level social cost of carbon.

In the long-term, price convergence at the global SCC is required to properly address the global nature of the emissions externality (Nordhaus, 2019; Weitzman, 2015; Weitzman, 2017). Only a global solution can fully account for a global issue like climate change. But this remains a distant prospect and ignores consideration of the concept of climate justice. A carbon price that is commensurate with scientific estimates of the impact of climate change within Malaysia itself would at least provide for an evidence-based approach to carbon price-setting. While estimates of the Malaysia-level SCC (MY-SCC) do exist in the economic literature, these are based on incomplete estimates of likely climate change-related damages (Rasiah et al., 2016; Ricke et al., 2018; Sarkar et al., 2019). Filling these knowledge gaps would allow for the estimation of a more robust set of science-based estimates for the MY-SCC. These can be used to inform prices under the CT and even the DETS, for instance by allowing prices to fluctuate only within a predetermined range of the MY-SCC.

C. Set emissions caps based on emissions cuts required for Malaysia to achieve its most ambitious decarbonization strategies and targets, e.g., net-zero emissions by 2050.

Emissions reductions outcomes of the DETS depend heavily on the ambition of Malaysia's emissions reduction targets. In contrast to the approach of carbon taxes, which entail setting a price on carbon, ETS sets quantity 'caps' on emissions. This means the price of carbon can vary, and in doing so, price signals that incentivize decarbonization are themselves variable, dependent on the supply of and demand for emissions allowances (Feng et al., 2011). Naturally, a more ambitious set of emissions reduction targets would imply higher carbon prices, and can drive up the price of carbon and encourage emitters to invest aggressively in low-carbon technology (ADB, 2021; Parry et al., 2021). Malaysia should also set its NDCs in terms of absolute emissions reductions targets; these would work more seamlessly with emissions caps under the DETS.

D. Gradually expand the scope of CPIs to cover all major economic activities.

CPIs should cover as broad a range of economic activities as possible, to ensure consistent decarbonization signals across industries and sectors (Chen & Hafsted, 2016; Macaluso et al., 2018). Nevertheless, implementing CPIs within industries where technology-switching is costly or infeasible risks generating costs which can come to the detriment of industrial and broader economic growth in return for little environmental benefit, at least in the short-term (Smulders & Vollebergh, 2001; Stavins, 2022). Instead, CPI scope first should be limited to activities with the potential for cost-effective low-carbon transitions and, following the gradualist approach prescribed for increasing the price of carbon, expand over time to cover a broader set of economic activities (ADB, 2021; OECD, 2016).

E. Limit cost pass-through of carbon regulation and develop a carbon rebate mechanism to support low-income and vulnerable population groups.

Regardless of intended or initial incidence, the costs imposed by CPIs may be passed down the value chain to end-users, causing adverse effects on households (Fabra & Reguant, 2014; Neuhoff & Ritz, 2019). Safeguards should be put in place to limit the extent of such cost pass-through. A portion of CPI revenues should also be reinvested towards reconciling any cost-of-living increases faced by low-income and vulnerable segments of the population (CBO, 2012; Joshi, 2019; Marron & Morris, 2016).

5.2.2. Policy Recommendations: Energy and Forestry

F. Continue pursuing a suite of policies in support of the expansion of low-carbon electricity generation in Malaysia.

Carbon pricing is a fundamental component of the policy response to climate change but not the sole solution. A greater understanding is needed of the interactions between CPIs and other economic and financial instruments, such as subsidies and financing for low-carbon electricity, which support the nation's energy transition (ADB, 2021; Baranzini et al., 2017; Dorband et al., 2022; Rosenbloom et al., 2020). As CPIs are implemented and practical evidence of their effects are assessed, other policy instruments, i.e., FiT, NEM, GTFS, etc., can be revised to ensure their continued effectiveness and efficiency.

G. Develop a long-term strategy to replace natural gas with low-carbon energy sources in electricity generation.

Natural gas is roughly half as emissions-intensive as coal, but remains significantly more polluting than low-carbon energy (IPCC, 2014). Replacing coal largely with natural gas contributes to a decrease in the emissions intensity of electricity generation of only 25% by 2050, from roughly 400 tCO_2e/GWh to 300 tCO_2e/GWh, relative to a scenario where coal usage continues beyond 2050. This is because energy demand is projected to rise with population and income growth, and any emissions reduction gains made by replacing a single unit of coal are negated by a two-unit increase in gas consumption. For Malaysia to continue decarbonizing electricity generation beyond 2050, a long-term strategy to reduce baseload electricity reliance on fossil fuels is a necessity. This will require investment in grid upgrades, RE, carbon abatement technologies, and other low-carbon energy generation and storage technologies such as batteries, hydrogen, and even nuclear power (Arbogast et al., 2018; Matek & Gawell, 2015). Natural gas may serve Malaysia's needs until 2050, and can play a role ensuring the security aspect of the energy trilemma until then, but consideration must be given to its longer-run phase-out.

H. Establish benchmark studies of investible carbon in Malaysia.

One of the key factors causing the long-term underinvestment in conservation and lack of environmental protections internationally remains a lack of detailed information, particularly in the valuation of environmental goods (Vardakoulias, 2013). Ultimately, this is a driver of inefficient and suboptimal resource use. Collecting data on the value of stored carbon across major forested areas across states in Malaysia can be a precursor towards enabling carbon projects across a wide geographical spectrum and encourage conservation and sustainable forest management nationally (Runting et al., 2020). Importantly, it can play a role in diverting conservation towards areas where it is most profitable, and exploitation where it remains most economically viable.

I. Ensure complementarity across policy instruments in support of conservation.

Carbon, whether emitted or sequestered, is not the only environmental variable counteracting pressures to exploit natural capital. A continued focus on EFTs, PES, and REDD+, in addition to other enabling regulations and certifications, will ensure incentives in favor of a broad set of environmental goods beyond those measured in terms of GHG emissions (Larjavaara et al., 2019; Rosenbloom et al., 2020). In land-use, carbon pricing can inform the value of sequestration, but cannot factor in the benefits of improved access to and quality of water, biodiversity conservation, flood mitigation, erosion prevention efforts, and other beneficial environmental actions. A suite of region-specific, nature-based solutions and policy instruments can address the various externalities causing the undersupply of environmental 'goods' and oversupply of environmental 'bads'. This combination of instruments can be more effective than a universal carbon pricing system.

J. Enable open access to granular data on energy and forestry sector GHG emissions and sinks.

This will encourage further research across academia, NGOs, think-tanks, and others and contribute to a greater public

of the key tradeoffs in energy policy, including ensuring affordability, security, and sustainability. More importantly, ensuring open data will allow for researchers to continuously monitor and assess the efficacy of policy instruments towards meeting their goals. This will take on greater importance following the implementation of some of the market failure-addressing policy instruments described in this study, including CPIs and PES.

Glossary

Carbon dioxide-equivalent, CO_2(e)
A commonly-used unit of measurement which converts the global warming potential (GWP) of various GHGs, including methane (CH_4) and nitrous oxide (N_2O) into units of CO_2.

Carbon-adjusted Levelized Tariff
In the context of this study, this describes the observed electricity tariff charged by the electricity generation facility in addition to the carbon-adjusted tariff premium.

Carbon-adjusted Tariff Premium
In the context of this study, this describes the additional costs imposed on electricity producers for electricity generated from fossil fuel sources at a given carbon price.

Carbon Pricing Instrument(s), CPI(s)
Economic instruments, typically referring to compliance market instruments such as carbon taxes and emissions trading schemes, which entail the association of a price, or cost, to GHG emissions.

Ecological Fiscal Transfer(s), EFT(s)
A form of intergovernmental transfer that sees the allocation of funds from, for example, federal to state levels of government contingent on the attainment of, in this case, ecological or environmental 'goods', e.g. conservation of forest cover

Greenhouse Gas(es), GHG(s)
Heat-trapping gases whose increasing atmospheric concentration, driven by emissions of CO_2, CH_4, and N_2O, drives surface-level temperature increases and exacerbates climate change.

Investible Carbon
Refers to certifiable carbon credits generated through forest protection projects. Certifiable carbon credits must abide by the 'additionality' requirement, whereby carbon stocks can generate credits only if faced with the threat of decline or loss if otherwise unprotected by conservation projects.

Levelized Cost of Electricity, LCOE
A measurement of the average cost of producing each unit of electricity, typically measured in kWh, for an electricity generating facility to break even over its operational lifespan.

Large-Scale Solar, LSS
The competitive bidding programs held by ST, of which there have been four as of 2022 (i.e. LSS1 through LSS4), that result in the award of contracts for the procurement of solar power generated through large-scale facilities, defined as having an installation capacity of greater than 1MW

Ministry of Natural Resources, Environment, and Climate Change, MNRECC
In early December 2022, the Malaysian government announced its new Cabinet. Amongst the changes from the previous administration was the merging of two Ministries, namely KeTSA and KASA, into MNRECC.

Nationally-Determined Contribution(s), NDC(s)
The targets set by individual nations party to the Paris Agreement related to the mitigation of the GHG emissions that cause climate change, and adaptation to the consequences of climate change. These are updated every five years.

Premium and Cess
These refer to the payments received by state governments from concessionaires who generate revenue from the harvest of forested land.

Payments for Ecosystem Services, PES
A system of compensatory payments issued, typically, to landowners in exchange for their performance of actions or interventions that protect or enhance the provision of ecosystem services, such as the supply and purification of water, flood mitigation, carbon sequestration, wildlife protection, and others.

Social Cost of Carbon, SCC
A measurement of the costs of each metric ton of GHG emissions, based on scientific evidence of the projected physical impacts of climate change, the translation of these physical impacts into economic damages, and the conversion of future damages into present-day economic costs.

Appendix

Table 4: Scenarios and Assumptions for Electricity Generation in Malaysia

<table>
<tr><th colspan="2">Assumption</th><th>Generation Scenario 1 (G-1) (High RE, no coal from 2045)</th><th>Generation Scenario 2 (G-2) (Moderate RE, minimal coal from 2045</th></tr>
<tr><td>1</td><td>Fixed data points</td><td colspan="2">• Gigawatt-hour (GWh) values for 2021, 2025 and 2035 were treated as anchor points and based on published data under the New Capacity Target scenario in MyRER.</td></tr>
<tr><td>2</td><td>Total generation growth from 2025 to 2035</td><td colspan="2">• Total electricity generation growth (in GWh) was interpolated linearly at 1.6% per year with anchor points of 2025 and 2035.</td></tr>
<tr><td>3</td><td>Total generation growth post-2035</td><td colspan="2">• Total electricity generation growth (in GWh) was assumed to be similar to Assumption #2, with 2035 as the anchor point.</td></tr>
<tr><td>4</td><td>Trend of all electricity sources between 2025 and 2035</td><td colspan="2">• Generation trends of each source were interpolated linearly with anchor points of 2025 and 2035, and annual rates as follows: Coal: -4.1%, Gas: 13.7%, Hydro: 3%, Renewables: 2.4%, Others: 13.1%.</td></tr>
<tr><td>5</td><td>Contribution of coal to the electricity mix</td><td>• No new coal stations will be built, and existing coal stations will not be operated beyond their power purchase agreement (PPA) expiry.
• Electricity from coal reaches 0MWh in 2045.[1]</td><td>• Coal capacity was calculated based on power plant additions, retirements and PPA expirations by ST (Suruhanjaya Tenaga, 2021b) and GSO (Grid System Operator, 2022).
• Added capacity was assumed to involve the repowering or PPA extension of existing coal stations and not new-builds.
• Coal continues to be part of the energy mix beyond 2050.</td></tr>
<tr><td>6</td><td>Trend of coal post-2035</td><td>• Coal GWh was interpolated linearly at -10% per year between anchor points of 2035 and 2045.</td><td>• Coal GWh was calculated based on Assumption #5.
• Coal capacity factor was 82% based on the MyRER average.</td></tr>
<tr><td>7</td><td>Contribution of hydro to the electricity mix[2]</td><td>• Hydro reaches full installed capacity potential throughout Malaysia by 2050 (13,619 MW).
• Hydro capacity factor was 54% based on MyRER average.
• Excess Sarawak hydro exported to Sabah and P. Malaysia.</td><td>• Hydro reaches full installed capacity potential in P. Malaysia and Sabah, and existing capacity doubles in Sarawak by 2050, totalling 10,619 MW.
• Hydro capacity factor was 54% based on MyRER average.
• Excess Sarawak hydro exported to Sabah and P. Malaysia.</td></tr>
<tr><td>8</td><td>Trend of hydro post-2035</td><td>• Hydro GWh was interpolated linearly at 4.3% per year between anchor points of 2035 and 2050.</td><td>• Hydro GWh was interpolated linearly at 1.9% per year between anchor points of 2035 and 2050.</td></tr>
<tr><td>9</td><td>Trend of other[3] sources post-2035</td><td colspan="2">• Contribution of other energy sources was assumed to comprise 0.1% of total generation based on the MyRER average for 2025 and 2035.</td></tr>
</table>

Assumption		Generation Scenario 1 (G-1) (High RE, no coal from 2045)	Generation Scenario 2 (G-2) (Moderate RE, minimal coal from 2045
10	Trend of renewable[4] sources post-2035	• Contribution of renewables was assumed to grow at an annual rate of 5% (almost double the 2025-2035 rate) with 2035 as the anchor point.	• Contribution of renewables was assumed to grow at an annual rate of 2.5% (similar to the 2025-2035 rate) with 2035 as the anchor point.
11	Trend of gas post-2035	• Gas was assumed to supply all electricity to make up the difference between total generation required and the sum of contributions from the other sources. • Gas = Total Generation – Coal – Hydro – Renewables – Others.	

[1] Jimah East Power is the newest coal power station in Peninsular Malaysia and commenced operations in 2019. Its PPA is scheduled to expire in 2044 (Grid System Operator, 2022).

[2] MyRER estimates for hydro potential are 3,126 MW in Peninsular Malaysia, 493 MW in Sabah and 10,000 MW in Sarawak (Sustainable Energy Development Authority, 2021). Existing installed capacity in Sarawak as of 2022 is approximately 3,500 MW (Sarawak Energy Berhad, 2021).

[3] It is assumed that the fuels under 'Others' include diesel oil and fuel oil, as per ST (2016; 2017; 2018; 2019).

[4] It is assumed that the fuels under 'Renewables' or 'RE' include to biogas, biomass, and solar in NEB. Although biomass and biogas are combustible with appreciable emissions intensities (Table 5), MyRER projects that these will comprise only about 14% of the RE installed capacity, with solar playing a dominant role. Hence, the emissions intensity of the aggregated "Renewables" category was assumed to be zero for this analysis.

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