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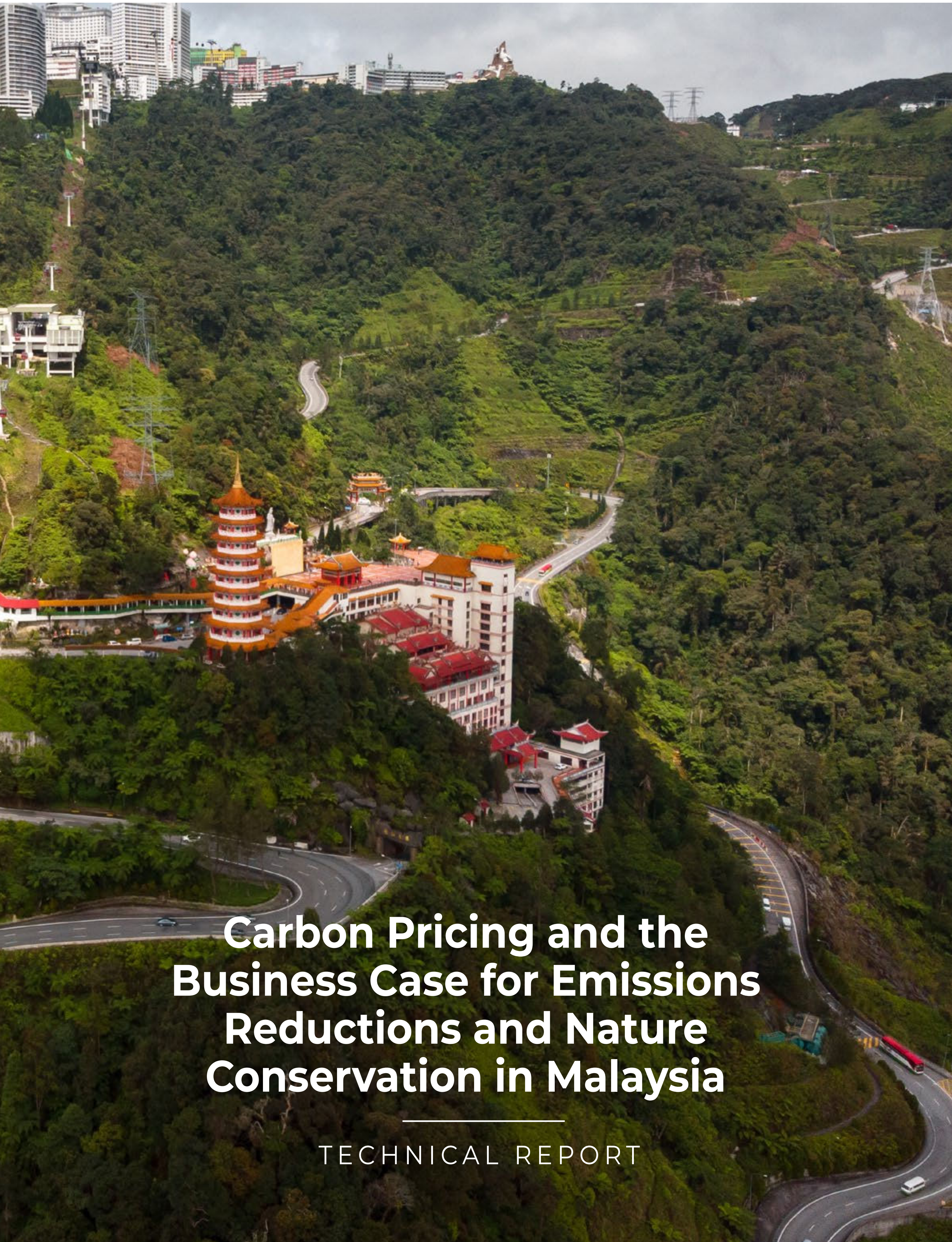

Carbon Pricing and the Business Case for Emissions Reductions and Nature Conservation in Malaysia

TECHNICAL REPORT

Carbon Pricing and the Business Case for Emissions Reductions and Nature Conservation in Malaysia

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List Of Abbreviations

12MP	12th Malaysia Plan
CO_2(e)	Carbon-dioxide (equivalent)
CPI(s)	Carbon Pricing Instrument(s)
CT	Carbon Tax
(D)ETS	(Domestic) Emissions Trading Scheme
EFT(s)	Ecological Fiscal Transfer(s)
EPU	Economic Planning Unit
ES	Ecosystem Services
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

Executive Summary

On Carbon Pricing

In the context of climate change mitigation, two market failures stand out: an oversupply of "negative externalities" in the form of greenhouse gas (GHG) emissions, and an undersupply of "positive externalities" in the form of the protection and conservation of natural capital.

The failure to address these market failures plays an important role in the continued worsening of climate change. From this economic perspective, climate change simply reflects a lack of incentives to reduce emissions and protect natural capital. Carbon pricing can address this lack of incentives by associating a direct cost to GHGs, whether emitted or sequestered.

Carbon pricing can transform energy markets by encouraging investment in low-carbon energy rather than fossil fuels and can strengthen incentives to conserve and rehabilitate natural capital, such as forests, by associating a monetary value to carbon sequestration.

However, carbon pricing does not completely resolve these market failures. The design of carbon pricing instruments (CPIs) is an important aspect of their effectiveness. The 68 CPIs implemented nationally or sub-nationally across the world differ greatly in design, featuring a wide range of carbon prices and sectoral coverages. Only a fraction of these price carbon either at levels commensurate with scientific evidence of the cost of carbon or consistent with the meeting of the Paris Agreement targets.

Malaysia's intentions to formulate a national policy on carbon pricing and implement CPIs was established in the Twelfth Malaysia Plan (12MP). The Ministry of Natural Resources, Environment, and Climate Change announced its intention to launch a domestic emissions trading scheme (DETS), while the Ministry of Finance is studying the feasibility of a carbon tax. Meanwhile, Bursa Malaysia, the capital market regulator, launched the voluntary carbon market (VCM) in December 2022.

On Carbon Pricing in the Energy Sector

Malaysia's energy sector policies demonstrate a clear commitment to decarbonization. Current targets include increasing installed RE capacity to 31% by 2025 and 40% by 2035, reducing the share of coal to 18.6 percent by 2040, and reaching net-zero emissions by around 2050. Existing policy mechanisms to incentivize RE, which include technology-support and financing instruments, imperfectly address the market failures driving climate change but their effects can be amplified by the introduction of CPIs.

In the electricity sector, carbon pricing would act as an additional per-unit cost imposed on electricity generation based on the GHG emissions intensity of a particular energy source.

At present, Malaysia relies heavily on coal and natural gas to generate electricity. These fossil fuels combined to account for 84 percent of electricity generated in Malaysia in 2019. Renewable energy (RE), including small and large hydro, accounted for the remaining 16 percent.

Our analysis developed two electricity generation scenarios (high and low ambition) and three carbon pricing scenarios (high, moderate, and low ambition) with the aims of identifying the costs of GHG emissions (in other words, potential carbon pricing revenues) and the carbon-adjusted levelized costs of electricity.

Among the key takeaways of the energy sector analysis are:

1. Substantial emissions reductions can be realized only by eliminating coal from the electricity mix and pursuing carbon-free energy sources instead.
2. While the planned replacement of coal with natural gas reduces electricity sector emissions in the short- and medium-term, a persistent reliance on gas causes a long-term upward trend in absolute emissions.
3. As coal is displaced, the emissions intensity of electricity generation will be reduced. This, however, is counteracted by projected growth in energy demand over the next 30 years owing to population and economic growth. This reinforces the importance of improving energy efficiency, as well as expanding Malaysia's RE capacity.
4. Carbon pricing would recognize GHG emissions as substantial costs, and conversely, equally substantial potential government revenues. Under our conservative carbon pricing and high ambition electricity generation scenario, cumulative GHG costs amount to roughly MYR 203 billion. This rises to almost MYR 1 trillion under our ambitious carbon pricing and low ambition electricity generation scenario.
5. Levelized tariffs for gas are roughly 40 percent higher than coal in the absence of carbon pricing. Coal will remain a cheaper source of electricity than gas until carbon prices exceed MYR 175/tCO_2e.
6. Even before accounting for carbon prices, levelized tariffs for coal are already on par with small hydro and biogas, and higher than those for solar during LSS4. Biomass and LSS3 solar prices reach parity with coal at a carbon price of just MYR 26/tCO_2e. Levelized tariffs for gas remain significantly higher than the observed bid prices of all low-carbon sources, even in the absence of carbon pricing.

On Carbon Pricing in the Forestry Sector

Malaysia's forest resources play integral roles in climate change mitigation and adaptation. In the context of carbon pricing, most forests and other natural capital have a pivotal role as carbon sinks.

Existing instruments to encourage conservation and enhance the contributions of the forestry sector toward climate change include the REDD+ financing scheme, payments for ecosystem services (PES), and ecological fiscal transfers (EFTs). These remain in early or limited stages of implementation. Significant scope exists for expansion and complementarity with carbon pricing.

Placing a high price on carbon reduces the likelihood of forest degradation or conversion. This is because the economics of conservation is dependent on opportunity costs; the higher the price of carbon, the more likely conservation will make greater business sense over the exploitation of forests.

Our analysis considered returns from oil palm, timber products, and limestone, key commodities produced at the expense of natural capital conservation, as well as potential returns from sequestered carbon. Among the key takeaways of the forestry sector analysis are:

1. Malaysia is the second-largest producer of oil palm globally. Returns vary substantially by state, averaging between MYR 10,000 and MYR 19,000 per hectare across Peninsular Malaysia, and between MYR 6,400 and MYR 11,400/ha in Sarawak.
2. For timber, average revenue ranged between MYR 52/ha in Negeri Sembilan to a high of MYR 233/ha in Selangor. However, the dwindling supply of natural tree resources, falling employment and profits, and increasing environmental costs threaten the long-term sustainability of timber.
3. Limestone is among the most commonly mined rocks in Malaysia, accounting for 78 of the 368 quarries nationwide. Average per-ton revenues range from MYR 9 in 2019 to MYR 14 in 2016.
4. 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.

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. These are not accounted for with carbon pricing instruments. Focusing solely on carbon stock accumulation can trigger unwanted consequences across other ecosystem services, and can cause the neglect of highly biodiverse, low-carbon areas.

Policy Recommendations

Carbon pricing can play an important role in Malaysia's response to climate change, particularly across the energy and forestry sectors. This potential, however, is dependent on the design and implementation of CPIs, as well as sector-level initiatives and policies. Our analysis culminated in the development of 14 policy recommendations; five are specific to the design of CPIs, and the others cover sector-level decarbonization efforts. These are only briefly described in this Executive Summary and expressed in detail in Chapter 5.

1. 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).
2. Establish estimates of the Malaysia-level social cost of carbon.
3. 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.
4. Gradually expand the scope of CPIs to cover all major economic activities.
5. Implement safeguards to ensure similarity, if not uniformity, in carbon prices across CPIs to create consistent price signals for decarbonization across industries.
6. Develop an understanding of the incidence of regulation on the varying impacts of CPIs on sector-level stakeholders and decarbonization pressures.
7. Protect the Rakyat by limiting cost pass-through of carbon regulation and developing a carbon rebate mechanism to support low-income and vulnerable population groups.
8. Develop a well-communicated and ambitious long-term timeline for carbon prices, emissions caps, and sectoral CPI coverages to ensure delivery of the requisite emissions reductions.
9. Continue pursuing a suite of policies in support of the expansion of low-carbon electricity generation in Malaysia.
10. Develop a long-term strategy to replace natural gas with low-carbon energy sources in electricity generation.
11. Establish benchmark studies of investible carbon in Malaysia.
12. Ensure complementarity across policy instruments in support of conservation.
13. Explore the development of carbon projects that can provide an alternative source of revenue to logging.
14. Enable open access to granular data on energy and forestry sector GHG emissions and sinks.

1. INTRODUCTION

Darshan Joshi[1]

Addressing climate change efficiently is, from an economic perspective, an exercise in addressing a variety of market failures (The Guardian, 2012; Stern et al., 2021). Market failures occur when the free market allocation of goods and services fail to lead to optimal economic outcomes. In the context of climate change, these include negative externalities (such as greenhouse gas emissions); incomplete and asymmetric information (a lack of valuations of nonmarket goods, such as natural capital); public goods (the atmosphere and the global "carbon budget"); and inefficient and suboptimal resource allocation (fossil fuel subsidies and underfunding of R&D). In the absence of regulatory action, market failures cause persistent suboptimal outcomes, as is the case with the continued exacerbation of climate change.

Measures that tackle these market failures can combine to play an important role in the pursuit of low-carbon transitions and 'sustainable' growth pathways. This includes carbon pricing, which can assist the transformation of energy markets by enhancing the economic case for investment in renewable and other low-carbon technologies. ahead of fossil fuel-based incumbents (Fang, 2018). Carbon pricing can also issue support for conservation and rehabilitation ahead of the exploitation of natural capital, such as forests (Busch and Engelmann, 2017).

Carbon pricing is widely regarded by economists and policymakers to be a fundamental step toward addressing climate change. For each of the major market failures associated with climate change (see Table 1), there is a role for carbon pricing to play in the policy response. Broader descriptions of these and other market (and government) failures associated with climate change, and the roles of various policy responses – including carbon pricing – are provided by Andrew (2008). The pricing of emissions associates a direct cost with a negative externality and places a fee on a global public good. Carbon pricing also allows for some degree of price discovery in the valuation of carbon-based nonmarket goods, such as forests. However, to fully address a broader information gap in ecosystem valuation, economic assessments of the value of these and other ecosystem services are needed. Ultimately, this would allow for further natural capital conservation and rehabilitation at 'optimal' levels, which achieve a balance between environmental degradation and economic growth.

Table 1: Market Failures Commonly Associated with Climate Change

Type of Market Failure	Examples of Market Failure	Relationship with Climate Change	Policy Response Options
Negative Externality	Greenhouse gas emissions	Causes rise in atmospheric concentration of carbon	Carbon pricing (through carbon tax, cap-and-trade, or use in regulatory rulemaking)
Incomplete or Asymmetric Information	Valuation of ecosystem services and nonmarket goods; Carbon or climate footprinting	Undervalues natural capital conservation, which can aid mitigation of climate change and adaptation to its consequences	Carbon pricing; Ecological fiscal transfers; Emissions footprint labeling; Payments for ecosystem services; Research funding
Public Goods	Global atmosphere; air quality	Increasing carbon concentration exacerbates temperature rise and associated impacts	Carbon pricing
Inefficient or Suboptimal Resource Allocation	Underinvestment in research and development (R&D); Subsidies for carbon-intensive or environmentally-harmful goods and services; Lack of financial support for low-carbon practices and technologies	Slows low-carbon transition through underinvestment in low-carbon goods and services; overinvestment in high-carbon goods and services	Carbon pricing; Fossil fuel subsidy rationalization and removal; Funding (e.g. subsidies) or access to funding (e.g. loans); Research funding

[1]Darshan Joshi is a climate consultant with The Asia Foundation in Malaysia, and a consultant with the World Bank's hub in Malaysia.

1.1 Addressing Market Failures through Carbon Pricing

Global recognition of the roles that carbon pricing can play in addressing climate change has grown significantly in recent years. In 2010, just 17 national, subnational, and supranational measures were in place, the bulk of which comprise of carbon taxes to complement the European Union's emissions trading scheme (EU ETS), introduced in 2005. By 2022, this figure had grown to 68, covering 46 national and 36 subnational jurisdictions and accounting for just under a quarter of global GHG emissions (World Bank, 2022). A further 19 jurisdictions are in the process of creating markets for carbon; included in this group are the Southeast Asian nations of Indonesia, Malaysia, Thailand, and Vietnam. In increasing the costs of high-carbon practices, carbon pricing can drive investment into and the deployment of low-carbon technologies that can spur emissions reductions and steer growth toward lower-carbon pathways.

A caveat is that only a small proportion of these carbon pricing programs, and mostly those in Europe, price the externality at levels commensurate with economic and scientific evidence of the costs of carbon. The social cost of carbon, an estimate of the economic damages caused by a marginal ton of CO_2 emissions, is dependent on numerous variables, some of which are difficult to estimate – such as economic damages of imperfectly foreseen climatic changes projected well into the future – and others still, which require more subjective contemplation – such as discount rates used to ascertain the present cost of future damages (see IWG, 2021 and Rennert and Kingdon, 2019).

For these reasons, estimates of the social cost of carbon vary significantly. IWG (2021) recommends a price of USD 53 per ton of CO_2 in 2022, while CPLC (2017) cites a figure of USD 50–100/tCO_2 by 2030 to meet the Paris Agreement goal to limit global warming to "well below" 2°C above preindustrial levels. These figures line up with Wang et al (2019), who in a meta-analysis of SCC estimates derive a mean of USD 54.70/tCO_2. Still, these figures may be understated. H. de Coninck et al. (2017) recommend prices of at least USD 135 in 2030 and USD 245 in 2050 to ensure warming of no more than 1.5°C above preindustrial levels. In a recent, widely cited study, Rennert et al (2022) provide a central SCC estimate of USD 185/tCO_2.[2] Nevertheless, only ten jurisdictions as of April 2022 were subject to carbon prices that met the lower bound CPLC (2017) estimates as implied by the Paris Agreement; in fact, twice as many price carbon below USD 10/tCO_2.

The failure to price carbon at optimal levels to address at least two of these market failures is largely due to socioeconomic and political circumstances. Most nations still rely significantly on the use of fossil fuels for economic development; some depend greatly on carbon-intensive commodities in the pursuit of economic growth. The imposition of high carbon prices is likely to have negative economic- and individual- or household-level impacts in the absence of, for instance, strong social welfare systems, the reallocation of carbon revenues, or even rapid decarbonization. Adverse political chicanery, meanwhile, means carbon pricing is often conflated with carbon taxation – emissions trading schemes have been labeled as taxes in disguise. Negative public perceptions of taxation and, in some cases, of public fiscal transparency, mean such legislation remains politically unpopular, to say nothing of steep taxes that can have tangible impacts on disposable income.

Beyond national-level CPIs, attention is turning toward border carbon adjustments (BCAs). BCAs are carbon taxes imposed on imports into jurisdictions that already have carbon regulations in place. Aimed at equalizing the stringency of carbon regulation across imports and domestic production, the cost of the tax would be based on carbon price differentials between the relevant jurisdictions. Within the host countries of BCAs, the rationale for their implementation centers around the preservation of domestic competitiveness and the prevention of carbon leakage. Externally, BCAs can 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 domestic CPIs now 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 context, the Malaysian government, in the 12th Malaysia Plan, indicated for the first time a federal-level interest in the implementation of carbon pricing instruments (EPU, 2021). The then-Ministry of Energy and Water (KASA) is assessing the potential of a domestic emissions trading scheme, while the Ministry of Finance is considering the implementation of a carbon tax (Aziz, 2021). Malaysia's stock exchange regulator, Bursa Malaysia, launched the Voluntary Carbon Market (VCM) in early December 2022, to enable

[2] This final study provides insight into the impact and importance of typically a more subjective element of the SCC – the choice of discount rate. US-IAWG (2021) and others utilize constant discount rates, whereas Rennert et al. (2022) follow the recommendations of Kelleher and Wagner (2018) in employing consumption-based discounting.

companies to offset emissions and meet climate targets. This may enable a smoother pathway toward the eventual implementation of compliance market instruments still scarce, attention must now turn toward ensuring that carbon pricing can meaningfully influence Malaysia's attainment of positive climate outcomes.

One important caveat to this study is that it considers the topics of carbon pricing and climate change from a largely economic perspective. This, however, reflects only one interpretation of these issues and their solutions. Non-economic considerations and enabling political mechanisms and motivations also play an important role in the broader climate response. This includes the development of a whole-of-society approach to climate change (e.g., bottom-up pressure, civil society participation, the protection of indigenous populations), stronger 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. Discussions on these, and other important perspectives, are beyond the intended scope of this study.

1.2 Study Objectives

Carbon pricing has the potential to enable Malaysia's low-carbon transition. As such, the price of carbon is positioned as a key and dynamic variable of interest throughout this analysis, which is comprised of three broad sections. The first two consider the sectoral impacts of carbon pricing in electricity markets and on the forestry sector. **The two key driving questions for this analysis are how carbon pricing would alter the economic case for low-carbon or renewable energy generation technologies over fossil fuel-based incumbents, and how it can alter the case for conservation over the exploitation of natural capital, particularly carbon sinks such as forests.**

The choice of focusing on Malaysia's energy and forestry sectors also allows us to consider two almost opposing aspects of carbon pricing; for the energy sector, we assess the impacts of carbon pricing on addressing the oversupply of emissions and the lack of economic incentives to drive emissions reductions; while for the forestry sector, we assess the impacts of carbon pricing on addressing the undersupply of carbon sequestration and a lack of economic incentives to drive the conservation of natural capital in the form of carbon sinks. Both emissions reductions and the protection of carbon sinks are crucial elements to achieve Malaysia's international climate pledges, such as its nationally determined contributions (NDCs),[3] as well as its long-term goal to achieve net-zero emissions 'as early as' 2050.

The third component of this study assesses the policy and stakeholder ecosystem around carbon pricing and its interactions with the energy sector (and electricity markets in particular) as well as the forestry sector. Addressing climate change makes for a complicated policymaking process because of its economy-wide impacts. For this reason, the policies required to minimize these impacts have implications across a wide range of economic actors and activities, cutting across the portfolios of various government ministries and agencies, as well as federal, state, and local levels of government. Identifying the key stakeholders and their respective roles in the context of carbon pricing, emissions reductions, and natural capital conservation is fundamental to developing the appropriate policy response to address these market failures.

Finally, we must recognize that carbon pricing represents the solution to only some of the market failures inherent to climate change – putting a price on a negative externality, in carbon emissions, which contribute to climate change through its effects on a global public good, in the atmosphere. The pricing of carbon is a first step toward 'fixing' markets and enhancing the business cases for the development and deployment of low-carbon technologies; as our analysis of the forestry sector shows, however, this is only the tip of the iceberg, particularly when it comes to conserving natural capital.

[3] Malaysia's latest NDC, announced in late 2021 in the build-up to COP26, calls for an unconditional 35 percent decrease in the GHG intensity of GDP by 2030, relative to a 2005 baseline.

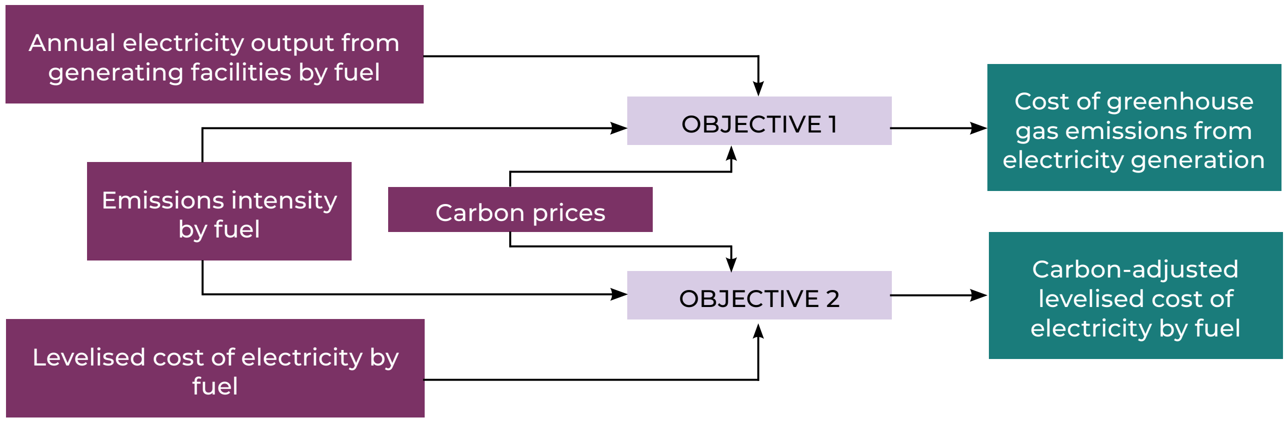
2. CARBON PRICING AND THE ENERGY SECTOR

Dhana Raj Markandu[4]

This chapter focuses on Malaysia's electricity sector. It is largely a quantitative analysis carried out to achieve two objectives. First, it establishes the aggregate costs of greenhouse gas (GHG) emissions associated with the production of electricity from various fossil fuel energy technologies through to 2050, across two electricity generation scenarios and three carbon pricing scenarios. Second, it estimates the levelized costs of electricity (LCOE), on a per kilowatt-hour basis, generated from various fossil fuel and renewable energy (RE) sources across the same three carbon pricing scenarios.

[4] Dhana Raj Markandu is an energy consultant and engineer formerly with Tenaga Nasional Berhad and the Malaysia Nuclear Power Corporation.

Figure 1: Input Parameters to Estimate GHG Costs and LCOE

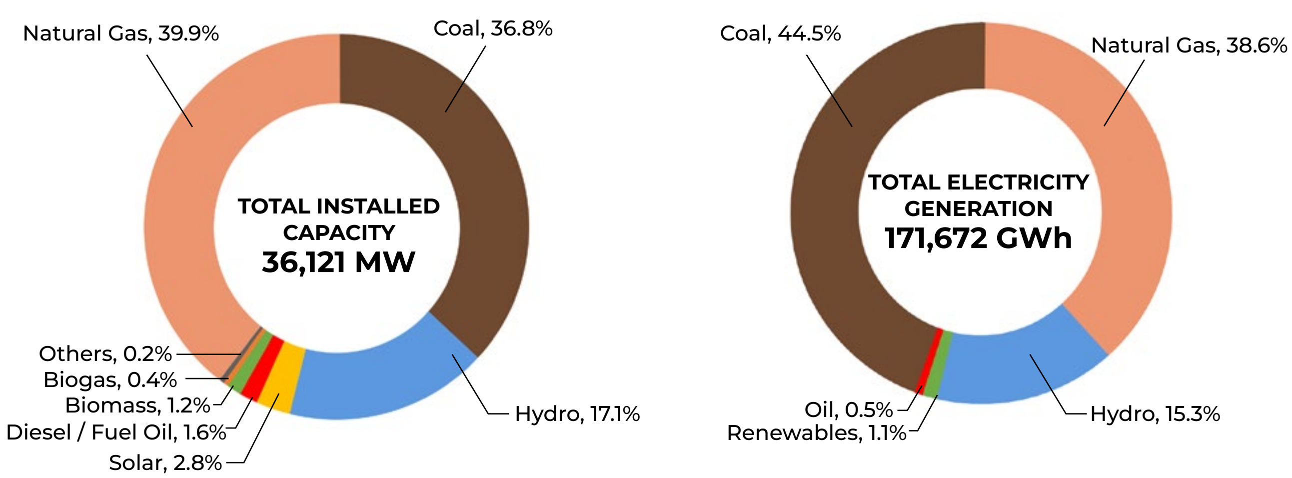


2.1 Background: Electricity in Malaysia

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

The Malaysian government has shown increasing recognition of the need to increase RE deployment to support its commitments to reduce emissions and meet its NDCs and other climate-related commitments and targets. In line with these ambitions, the 2021 Malaysia Renewable Energy Roadmap (MyRER), published by the Sustainable Energy Development Authority (SEDA), describes a framework designed to achieve Malaysia's current RE target of 31 percent of total installed capacity by 2025, increasing to 40 percent by 2035 (SEDA, 2021). The Twelfth Malaysia Plan 2021-2025 (12MP)

Figure 2: Installed Capacity and Electricity Generation in Malaysia, 2019



Source: Adapted from National Energy Balance 2019, Energy Commission establishes the goal of carbon neutrality by 'as early as' 2050 and pledges to introduce measures such as carbon pricing instruments, along with a commitment to cease building new coal-fired power stations (EPU, 2021).

A holistic strategy for the entire energy ecosystem was established in September 2022 through the National Energy Policy (NEP), which incorporates the goals of Malaysia's Low Carbon Nation Aspiration (LCNA) 2040 (EPU, 2022). Among the electricity-sector targets in the LCNA, to be achieved by 2040, include energy efficiency savings of 11 percent from industrial and commercial use and 10 percent for residential use; an increase in the total RE installed capacity to about 18,000 MW (compared to 7,600 MW in 2018); an increase in the share of RE in primary energy supply to 17 percent (compared to 7.2 percent in 2018); and a reduction in the installed capacity share of coal to 18.6 percent (compared to 31.4 percent in 2018). Table 2 summarizes the national targets from MyRER and NEP.

Table 2: Summary of National Energy Targets

Metric		Source	Status*	Target	Target Year
Share of RE, Installed electricity capacity		MyRER	23% (2020)	31%	2025
				40%	2035
% Energy efficiency savings	Industrial & commercial	NEP	<1%	11%	2040
	Residential		<1%	10%	
Total RE installed capacity (MW)			7,597	18,431	
% RE in total primary energy supply			7.2%	17%	
% Coal installed capacity			31.4%	18.6%	

**2018 unless otherwise stated*

2.2 Methodology

As illustrated in Figure 1, both objectives of this electricity sector analysis require the establishment of two common, foundational input parameters. These are as follows:

a) The operational emissions intensity of each combustible fuel used in the Malaysian electricity generation mix, defined as tons of carbon dioxide equivalent per unit of energy generated (tCO_2e/GWh).

b) The price of carbon, defined in US dollars per ton of carbon dioxide equivalent emitted (USD/tCO_2e) for the international context, and in Malaysian ringgit per ton of carbon dioxide equivalent emitted (MYR/tCO_2e) for the domestic context.

This section outlines the methods employed to obtain these inputs.

2.2.1 Operational Emissions Intensities Across Energy Sources

Accurately determining the operational emissions intensity of the various combustible fuels used to generate electricity in Malaysia would require measurements of GHG emissions at the level of the electricity generating facility.[5] Due to an absence of such data in the public domain (Abdul Latif et al., 2021), authoritative secondary sources were used to derive the required fuel emission factors instead.

Malaysia, in its December 2020 submission of its Third Biennial Update Report (BUR3) to the United Nations Framework Convention on Climate Change (UNFCCC) (KASA, 2020), uses default fuel emission factors provided in IPCC (2006) to estimate electricity sector emissions. These default emission typically presented in kilograms per terajoule (kg/TJ), are commonly utilized across other Malaysia-specific studies, including Abdul Latif et al. (2021), Zakaria et al. (2021), and MGTC (2017). Based on the prevailing use of IPCC (2006) for emission factors in the Malaysian context, these figures are also used in this study.

IPCC (2006) estimates that carbon dioxide accounts for approximately 95 percent of energy sector emissions; methane (CH_4) and nitrous oxide (N_2O) largely make up the balance. The emissions intensity of these gases is typically expressed in terms of their carbon dioxide equivalence (CO_2e), with CH_4 and N_2O converted to this metric based on their global warming potential (GWP) values, as established in KASA (2020). Table 3 lists the relevant GHG emissions factors from IPCC (2006) and KASA (2020).

[5] Recognizing that solar, biomass, and biogas installations are typically not referred to as "power stations" or "plants", the term "electricity generating facility" is used when referring to the entire spectrum of generation sources. The term "power station" is used when reference is made only to installations utilizing coal, natural gas, or hydro.

Table 3: GHG Emissions Factors, from IPCC (2006); KASA (2020)

Greenhouse Gas	Fuel Emission Factor (kg/TJ)						Global Warming Potential (GWP)
	Coal	*Natural Gas*	*Diesel*	*Fuel Oil*	*Biomass*	*Biogas*	
Carbon Dioxide (CO_2)	96,100	56,100	74,100	77,400	100,000	54,600	1
Methane (CH_4)	1	1	3	3	30	1	25
Nitrous Oxide (N_2O)	1.5	0.1	0.6	0.6	4	0.1	298

Historical data for energy input to electricity generating facilities (provided in reference documents as kilotons of oil equivalent, or ktoe) and the gross electricity generation output (in GWh), disaggregated by source, are also required to calculate the required fuel emission intensities. These values were obtained from the NEB reports published by ST from 2016 to 2019[6] (ST, 2018; ST, 2019[a]; ST, 2021[a]; ST, 2022), and are reproduced in Tables 4 and 5. Figure 3 illustrates the inputs and processes used to derive these results.

Table 4: Inputs by Source to Electricity Generating Facilities in Malaysia, 2016–2019

Generation Source	2016		2017		2018		2019	
	%	ktoe	%	ktoe	%	ktoe	%	ktoe
Coal	52.5%	17,101	56.5%	18,967	58.9%	20,472	54.5%	19,351
Natural Gas	40.7%	13,260	35.4%	11,872	33.2%	11,542	36.8%	13,072
Diesel Oil	0.5%	165	0.4%	147	0.5%	187	1.5%	517
Fuel Oil	0.5%	155	0.3%	99	0.0%	17	0.1%	19
Biomass	0.2%	58	0.2%	52	0.2%	57	0.2%	68
Biogas	0.1%	18	0.1%	40	0.2%	64	0.3%	95
Hydropower	5.3%	1,723	6.8%	2,287	6.5%	2,265	6.3%	2,251
Solar	0.3%	92	0.3%	93	0.4%	155	0.4%	125
TOTAL	**100.0%**	**32,572**	**100.0%**	**33,557**	**100.0%**	**34,759**	**100.0%**	**35,498**

Totals may not necessarily add up due to rounding

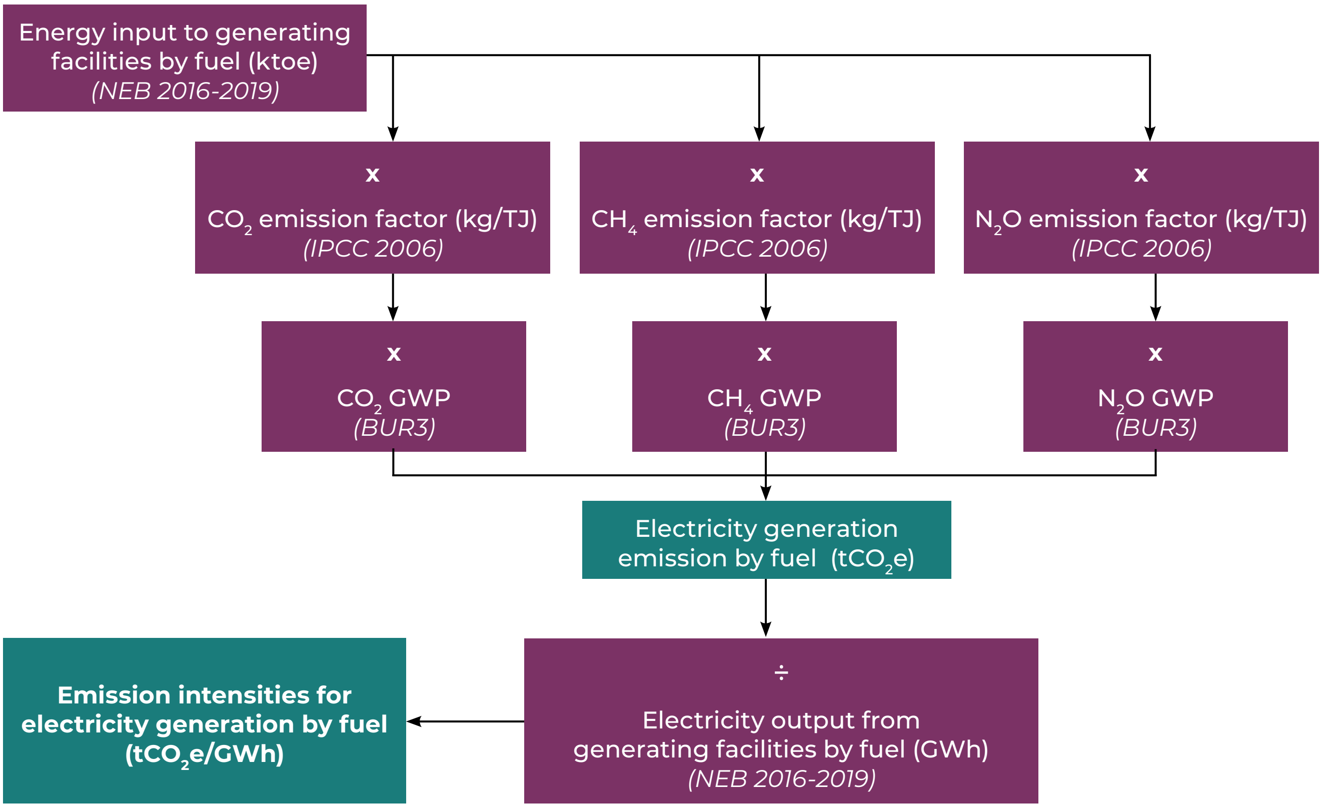
Table 5: Gross Electricity Output by Energy Source in Malaysia

Generation Source	2016		2017		2018		2019	
	%	GWh	%	GWh	%	GWh	%	GWh
Coal	46.0%	69,153	44.3%	68,866	47.3%	77,286	44.5%	76,411
Natural Gas	39.7%	59,672	37.4%	58,201	35.7%	58,416	38.6%	66,306
Diesel Oil	0.2%	328	0.4%	688	0.2%	354	0.4%	686
Fuel Oil	0.5%	700	0.1%	202	0.0%	38	0.1%	90
Biomass	0.1%	198	0.1%	185	0.1%	198	0.1%	223
Biogas	0.0%	62	0.1%	142	0.1%	224	0.2%	312
Hydropower	13.3%	20,019	17.3%	26,841	16.1%	26,325	15.3%	26,196
Solar	0.2%	310	0.2%	330	0.4%	573	0.8%	1,448
TOTAL	**100.0%**	**150,442**	**100.0%**	**155,455**	**100.0%**	**163,414**	**100.0%**	**171,672**

Totals may not necessarily add up due to rounding

[6] From April 2015 to December 2019, 5,000MW of new coal capacity was added to Malaysia's electricity grid. The last coal power station commissioned prior to that was in 2009. Hence, commencing the historical dataset in 2016 was deemed appropriate to represent the relative composition of current generation mix in Malaysia. The 2019 National Energy Balance, published in 2022, is the most recent edition at the time of this study and marks the last year of the historical dataset.

Figure 3: Inputs and Processes for Derivation of Fuel Emissions Intensities



The results of these calculations are presented in Table 6, alongside the range of fuel emission intensities over the four-year historical dataset used[7] and the share of total electricity sector emissions from each energy generation source. These results are contrasted against published estimates (also displayed in Table 6) for Malaysia's electricity sector by the International Renewable Energy Agency (2022) and Electricity Maps (2022) and found to be within an acceptable variance margin of ± 3 percent.

Table 6: Emissions Intensities and Shares of Electricity Sources in Malaysia

Generation Source	Average Emissions Intensity, 2016–2019 (tCO_2e/GWh)	Range of Emissions Intensities, 2016–2019 (tCO_2e/GWh)	Share of Electricity Emissions (%)
Coal	1,051	999 - 1,113	71.5%
Natural Gas	482	463 - 522	27.2%
Diesel Oil	1,554	665 - 2,345	0.7%
Fuel Oil	1,113	686 - 1,592	0.2%
Biomass	1,244	1,199 - 1,301	0.2%
Biogas	664	644 - 696	0.1%
Hydropower	N/A	N/A	0.0%
Solar	N/A	N/A	0.0%
Electricity Sector Comparison			
This study (2016–2019)	670	647 - 679	
IRENA (2015–2019)[8]	680	650 - 700	
Electricity Maps (2017–2019)[9]	648	626 - 660	

Totals may not necessarily add up due to rounding

[7] Fuel emission intensities derived purely from historical electricity generation inputs and outputs from 2016 to 2019 are used for this analysis. Potential improvements resulting from efficiency improvements in technology and/or utilization patterns are not accounted for.
[8] Estimated from graphic "CO_2 emission factor for elec. & heat generation" on page 3 of IRENA energy profile for Malaysia, last updated on August 22, 2022.
[9] Data available for Peninsular Malaysia only.

These results confirm that coal power stations are the largest source of emissions from the electricity sector. Between 2016 and 2019, coal accounted for 71.5 percent of total sectoral emissions, producing roughly 1,051 tCO_2e/GWh. Natural gas power stations, the second-largest emitters, account for a 27.2 percent share, producing 482 tCO_2e/GWh. Finally, although the emissions intensities of diesel oil, fuel oil, and biomass are higher than that of coal, and biogas higher than that of natural gas, their impacts are minimal as they comprise less than 1 percent of both electricity generation and sectoral emissions.

Finally, since this analysis focuses on direct emissions created during the process of electricity production – and not lifecycle or indirect emissions[10] – equivalent values for non-combustible generation sources, i.e. hydropower and solar, are considered to be zero.

2.2.2 Carbon Prices[11]

According to the World Bank (2022), 68 carbon pricing initiatives have been implemented globally as of April 1, 2022. These CPIs cover 23 percent of global GHG emissions and come in the form of either carbon taxes (CT) or emissions trading schemes (ETS). Prices of carbon (i.e. the tax rate in CTs and the allowance price in ETS) vary greatly across these initiatives, with Uruguay's CT being the highest at USD 137.30/tCO_2e and Poland's being the lowest at USD 0.08/tCO_2e.

Regionally, Singapore and Indonesia are the only ASEAN countries profiled in detail by the World Bank (2022). In 2019, Singapore implemented a CT for all facilities with annual direct GHG emissions above 25 $ktCO_2$. Singapore's current tax rate is SGD 5 per ton of carbon dioxide equivalent (SGD/tCO_2e), equivalent to roughly USD 3.69/tCO_2e. This tax will increase to SGD 25/tCO_2e in 2024/2025 and SGD 45/tCO_2e in 2026/2027, with a view to rising further to SGD 50 to 80/tCO_2e by 2030. Indonesia is planning to implement a CT covering coal power stations, with the initial tax rate set at IDR 30,000 per ton of carbon dioxide equivalent (IDR/tCO_2e), or about USD 2.09/tCO_2e.

Current regional carbon prices, however, are significantly lower than the European Union's ETS (EU-ETS) price of USD 86.53/tCO_2e (World Bank, 2022). The price of carbon under the EU-ETS has fluctuated significantly in recent years – unsurprising given the dynamic nature of carbon prices under an ETS – with valuations of USD 49.78/tCO_2e in April 2021 and USD 18.54/tCO_2e in February 2020. The price of carbon under the EU-ETS will be a critical metric moving forward as this will likely inform the carbon price used to enforce the EU's planned Carbon Border Adjustment Mechanism (CBAM), which will be fully implemented in 2026 (European Commission, 2021).

Another metric that is often used to form the basis for establishing a price on GHG emissions is the social cost of carbon (SCC). The SCC measures the value of economic damages caused by an incremental metric ton of CO_2 emissions, attempting to quantify the price of carbon based on scientific and economic models of future climate and socio-economic scenarios. Estimates vary, however, based on the assumptions and types of models used (Carbon Brief, 2017; Resources for the Future, 2019). The United States Government currently uses a value of USD 53/tCO_2 while a paper published in *Nature* in 2022 estimates a range of USD 44 to 413/tCO_2, with a mean of USD 185/tCO_2 (Rennert et al., 2022).

The IPCC has also published estimates of the price of carbon, with IPCC (2018) estimating that to limit the average global surface temperature increase to 1.5°C above pre-industrial levels in line with the 2015 Paris Agreement, a carbon price of USD 135 to 5,500/tCO_2 in 2030 and USD 245 to 13,000 /tCO_2 in 2050 would be required. CPLC (2017), meanwhile, cites values of at least USD 40 to 80/tCO_2 by 2020 and USD 50 to 100/tCO_2 by 2030 to meet Paris Agreement temperature targets.

Malaysia is yet to establish a national price on carbon emissions, but intentions to introduce carbon pricing and carbon taxation have been outlined in the 12MP (EPU, 2021). Bursa Malaysia, the national stock exchange regulator, launched the VCM in December 2022, with inaugural transactions to be determined via auction (Chung, 2022). This acts as a preliminary form of domestic carbon price discovery, albeit through a matching of supply of credits and demand for offsets rather than economic and scientific evidence as per estimates of the SCC.

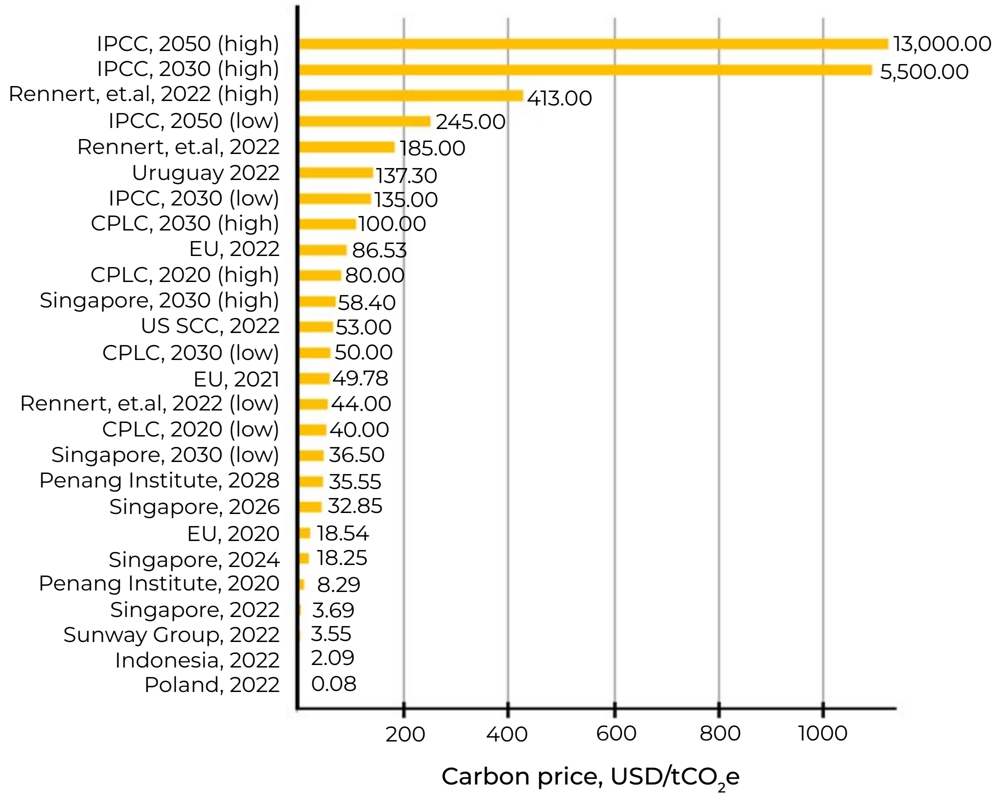
In the corporate sector, the Sunway Group introduced an internal carbon price (ICP) in 2022 to guide business decisions and investment strategies. From 2022 to 2024, the price will be set at MYR 15/tCO_2e above a pre-defined threshold level and will be recalibrated in subsequent years (Sunway Group, 2022). CIMB Bank Berhad has also set an ICP of MYR 70/tCO_2e, which will commence in 2023 and is projected to escalate to MYR 335/tCO_2e by 2028 to 2030, while Malayan Banking Berhad introduced similar measures in 2021 but has not revealed its carbon price (Tan, 2022).

[10] Lifecycle emissions include greenhouse gases created beyond the direct operations of the electricity generating facility, including contributions from construction, decommissioning, supply chains and other indirect processes. Lifecycle emissions for non-combustible generation sources are non-zero (IPCC 2014).
[11] US dollar values are as reported by World Bank (2022) based on nominal prices on April 1, 2022.

Penang Institute (2019) proposed an initial rate of MYR 35/tCO_2e for Malaysia in 2020, based on published country-level SCC estimates (Ricke, et al., 2018) that rises incrementally to MYR 150/tCO_2e in 2028, a figure closer to published estimates of the SCC as well as figures cited by CPLC (2017) as necessary to meet the Paris Agreement's temperature goals.

Figure 4 illustrates the spectrum of carbon prices across the references explored for this study.[12]

Figure 4: Indicative Carbon Prices Implemented Internationally



Recognizing that a wide range of carbon prices have either been implemented globally or established by the scientific and economic literature, this report explores three carbon pricing scenarios for the parameters to be analyzed in the first objective of this section, which is to estimate the projected costs of GHG emissions. All scenarios encompass a 30-year period from 2020 to 2050, with analysis conducted for each five-year interval. For simplicity, carbon taxes are assumed to commence in Malaysia in 2025, with the tax rate escalating every 2 to 3 years. Table 7 and Figure 5 describe the carbon prices used.

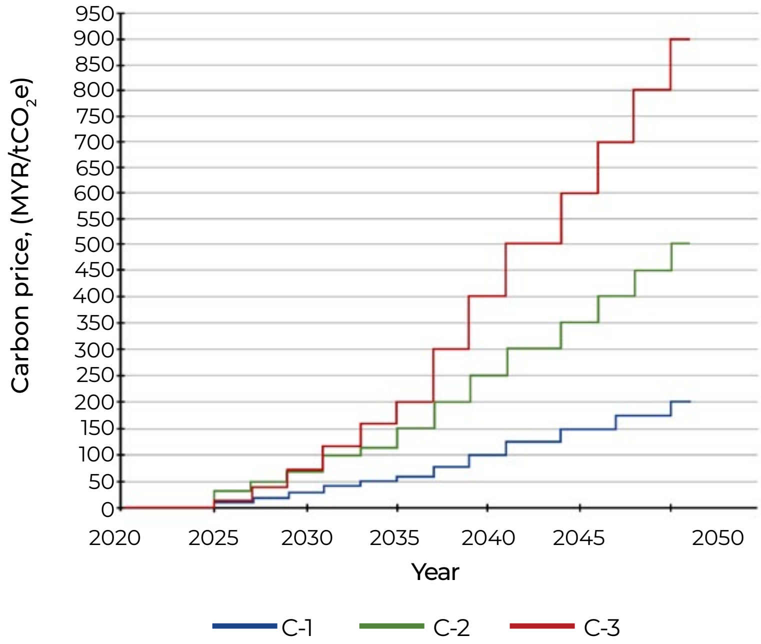
Table 7: Proposed Carbon Pricing Scenarios (Tabulated)

Scenario	Carbon Price MYR/tCO_2e							Description[13]
	2020	2025	2030	2035	2040	2045	2050	
C-1 ***(Conservative)***	0	10	30	60	100	150	200	• 2025: Proposed price for Indonesia. • 2050: Low SCC price by Rennert et al., 2021 • Other values: Extrapolated
C-2 ***(Moderate)***	0	35	75	150	250	350	500	• 2025-2035: Proposed price by the Penang Institute, time-shifted to start in 2025 instead of 2020. • Other values: Extrapolated
C-3 ***(Ambitious)***	0	15	80	200	400	600	900	• 2025-2035: Current and projected Singapore prices, time-shifted to start in 2025 instead of 2019. • Other values: Extrapolated

[12] The 3-year average exchange rate as of October 15, 2022 was applied for all currency conversions where required: 1 USD = 4.22 MYR; 1 USD = 1.37 SGD; 1 SGD = 3.09 MYR; 1 MYR = 3428 IDR

[13] Extrapolated values rounded to facilitate analysis.

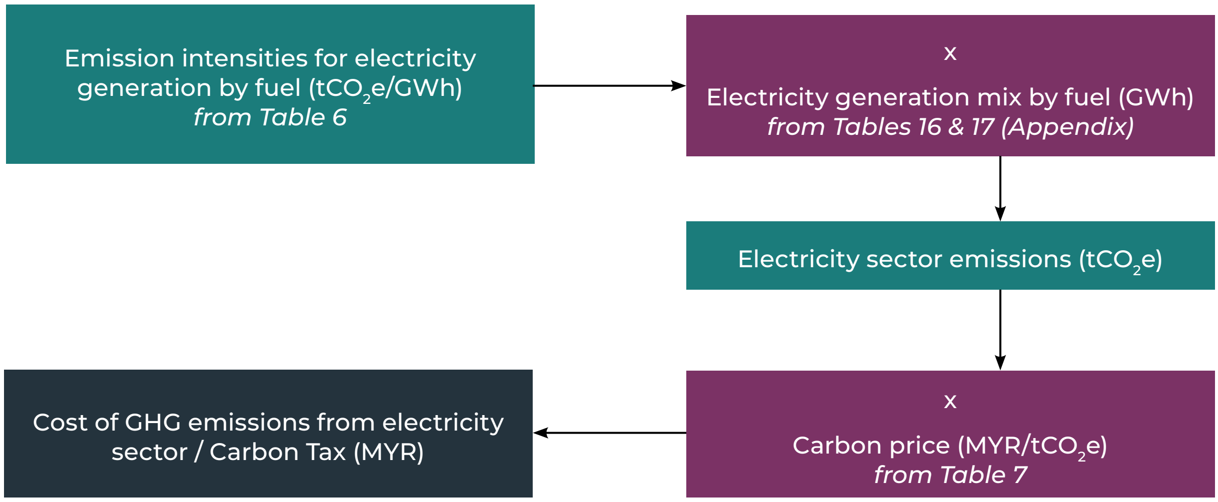
Figure 5: Proposed Carbon Pricing Scenarios (Illustrated)



2.3 Costs of GHG Emissions from Electricity Generation in Malaysia

This section establishes the aggregate costs of GHG emissions associated with the production of electricity from various fossil fuels, through to 2050, at varying carbon prices. Figure 6 illustrates the inputs and processes for this analysis.

Figure 6: Establishing the Costs of GHG Emissions



2.3.1 Projections: Electricity Generation and GHG Emissions

In addition to the input parameters described in Chapter 2.2, estimating the costs of accrued sectoral GHG emissions also required data on Malaysia's projected electricity generation mix, disaggregated by source and defined in units of energy (GWh). The year 2020 is used as the base year for these projections, with subsequent analysis conducted at five-year intervals and ending in 2050.

Two scenarios were examined to project the electricity generation over this 30-year timeline. Between 2021 to 2035, both scenarios follow the generation projections described by MyRER. Deviations between the two scenarios occur post-2035. The first scenario (G-1) assumes a high penetration of low-carbon energy from 2035 to 2050, with no coal in the energy mix beyond 2045. The second scenario (G-2) assumes a moderate penetration of low-carbon energy from 2035 to 2050, with coal continuing to be used until 2050 (and beyond). Table 15 (Appendix) provides a detailed summary of the assumptions used for calculations under both scenarios.

The fuel emission intensities from Table 6 were applied to the projected generation mixes to obtain total GHG emissions from electricity generation from 2020 to 2050. Figure 7 shows the projections for scenario G-1, while Figure 8 shows projections for scenario G-2. This data is also presented in Tables 16 and 17 in the Appendix. Figure 9 compares the projections for total emissions and emission intensities for both scenarios, while Figure 10 presents the cumulative emissions.[14] A discussion of these results is presented in Chapter 2.3.3.

Figure 7: Electricity Generation and GHG Emissions, Scenario G-1

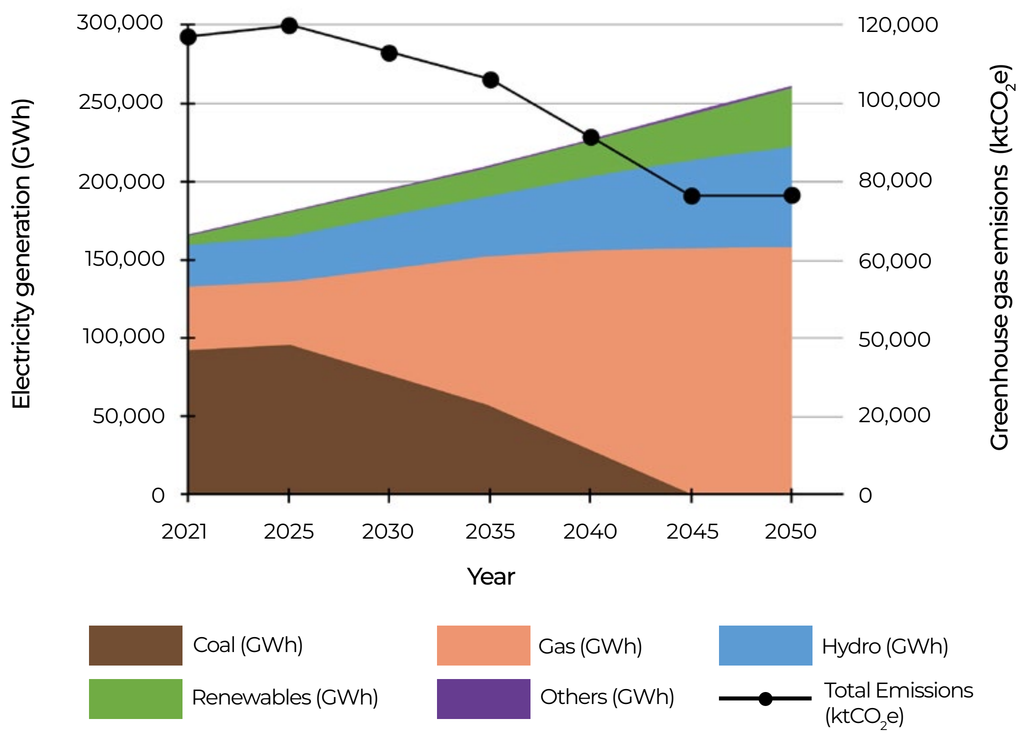
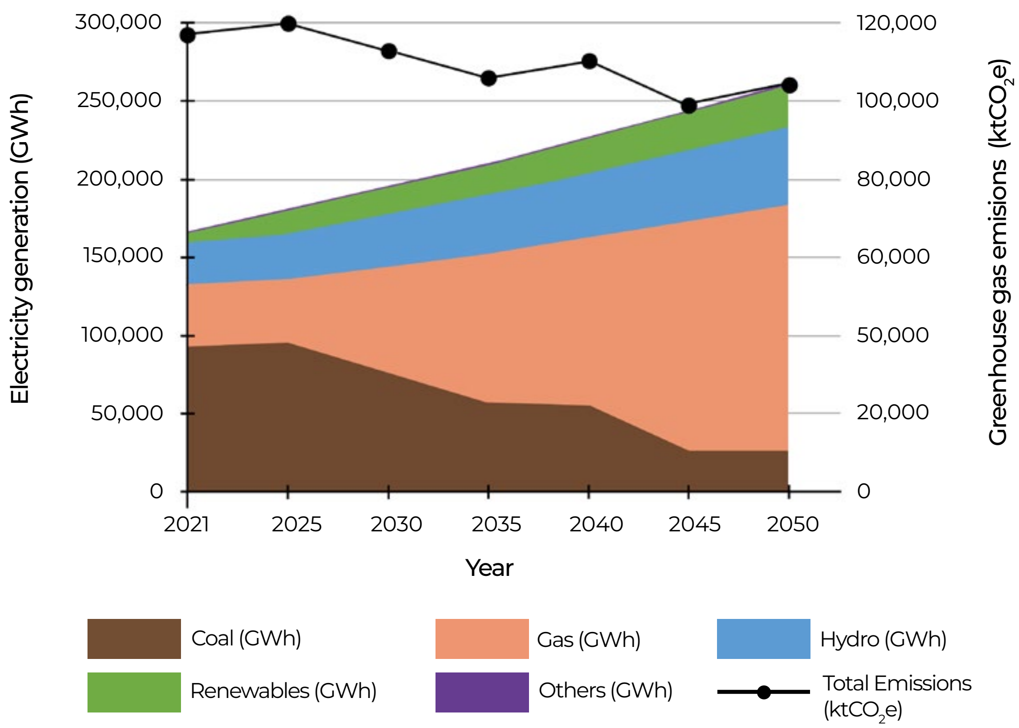


Figure 8: Electricity Generation and GHG Emissions, Scenario G-2



[14] Cumulative emissions are calculated annually from 2020-2050 but presented in 5-year intervals.

Figure 9: Total Electricity Emissions and Emissions Intensities, Scenarios G-1 and G-2

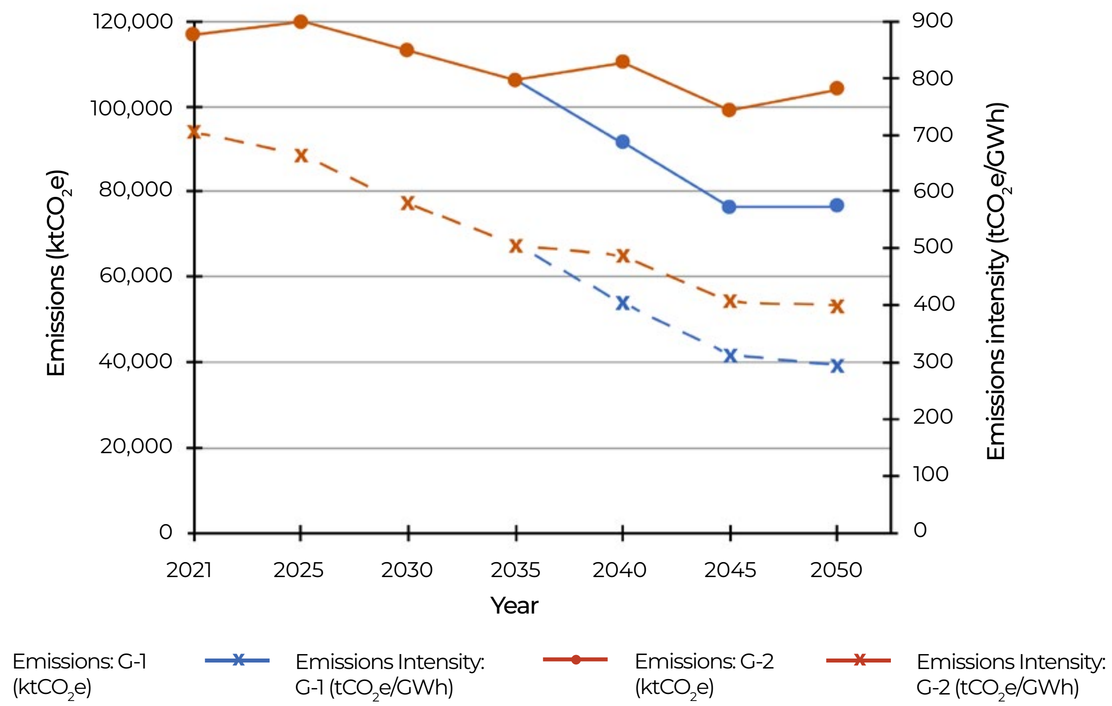
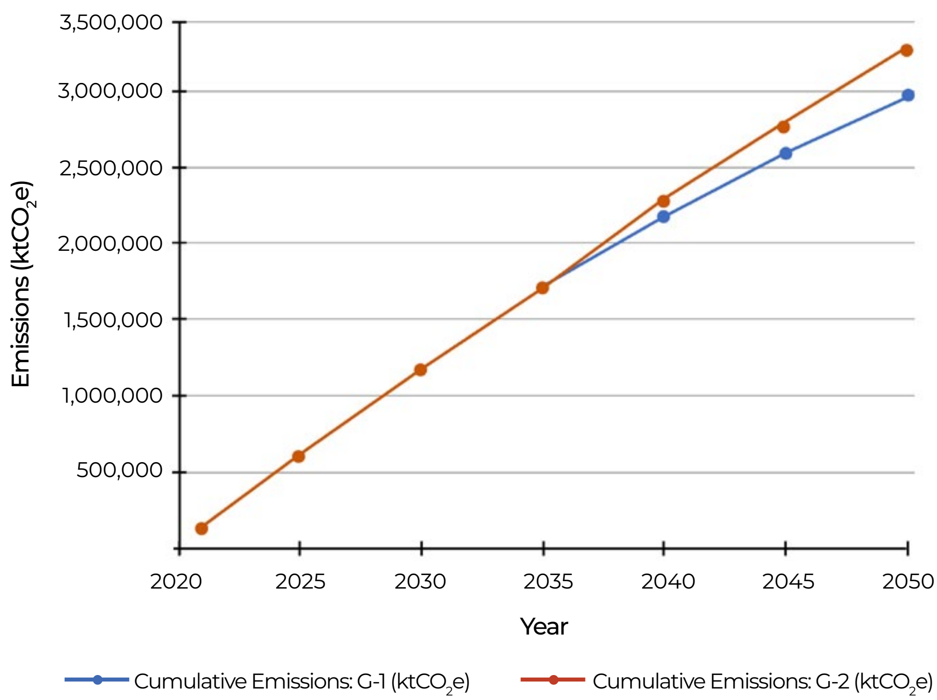


Figure 10: Cumulative Emissions, Scenario G-1 and G-2



2.3.2 Costs of GHG Emissions

Tables 8 and 9 present the estimated costs of GHG emissions under electricity generation scenarios G-1 and G-2, respectively. Annual and cumulative[15] costs are presented for the three carbon price scenarios (C-1 to C-3) described in Table 7. Figures 11 and 12, meanwhile, present the annual and cumulative GHG costs, respectively, across all six scenarios.

[15] Cumulative costs are calculated annually from 2020 to 2050 but presented in 5-year intervals.

Table 8: Costs of GHG Emissions, 2020 to 2050, Scenario G-1

GENERATION SCENARIO G-1	2020	2025	2030	2035	2040	2045	2050
Carbon Tax Scenario	Annual Costs of GHG Emissions (billion MYR)						
CT-1 *(Conservative)*	0.0	1.2	3.4	6.4	9.2	11.5	15.3
CT-2 *(Moderate)*	0.0	4.2	8.5	15.9	22.9	26.7	38.3
CT-3 *(Ambitious)*	0.0	1.8	9.0	21.2	36.6	45.8	68.9
	Cumulative Costs of GHG Emissions (billion MYR)						
CT-1 *(Conservative*	0.0	1.2	13.9	39.9	80.5	135.9	202.9
CT-2 *(Moderate)*	0.0	4.2	38.2	103.3	204.8	336.3	504.7
CT-3 *(Ambitious)*	0.0	1.8	32.2	114.7	269.0	490.7	789.2

Table 9: Costs of GHG Emissions, 2020 to 2050, Scenario G-2

GENERATION SCENARIO G-2	2020	2025	2030	2035	2040	2045	2050
Carbon Tax Scenario	Annual Costs of GHG Emissions (billion MYR)						
CT-1 *(Conservative)*	0.0	1.2	3.4	6.4	11.0	14.9	20.8
CT-2 *(Moderate)*	0.0	4.2	8.5	15.9	27.6	34.7	52.0
CT-3 *(Ambitious)*	0.0	1.8	9.0	21.2	44.1	59.4	93.6
	Cumulative Costs of GHG Emissions (billion MYR)						
CT-1 *(Conservative*	0.0	1.2	13.9	39.9	86.6	155.8	245.2
CT-2 *(Moderate)*	0.0	4.2	38.2	103.3	220.1	384.2	608.9
CT-3 *(Ambitious)*	0.0	1.8	32.2	114.7	292.8	569.5	967.9

Figure 11: Annual Costs of GHG Emissions Across Generation and Carbon Pricing Scenarios

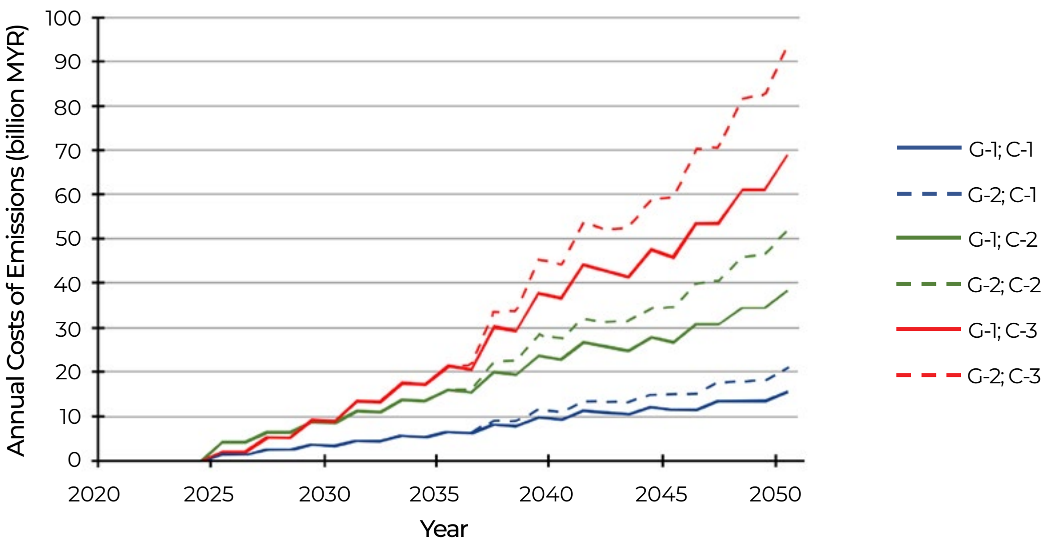
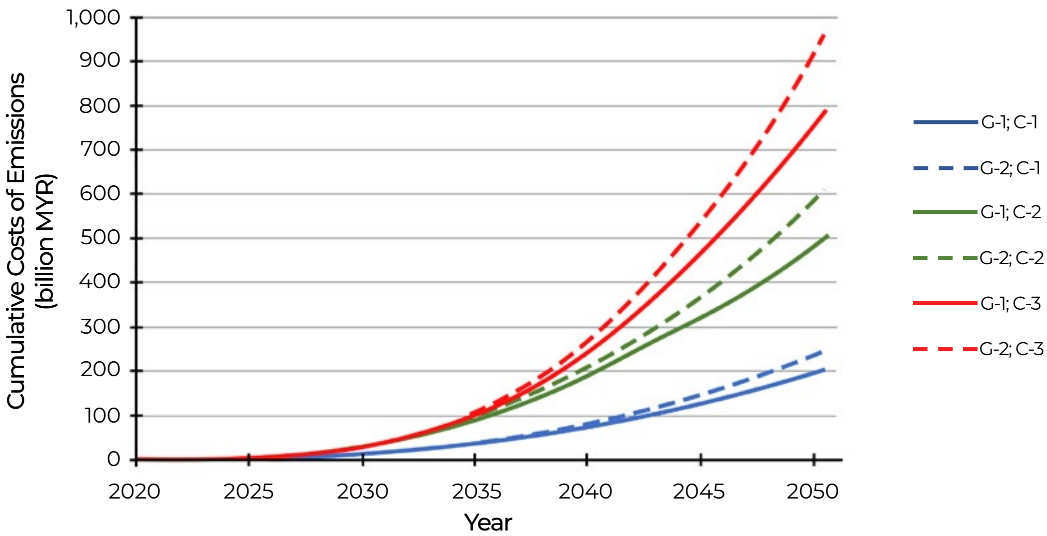


Figure 12: Cumulative Costs of GHG Emissions Across Generation and Carbon Pricing Scenarios



2.3.3 Discussion of Results

a. Electricity Generation and GHG Emissions Projections

Figures 7 and 8 show that steep reductions in emissions from electricity production correlate with the declining use of coal. Annual emissions are projected to decrease by 35 percent in 2050 compared to 2021 for scenario G-1 (high RE; no coal from 2045), but only by 11 percent for scenario G-2 (moderate RE; minimal coal from 2045). It is therefore evident that substantial emissions reductions can only be realized by eliminating coal from the electricity mix, while aggressively pursuing carbon-free generation sources in replacement.

Notably, during periods where generation from coal is unchanged, (scenario G-1, between 2045-2050; and scenario G-2, between 2035-2040 and 2045-2050), aggregate emissions will instead rise due to the increasing share of gas. As highlighted in Table 6, the emissions intensity of gas (482 tCO_2e/GWh) is about half that of coal (1,051 tCO_2e/GWh), therefore, any emissions reduction gains made by removing one unit of coal-generated energy would be negated by an increase in two units of gas-generated energy. This adds further impetus to Malaysia's need to continue expanding its RE capacity, while also exploring alternative sources of low-carbon energy.

While the displacement of coal would reduce electricity sector emissions in the medium term, a persistent and significant reliance on natural gas would eventually result in absolute emissions trending upwards in the long run. Technological advancements resulting in higher gas turbine efficiencies may alleviate this concern to a degree, as may other carbon-abatement technologies such as carbon capture, utilization, and storage (CCUS). However, effecting long-term emissions reductions beyond 2050 requires aggressively pursuing all low-carbon energy technologies, beyond just hydro and solar, to an even greater extent than that projected by the more ambitious scenario G-1.

The emissions intensity of electricity generation, shown in Figure 9, is estimated to reach 700 tCO_2/GWh in 2021, reducing to ~300 tCO_2/GWh in 2050 under scenario G-1 and ~400 tCO_2/GWh under scenario G-2. The impact of these appreciable reductions, of 58 percent and 43 percent, respectively, are however counteracted by the substantial 60 percent growth in electricity demand. This enhances the importance of continuous improvements in energy efficiency outcomes and minimizing electricity losses and wastage. Ultimately, the most effective means of achieving a sustainable, long-term reduction in Malaysia's emissions intensity remains an expansion of RE and low-carbon energy.

Despite the considerable differences between the two scenarios in terms of grid composition, absolute emissions, and emissions intensities post-2035, cumulative emissions by 2050 (illustrated in Figure 10) are projected to vary only by roughly 9 percent. It is therefore critical to ensure the continued presence and protection of natural carbon sinks, as well as the pursuit of other carbon-abatement measures, such as RE and EE, to counteract the increasing concentration of atmospheric CO_2.

In deriving the generation and emissions projections, only the primary energy sources currently listed in the National Energy Balance studies and Malaysia Renewable Energy Roadmap were considered. There are opportunities for secondary energy sources such as hydrogen and battery storage to have a mitigating impact on the carbon intensity of electricity in Malaysia if their inputs are also obtained from low-carbon generation sources. For example, excess electricity from hydro, especially from Sarawak (which has significant potential in this regard), could be channeled toward these objectives to further accelerate efforts to decarbonize the energy sector in Malaysia, provided the necessary infrastructure is built.

b. Costs of GHG Emissions

Under generation scenario G-1, aggressive RE deployment and the complete removal of coal from the generation mix from 2045 onwards would result in an approximate rise of annual emission costs by about MYR0.6 billion (under carbon tax scenario C-1), MYR1.4 billion (C-2), and MYR2.6 billion (C-3) annually. Under scenario G-2, where coal is still utilized post-2045, decarbonization is projected to occur at a slower pace, causing annual emission costs to grow at higher rates of about MYR0.8 billion (C-1), MYR1.9 billion (C-2), and MYR3.5 billion (C-3).

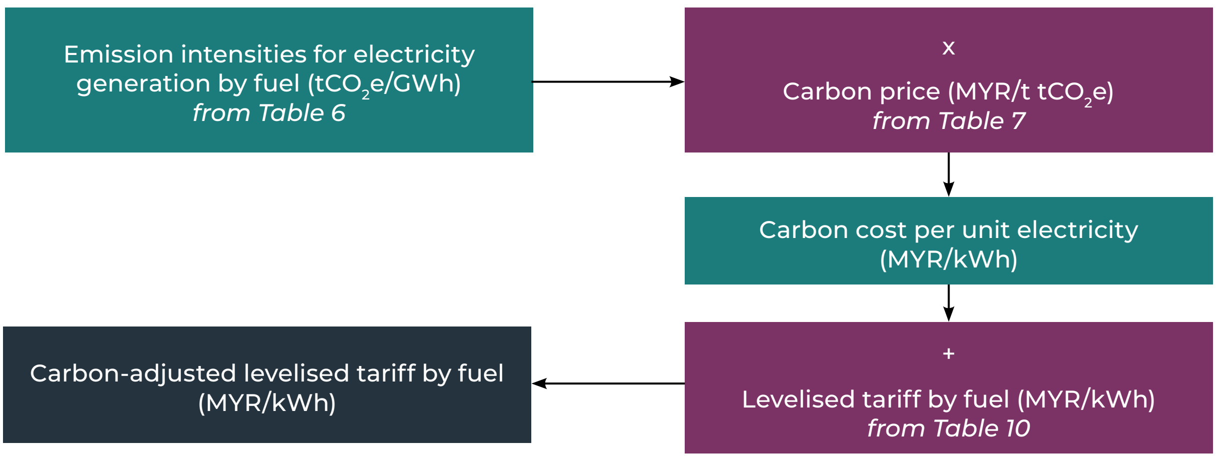
Under the moderate and aggressive carbon pricing scenarios (C-2 and C-3), the emissions costs that are attained in the early-to-mid 2030s are only achieved by the conservative projection (C-1) in 2050. Despite being more aggressive in the long term, C-3, which emulates the carbon tax of Singapore, starts lower than or on par with the moderate C-2 for the initial 5-year period from 2025 to 2030, but subsequently grows at a more rapid rate.

In terms of cumulative costs, carbon pricing scenario C-1 accrues roughly MYR 200 billion under generation scenario G-1, and MYR 250 billion under generation scenario G-2, by 2050. Under carbon pricing scenario C-2, this rises to between MYR 500 billion (G-1) and MYR 600 billion (G-2), and under carbon pricing scenario C3, between MYR 800 billion (G-1) and almost MYR 1 trillion (G-2). These are substantial emissions costs and, from the opposing perspective, are substantial carbon tax revenues for the government. These revenues could – and should – be channeled to stimulate further investment in low-carbon energy infrastructure, including research and development into new technologies, while simultaneously disincentivizing the use of fossil fuels. Indeed, revenue recycling is increasingly becoming a key design feature of carbon tax mechanisms in place around the world, as an avenue toward further aiding decarbonization efforts and addressing other socioeconomic needs However, an optimal carbon pricing framework should account for all three pillars of the energy trilemma, namely sustainability, affordability, and security. While a carbon tax should help address the issue of emissions and cleaner energy infrastructure (sustainability), it must be balanced against the subsequent direct impacts on end-user electricity rates (affordability) and the integrity of the electricity network (security). The informed reinvestment of carbon tax revenues can ensure that these other aspects of the energy trilemma are not neglected.

2.4 Establishing Levelized Electricity Tariffs with Carbon Pricing

This section seeks to establish the levelized costs of electricity generated from various fossil fuel and renewable sources in the presence of varying carbon prices, and in the absence of carbon pricing. However, due to limitations on the availability of data (as explained further in Chapter 2.4.1), published levelized tariffs were utilized instead as a proxy for the LCOE. Figure 13 illustrates the inputs and processes to establish the carbon-adjusted levelized tariff.[16]

Figure 13: Establishing the Carbon-Adjusted Levelized Tariff



[16] A discussion behind the reasoning for estimating the "levelized tariff" rather than "levelized costs" is presented in Chapter 2.4.1.

2.4.1 Levelized Costs of Electricity Generation by Source

In addition to the input parameters described in Section D of this report, the levelized cost of electricity (LCOE) for each source in Malaysia's electricity generation mix, defined in Malaysian ringgit per kilowatt-hour (MYR/kWh) was also required to address this objective.

The LCOE measures the total costs of producing electricity divided by the total amount of electricity generated, with both parameters evaluated over the entire lifetime of the generating facility (Corporate Finance Institute, 2022[b]; United States Department of Energy, 2015; Rodriguez, 2022). The resulting value reflects the average cost to produce each unit of electricity for the facility to reach a break-even point over its operational lifespan.

Calculating the LCOE requires estimates of several cost variables; these include capital construction costs for the facility; operational and maintenance costs; fuel costs; decommissioning costs; and other expenses incurred during its lifetime. The generation component estimates electricity production by applying a constant capacity factor[17] to convert the rated power of the facility, in megawatts (MW), into energy output, in megawatt-hours (MWh), across its lifetime. Finally, a discount rate is used to convert future costs and revenues into their net present values (NPV) (Corporate Finance Institute, 2022a). Figure 14 provides a simplified equation used to estimate the LCOE.

Figure 14: Estimating the Levelized Costs of Electricity Generation

$$\textit{Levelised Cost of Electricity (LCOE)} = \frac{\textit{Total lifetime costs of generating electricity}}{\textit{Total lifetime electricity generated}}$$

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

I_t = Investment costs in year t
M_t = Operations & maintenance costs in year t
F_t = Fuel costs in year t
E_t = Electricity generation in year t
r = Discount rate
n = Facility lifespan

While the LCOE is a straightforward and widely used method to present the costs of electricity generation, it has some limitations. For example, typical LCOE calculations tend to oversimplify contexts, ignore externalities,[18] fail to account for risks, and incorporate many input assumptions which will inevitably vary over the multi-decade lifespan of a facility (Shah et al., 2020; Valeri, 2019).

Within the Malaysian context, specific LCOE values for electricity-generating facilities are not available in the public domain, nor is data pertaining to the many input parameters required to derive the LCOEs from first principles. To minimize uncertainties arising from making broad assumptions about the various cost parameters to facilitate direct comparisons between generation sources, published levelized tariff values were instead used, where available. Levelized tariffs represent the cost per unit of electricity, as declared by the project developer and can be considered as an acceptable proxy, albeit with an integrated profit margin, for the LCOE of the respective facility.

Table 10 lists the levelized tariffs for selected coal, natural gas, large-scale solar, biomass, biogas, and small hydropower electricity generating facilities, sourced from Tenaga Nasional Berhad (TNB), ST, and SEDA. Equivalent values for large hydropower in Malaysia are not publicly available.

[17] The capacity factor is defined as the ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period (United States Energy Information Administration, 2022).
[18] Examples of externalities not usually considered in LCOE are emissions from fossil fuels, backup generation for variable generation, and grid infrastructure costs.

Table 10: Levelized Tariffs for Electricity Generation Facilities in Malaysia

Generation Source	Levelized Tariff (MYR sen /kWh)	Reference
Coal	24.73	Average levelized tariff for Manjung 5 (1 x 1,000MW) and Jimah East (2 x 1,000MW) coal power stations (TNB, 2016).
Natural Gas	34.70	Levelized tariff for Prai (1,071MW) combined cycle gas turbine (CCGT) power station from competitive bidding results (ST, 2012).
Biomass	27.61	Average bid price for all 5 bids (1.5MW to 10MW) from 2021 feed-in-tariff quota application e-bidding process (SEDA, 2022).
Biogas	24.68	Average bid price for all 18 bids (0.425MW to 4MW) from 2021 feed-in-tariff quota application e-bidding process (SEDA, 2022).
Small Hydro	24.22	Average bid price for all 22 bids (2MW to 30MW) from 2021 feed-in-tariff quota application e-bidding process (SEDA, 2022).
Solar (LSS3)	27.38	Average bid price for all 112 bids (5MW to 100MW) from LSS3, the 3rd bidding cycle for large-scale solar (ST, 2019b).[19]
Solar (LSS4)	20.64	Average bid price for all 138 bids (7MW to 50MW) from LSS4, the 4th bidding cycle for large-scale solar (ST, 2020).

2.4.2 Carbon-Adjusted Levelized Tariffs for Electricity

For this study, the carbon cost per unit of electricity (tCO_2e/kWh) is treated as an emissions premium charge (in NPV terms) and added onto the published levelized tariff for coal and natural gas. Although biomass and biogas also generate GHGs from combustion, these sources are defined as renewable resources by SEDA (2021) and are exempted from the carbon tax to prevent disincentivizing their development.

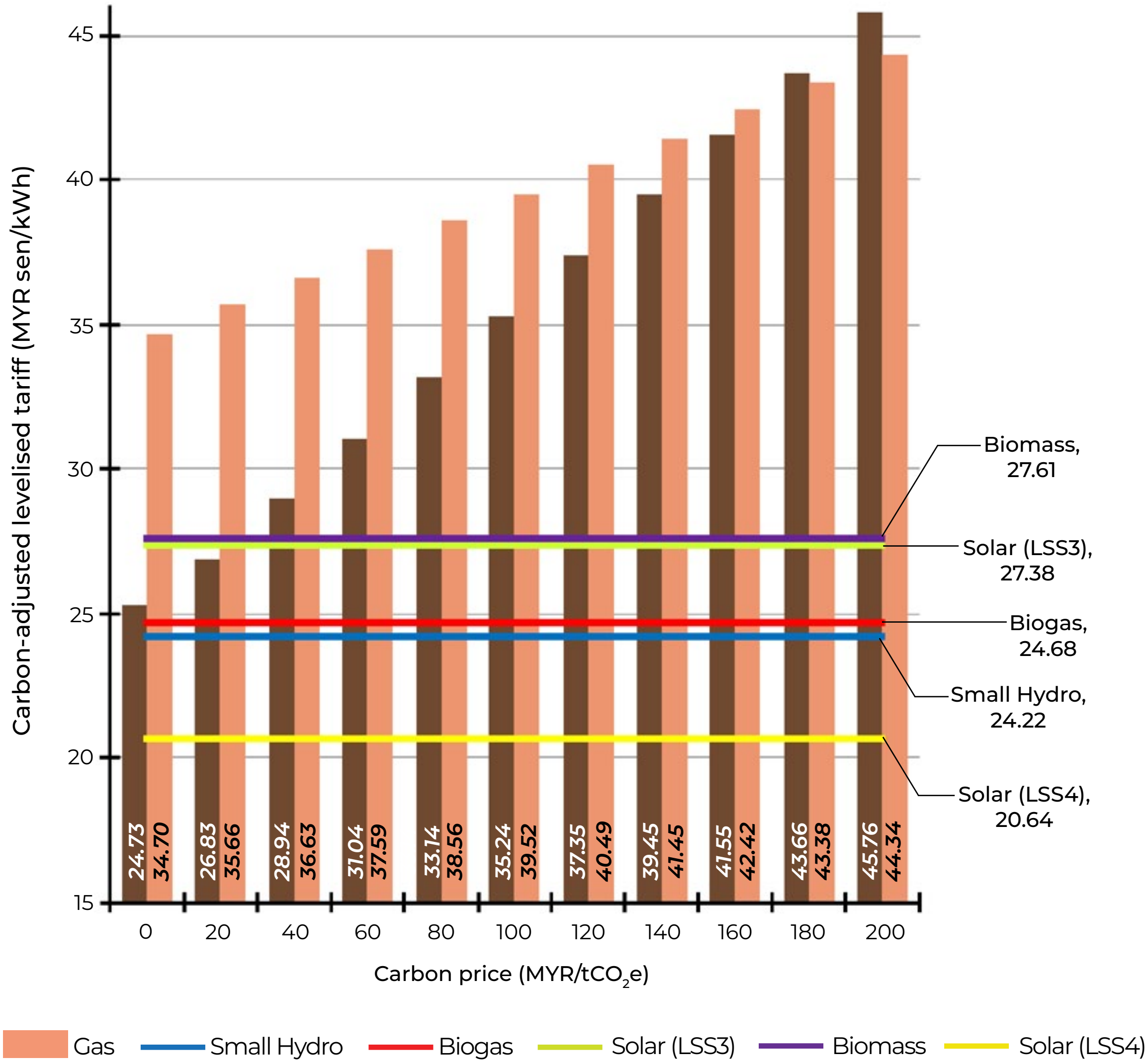
The carbon prices used for this analysis are obtained from scenario C-1 in Table 7, as the range of MYR 0 to 200/tCO_2e was deemed sufficient to illustrate its salient points. Table 11 details the carbon-adjusted levelized tariffs for coal and gas, while Figure 15 contrasts the results for fossil fuel-generating technologies against low-carbon alternatives.

Table 11: Carbon-Adjusted Tariffs for Coal and Gas

Carbon price (MYR/tCO_2e)		0	20	40	60	80	100	120	140	160	180	200
Coal	CO_2 tax (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
	CO_2-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	CO_2 tax (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
	CO_2-adjusted levelized tariff (MYR sen/kWh)	34.70	35.66	36.63	37.59	38.56	39.52	40.49	41.45	42.42	43.38	44.34

[19] LSS3 bid prices (average MYR 0.2738/kWh) from 2019 are used for the analysis alongside the more recent LSS4 bid prices (average MYR 0.2064/kWh) from 2020. Although LSS4 prices are significantly lower than LSS3, news reports in August 2022 indicate that successful LSS4 bidders received extensions to their power-purchase agreements (PPA) from ST due to project viability concerns from the impact of rising solar panel prices (Aziz, 2022; Ong, 2022; Salim, 2022). It was also reported that requests for ST to review the LSS4 bid prices were rejected. Hence, there exists some uncertainty around the feasibility of purely using LSS4 prices to reflect the current price of utility-scale solar in Malaysia. For comparison, the average bid prices were MYR 0.4783/kWh for LSS1 in year 2016 (ST, 2016) and 0.4121 (ST, 2017) for LSS2 in year 2017.

Figure 15: Carbon-Adjusted Levelized Tariffs for Coal, Gas, and RE Sources



2.4.3 Discussion of Results

The levelized tariffs for coal, without carbon adjustments, are already on par with the average bid prices for small hydro and biogas. It reaches parity with LSS3 and biomass when the price of carbon is approximately MYR 26/tCO_2e. The levelized tariffs for gas, on the other hand, are much higher than the bid prices of all RE sources, even in the absence of carbon adjustments.

The average bid prices for LSS4 are the lowest in the analysis at 20.64 sen/kWh, with individual bids reaching as low as 13.99 sen/kWh (ST, 2020). However, as highlighted in Footnote 19, the feasibility of prices at this range is currently uncertain due to the impacts of rising solar panel costs, necessitating some degree of amendment to the prior agreements between ST and the successful bidders. Comparing both fossil fuels, the levelized tariffs for gas are already about 40 percent higher than coal without carbon adjustments. **Coal will remain a cheaper source of electricity than gas until carbon prices exceed MYR 175 MYR/tCO_2e.**

The assumption that fuel input prices will remain unchanged is itself tenuous; both coal and gas prices 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, drives global momentum in favor of alternative fuels, including RE and other low-carbon energy sources such as nuclear.

While pricing carbon as an externality can incentivize or disincentivize the use of various sources of electricity, other considerations should be considered which are not typically represented in the levelized cost or tariff metric. Dispatchability, fuel on-site, intermittency, backup supply, grid stability, and grid reinforcement are among the crucial technical factors that must be assessed holistically, alongside generation cost and emissions, to determine the optimal mix of electricity sources.

3. CARBON PRICING AND THE FORESTRY SECTOR

Gopalasamy Reuben Clements and Goh Chun Sheng[20]

3.1 Establishing the Economic Returns of Exploitation

In contrast to the electricity sector, through which fossil fuel combustion causes GHG emissions and an increase in the atmospheric concentration of carbon, the conservation of Malaysia's forests aids their ability to absorb and sequester carbon. Yet, the economics of conservation against the alternative of exploitation is dependent upon opportunity costs. If it is more profitable to exploit forests for oil palm products, timber, and the mining or quarrying of metals or rocks (or other activities or products that cause deforestation) than it is to maintain and conserve natural capital, then exploitation will occur. To establish incentives for conservation, then, a comprehensive accounting of the monetary value of the benefits of conservation needs to be established. As this chapter discusses, forests and natural capital serve many functions, including as stores of carbon, which impact climate change mitigation and adaptation. Malaysia's current policy focus on carbon pricing opens up the immediate possibility that greater conservation may occur as a result of maintaining the nation's carbon sinks and monetizing its investible carbon. As a first step toward assessing these tradeoffs, this section quantifies the economic benefits associated with the exploitation of natural capital in Malaysia, focusing on three major product groups historically associated with deforestation in the country: oil palm products; timber products; and limestone.

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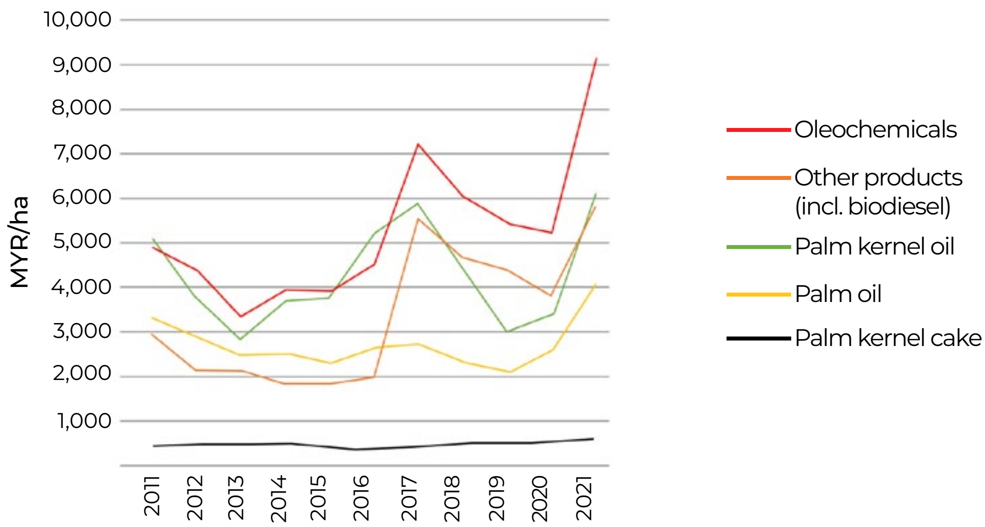
3.1.1 Oil Palm

Palm oil is the leading source of vegetable oil globally, closely followed by soya oil. The industry generates substantial revenues for Malaysia, the world's second-largest producing nation. Assuming that any further expansion of the country's oil palm plantations would be catered toward meeting export demand, revenues generated from exports are a key indicator in establishing the economic returns of the sector.

Figure 16 depicts revenues generated from the export of palm oil and palm-based products between 2011 to 2021. The figures fluctuate greatly, with revenues from the export of palm oil in 2019 amounting to just over MYR 2,000 per ton, and more than doubling by 2021.

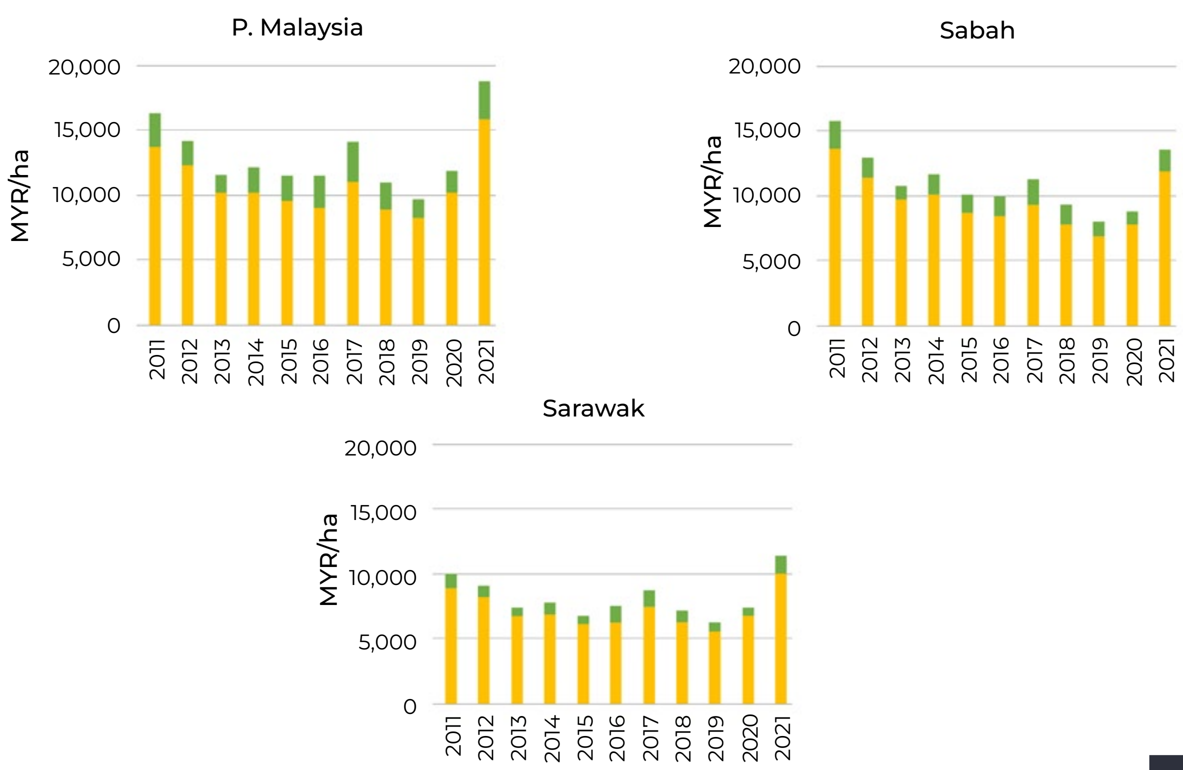
Figure 16: Export Revenues from Oil Palm Products, 2010–2021 (MPOB, 2022)



The economic returns of oil palm vary substantially by state due to agroecological conditions (e.g. peatland in Sarawak) and business models. Figure 18 shows estimated revenues generated per hectare of oil palm cultivation in Peninsular Malaysia, Sabah, and Sarawak using the data in Figure 17 and state-level production statistics.

Oil palm cultivation in Peninsular Malaysia generates the highest returns, with revenues ranging from nearly MYR 10,000 to MYR 19,000 per hectare between 2011 and 2021. During the same period, Sarawak generated the lowest returns, with revenues ranging from approximately MYR 6,400 to MYR 11,400 per hectare.

Figure 17: Oil Palm Revenues by State, 2011–2021 (MPOB, 2022)



3.1.2 Timber

Despite Malaysia's ambitious goals in timber trading, the continued decline in its tree cover represents a major problem for the forestry sector. Given the persistent demand for timber products and a dwindling supply of natural tree resources, based on deforestation rates, the forestry sector in Malaysia may be on its way to becoming a sunset industry; while it continues to be important to the economy, it is losing favor due to falling employment and profits, and comparatively higher environmental costs.

Generally speaking, it will be challenging for the forestry sector to thrive owing to the hidden costs and poor enforcement of forestry regulations (Habibu, 2017). Unregulated forest harvesting has negatively impacted forest industries in Malaysia as several plywood mills were forced to halt their products due to the shortage of log supply (Wong, 2018). The Japan Lumber Report (JLR) also stated that the high costs of logging coupled with low sales prices have placed plywood mills in a 'life or death' situation in Malaysia (Wong, 2018).

As state governments do not receive sufficient incentives from the federal government to protect natural forests, they still need to obtain revenue from forests in the form of premium and cess from land, and royalties from timber and other forest-based products. According to a report from Macaranga (Law, 2021) that analyzed average forestry revenues collected per hectare of forest between 2007 and 2019 in Peninsular Malaysia, revenues per hectare (and therefore opportunity costs from managing a forest for carbon) are highest in Selangor and lowest in Negeri Sembilan.

3.1.3 Mining (Limestone)

According to revenue and tons of quarried limestone in Malaysia between 2015 and 2020 (JMG, 2022), revenue and quarried limestone appears to be decreasing after 2018, with a 6-year average of around MYR 12/ton (see Table 12).

Table 12: Revenues from Quarried Limestone, 2015–2020

Year	Quarried Limestone (million tons)	Revenue (MYR millions)	Revenue (MYR/ ton)
2015	24.2	323	13
2016	25.4	351	14
2017	25.7	307	12
2018	25.3	283	11
2019	24.2	225	9
2020	22.4	217	10

Granite and limestone are the most common of the 13 types of rocks being mined in Malaysia. Limestone has the potential to sequester carbon – and thereby generate carbon credits – and plays an important role within the habitats of threatened and endemic biodiversity (Clements et al., 2006). Out of the 368 quarries reported by the Malaysia Mineral Yearbook 2016, 78 are limestone quarries, and these are most numerous in Perak.

3.2 Establishing the Economic Returns of Conservation

A key component of the assessment of the trade-offs between the exploitation and conservation of natural capital, such as forests, requires an understanding of the valuations of the various elements of natural capital. One of these is the role of natural capital as a store of carbon, which can aid in achieving climate change mitigation targets as well as provide natural infrastructure which aids in adapting and enhancing resilience to the impacts of climate change. As such, this section assesses the value of investible carbon across three common sources of carbon storage in tropical forests, i.e., aboveground and belowground carbon, and soil organic carbon.

The relative profitability of developing low-carbon projects in these areas was modeled by Koh et al. (2021) to produce estimates of the NPV of returns based on several assumptions following established values from previous studies.

The cost of project establishment can be set at USD 25 per hectare. This figure is based on estimates of a range of costs that are key to project development, including, but not limited to, project design, governance and planning, enforcement, zonation, land tenure and acquisition, surveying, and research. The cost for annual maintenance can be estimated to be USD 10 per hectare, which includes elements such as education and communication, monitoring, sustainable livelihoods, marketing, finance, and administration. However, these costs do not yet include opportunity costs to the government of keeping forests intact.

In simple terms, carbon prices should consider establishment costs, maintenance costs, and opportunity costs. A constant carbon price of USD 5.80/tCO_2e for the first five years is applied, based on the average carbon price for avoided deforestation projects reported recently by Forest Trends' Ecosystem Marketplace for the period between 2006 and 2018. A subsequent 5 percent annual price appreciation is then applied over a project timeframe of 30 years, as well as a 10 percent risk-adjusted discount rate to estimate the NPV of annual and accumulated profits over a 30-year time period.

Koh et al. (2021) use published data from 1-km resolution global maps of tropical forests to estimate aggregated investible forest carbon (tCO_2e/y-1) for each Malaysian state based on the total volume of CO_2e associated with the three main carbon pools commonly found in the tropics. These are aboveground carbon; belowground carbon; and soil organic carbon. Areas of forest carbon stocks in Malaysia were deemed 'investible' following the application of key Verified Carbon Standard (VCS) criteria, which includes the requirement of 'additionality'.

3.2.1 Calculating Carbon Stocks

Aboveground and belowground carbon stocks. A stoichiometric factor of 0.475 is applied to recent spatial data on aboveground carbon biomass (Avitabile et al., 2016) to calculate carbon stock based on established carbon accounting methodologies. An uncertainty analysis is also performed to account for potential variability in the stoichiometric factor. Subsequently, a conversion factor of 3.67 is applied to the carbon stock layer to obtain the volume of CO_2e associated with this carbon pool (Griscom et al., 2020). Belowground carbon biomass is firstly derived by applying two allometric equations (Mokany et al., 2006) relating to root to shoot biomass to the most recent spatial dataset on aboveground carbon biomass, again following established carbon accounting methodologies.

Soil Organic Carbon. Organic carbon density of the topsoil layer (the first 30 cm) can be obtained from the European Soil Data Centre (https://esdac.jrc.ec.europa.eu/resource-type/datasets), which presents the best data available for soil organic carbon. A conversion factor of 3.67 is subsequently applied to derive the volume of CO_2e associated with this carbon pool.

Applying VCS criteria. The criterion of additionality is a pre-condition for carbon credits to be certified under VCS. This implies that only forest carbon stocks under imminent threat of decline or loss, if left unprotected by a conservation intervention, can be certified under the VCS. The determination of the volume of forest carbon under such threat is based on the best available data of predicted deforestation rates across the tropics (available only through to 2029) and annualized over the predicted 15-year period. Estimated annual deforestation rates are then applied to the total volume of CO_2e associated with tropical forests as estimated above, deriving a volume of CO_2e certifiable – and thus investible – under the VCS.

In addition, a conservative 10-year decay estimate is assumed for estimates of the belowground carbon pool, and lands that will likely not be certifiable for other reasons, including recently deforested areas (i.e. during the period of 2010-2017), as well as human settlements, should be excluded. Lastly, the VCS requirement to set aside buffer credits of 20 percent is accounted for, to consider the risk of non-permanence associated with Agriculture, Forestry and Other Land Use (AFOLU) projects. One caveat from such an analysis is that the extent of investible carbon does not translate to the number of carbon credits generated from the forest, as the use of different methodologies will yield different quantities of carbon credits.

Carbon project developers should explore the purchase of carbon credits in Malaysian states that have relatively large areas of investible carbon. State governments with large tracts of investible carbon should explore the development of carbon projects to provide alternative revenue to logging.

The top five states in terms of volume of investible carbon in Malaysia, and aggregated NPV of annual and accumulated profits from forests with investible carbon (USD/year) over a 30-year timeframe (in decreasing order) are: 1) Sabah, 2) Sarawak, 3) Pahang; 4) Terengganu and 5) Johor. Further details are provided in Table 13.

Table 13: Ranking of States in Malaysia by Volume of Investible Carbon (Koh et al., 2021)

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

3.3 Other Aspects of Forest Ecosystem Services

Forests and natural capital more broadly offer a large variety of valuable services to society and the economy beyond acting as just a store of carbon. In that respect, this assessment of the investible carbon inherent to Malaysia represents just the tip of the iceberg. This section seeks to discuss the other aspects of ecosystem services that should be included in any assessment of the economic value of natural capital and the services rendered by nature and natural resources that would otherwise be lost through exploitative practices.

3.3.1 Overview

The disruption of ecosystem services (ES) can engender a variety of economic damages. Peat fire is among the most vivid examples in the context of forestry and oil palm, causing significant economic costs. Peat fires in Indonesia in 2015 caused damages estimated at around USD 16 billion (Purnomo et al., 2017). The latest cost estimate from the World Bank in 2019 for fires, which may have been triggered by climate change-driven temperature increases, amounts to USD 5.2 billion across the agricultural and environmental sectors – and this is likely an underestimate as it does not account for health-related effects and costs. The worst-hit provinces, Central and West Kalimantan, incurred losses estimated at 7.9 percent and 6.1 percent of their respective GDPs (Jong, 2019).

Conceivably, economic damages caused by widespread fires on farms can be pernicious. But more drastic is the potentially transboundary nature of these damages, due to the dispersion of haze that contains carbon monoxide and particulate matter, mainly across Indonesia, Malaysia, and Singapore (Tan-Soo and Pattanayak, 2019). These damages include not only direct costs, such as additional healthcare-related burdens, flight cancellations, and disruptions to business operations, but also costs that cannot be directly or easily quantified, such as life expectancy, premature death, climate change, disruption of lifestyles, social unrest, and undiscovered mental health problems (Nguitragool, 2010).

In addition, there is a wide range of interlinked economic impacts due to various environmental changes. Impacts on water resources can be especially critical in the context of oil palm. Evidence shows that changes in forest cover have altered precipitation cycles, river flows, and water availability (Herawati et al., 2018, McAlpine et al., 2018). Ironically, despite being one of the biggest drivers of tropical deforestation, oil palm plantations are also among the biggest victims as their productivity depends heavily on water availability (Safitri et al., 2018).

Public health is another important dimension to consider. Multiple studies have reported linkages between deforestation and outbreaks of malaria, hyperthermia, dengue fever, and other human disease risks (Jeffree et al., 2018, Ahmed et al., 2019). These examples are yet to include more long-term, subtle impacts such as increasing local temperatures (Masuda et al., 2019), as well as the complex feedback loops in connection with

multiple systems, such as flowering and fruiting (Ushio et al., 2019).

In addition to carbon, biodiversity also receives enormous attention globally, with international funding a key component of conservation financing. Biodiversity has close linkages to carbon stock management and in many cases, both are assessed together (see, for example, the work by Verstegen et al. (2019) for a case study in East Kalimantan). Extensive consideration has been given to assessing the incorporation of biodiversity conservation into a carbon-based framework (Ansell et al., 2011).

3.3.2 Biodiversity

Quantifying biodiversity is much more challenging than pricing carbon, and there are no 'standard' methodologies like the IPCC framework. In past decades, various concepts, methodologies, or frameworks have been developed to measure biodiversity. For research purposes, various studies have assessed certain species in Sabah, such as the monitoring of the proboscis monkey with unmanned aerial vehicles (Stark et al., 2018), and the gibbon with semi-automated vocal fingerprinting (Clink et al., 2019). On a larger scale, proposals to measure biodiversity have also been made to evaluate the effectiveness of various conservation programs. These include the 'ecological health' indicators proposed by Wulffraat and Morrison (2013) for the Heart of Borneo (HoB) program and the common framework of biodiversity accounting proposed by Khan (2014) for REDD+.

A platform similar to the IPCC, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was established in 2012. Experts and researchers from IPBES have concluded that there are no simple ways of valuing biodiversity and other ecosystem services as these are highly subjective and depend on place, time, and people (Pascual et al., 2017). Technically, the choice of base cases for comparison will have a profound impact on measurement. For example, a logged forest may show relatively low species richness compared to a pristine forest but may still be much higher than a plantation (Edwards et al., 2011).

Moreover, structural changes in biodiversity cannot be simplified into a few indicators when various types of land cover are interconnected with gradual transitions. The mosaic may also change with time due to dynamic variables such as forest growth, regrowth, and degradation. The environmental gradient, e.g., from pristine forest to severely-logged forest, must be taken into account and a more thorough understanding of spatio-temporal dynamics is needed (Struebig et al., 2013). More importantly, any indicators to measure biodiversity should not be used independently for land-zoning and land-use decisions, as degraded forests may still provide important functions in biodiversity conservation (Woodcock et al., 2011). Further, the perspectives of indigenous forest-dwelling people can be essential to understanding the dynamics across the landscape, as these groups have the most direct experience with changes in plant diversity and patterns (Sheil and Salim, 2011).

3.3.3 Pricing Beyond Carbon

Importantly, incentivizing only carbon stock conservation may trigger unwanted consequences across other ecosystem services. For example, focusing solely on carbon stock accumulation may not only lead to the neglect of high biodiversity areas but also deprivation of biodiversity, noting that a low-carbon area may still have high biodiversity, and vice versa. Although co-benefits can be more accurately detected with high-resolution and locally validated data, as shown in the case of Sabah (Deere et al., 2018), current mechanisms do not guarantee the protection of other ES when maximizing profits from carbon stock accumulation. Offsetting biodiversity losses would cost between 2.5 and 10 times more than restoring carbon stocks in all of Kalimantan's peatlands (Budiharta et al., 2018).

Theoretically, to create a combination of mechanisms that avoid all these leakages and trade-offs, ES has to be measured, valued, and compared in the same dimension. This is in line with the concept of 'inclusive wealth' that was proposed as a measure to quantitatively cover all these costs in a single index (Managi and Kumar, 2018). Other proposals exist, such as the concept of ecological supply by Yan et al. (2020), i.e., the ability of the natural environment to provide bio-resources and absorb waste for certain population sizes to measure the impacts of land cover changes on the environment. However, this assessment is troubled by very coarse assumptions made for different land classes, leading to biased results. Some other studies also attempt to integrate provisioning services (such as food, fiber, and cash crops), regulating services (carbon cycle), and even cultural services (nature recreation) on a monetary basis (Sumarga et al., 2015, Sumarga and Hein, 2016). However, any attempts to measure overall sustainable development in a harmonized fashion inevitably run into substitutability issues, e.g., the volume of carbon stock equivalent to the satisfaction generated from nature-based recreation is a highly subjective assessment that changes with time.

Another potential pricing mechanism to encourage conservation entails correlating compensation with communities' livelihood for conserving certain areas. This is a form of non-market valuation, in contrast to market-based carbon credit approaches. As an example of the¬¬¬ concept of 'willingness to accept', a case study in Lubuk Antu, Sarawak estimates that a monthly fee of just over USD 100 per household may be sufficient for communities to forego slash-and-burn practices. Moreover, compensation may not necessarily come in the form of cash, but through material and technical support for rubber cultivation (Phua et al., 2014). Meanwhile, Ota et al. (2020) describe an example of 'willingness to pay', where swiftlet farmers are asked to pay a tax for using or otherwise affecting ecosystem services based on their revenues. This approach may also potentially resolve the inherent difficulties associated with valuing other ecosystem services, such as biodiversity. However, it relies heavily on community awareness and knowledge about tangible and intangible benefits (Shah et al., 2016).

Considering these drawbacks, a region-specific, impact-based approach to compensation may be more effective in ensuring overall sustainability than just a universal carbon pricing system. Technically, multiple policy instruments, such as regulations and certifications, would be needed to address the various externalities (Bataille et al., 2018). In that sense, payments for ecosystem services (PES) and carbon pricing instruments (CPIs) can be useful options for policymakers to include in development and conservation plans. This is particularly important when put into a local and regional context to minimize conflicts between development and conservation (Venter et al., 2013).

Seeing the urgency of avoiding further environmental degradation, different approaches that bring faster actions than 'muddling through' strict technical quantification are worth exploring. Compensation schemes for conservation may need to be developed with more creativity and flexibility with a diverse suite of techniques and mechanisms that can work effectively in varying local and regional conditions.

4. STAKEHOLDER AND POLICY ECOSYSTEM: CARBON PRICING, ENERGY, AND FORESTRY

Alizan Mahadi[21]

4.1 Stakeholder Ecosystem

4.1.1 Carbon Pricing

The pricing of carbon will most deeply affect stakeholders operating within the most carbon-intensive industries and sectors. Roughly 75 percent of Malaysia's GHG emissions are the direct result of fossil fuel combustion. Electricity and heat production account for just under 31 percent of the total, with transport and oil and gas production processes responsible for a further 19 percent and 16.5 percent, respectively. The remainder is comprised of, for the most part, a combination of a wide range of activities within the agriculture, industrial, manufacturing and construction, and waste sectors (KASA, 2020). A detailed breakdown of GHG emissions in Malaysia is provided in Table 14.

[21] Alizan Mahadi is the research director at the Institute of Strategic and International Studies (ISIS) Malaysia.

Table 14: Sources of GHG Emissions in Malaysia, 2016 (KASA, 2020)

Activity	Gas	GHG Emissions, tonnes of CO_2e	Share of National GHG Emissions
Electricity and Heat Production	CO_2	103,046,910	30.79%
	CH_4	40,250	0.01%
	N_2O	348,660	0.10%
Transport	CO_2	61,904,100	18.50%
	CH_4	514,750	0.15%
	N_2O	858,240	0.26%
Petroleum Refining	CO_2	9,498,100	2.84%
	CH_4	9,750	0.00%
	N_2O	23,840	0.01%
Industrial Processes and Product Use	CO_2	20,807,760	6.22%
	CH_4	338,000	0.10%
	N_2O	71,520	0.02%
Manufacture of Solid Fuels and Other Energy Industries	CO_2	18,378,760	5.49%
	CH_4	8,250	0.00%
	N_2O	8,940	0.00%
Fugitive Emissions from Oil and Natural Gas	CO_2	1,942,150	0.58%
	CH_4	25,327,750	7.57%
Agriculture	CO_2	523,430	0.18%
	CH_4	4,083,404	1.39%
	N_2O	5,853,037	1.99%
Land Use Change	CO_2	17,472,825	5.31%
	CH_4	28,473	0.01%
	N_2O	18,828	0.01%
Manufacturing Industries and Construction	CO_2	23,855,750	7.13%
	CH_4	28,500	0.01%
	N_2O	50,660	0.02%
Solid Waste Disposal Sites	CH_4	11,214,250	3.35%
Wastewater Treatment and Discharge	CH_4	621	0.00%
Wastewater Treatment and Discharge	N_2O	375,480	0.11%
Total Aggregate GHGs		306,632,988	93.1%

This assessment demonstrates that carbon pricing instruments (CPIs) will most significantly impact the electricity and transport sectors, owing to their larger shares of total GHG emissions, and require emitters to either reduce emissions, trade emissions allowances under an emissions trading scheme, or incur additional costs in the presence of a carbon tax.

CPIs adopting an emissions trading approach will benefit generators of carbon credits through the production and sale of carbon credits. These are certificates issued when emissions are 'removed' from the atmosphere through projects contributing to greater carbon storage or avoidance. This can be achieved through carbon capture and storage (CCUS) and other technologies which create avoidance (e.g. replacing a coal plant with a planned life of thirty years with solar for the final five years), or removals by avoiding deforestation, engaging in reforestation, or other conservational practices. In the context of Malaysia and this study, the key stakeholders are those operating within the energy (avoidance) and forestry and land-use sectors (both avoidance and removal).

4.1.2 Energy and Electricity

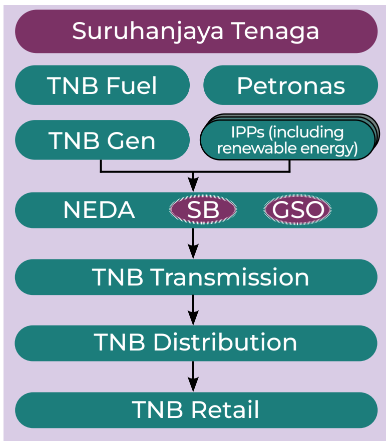
Governance of the energy sector – and the electricity sector, more specifically – cuts across various economic actors and stakeholders. These can be divided into four key subgroups: policymakers, regulators, suppliers, and producers.

From a policy perspective, the ministries and agencies with direct responsibilities within the energy sector include the Economic Planning Unit (EPU) and the energy division of the Ministry of Natural Resources, Environment, and Climate Change (MNRECC) (EPU, 2022). The EPU's energy division sets overarching policy directives, while the MNRECC's energy division formulates policies designed to ensure energy supply. One of the core objectives under its remit includes increasing RE penetration. The Ministry of Plantation Industries and Commodities (MPIC) is also responsible for the supply of biofuels. The Energy Commission, established in 2001, regulates the electricity sector and works closely with the MNRECC to meet its objective of ensuring secure, reliable, safe, and affordable supply to the general public and industries (Yatim et al., 2016). In Sabah and Sarawak, state-level economic planning units play an important role in formulating energy policies, with Sabah Electricity Board (SESB) and Sarawak Energy Berhad (SEB) as the state-level utility companies.

On the side of energy demand planning, the Ministry of Transport, Ministry of Housing and Local Government, Ministry of International Trade and Industry, Ministry of Rural Development, Ministry of Federal Territories, and the Ministry of Agriculture and Food Industry all have roles to play (EPU, 2022). Due to the broad and cross-cutting nature of the energy sector, this assessment focuses specifically on electricity generation.

The structure of Malaysia's electricity sector has evolved in a more liberalized fashion following recent efforts to restructure the industry. Previously, it was a vertically integrated monopoly system with Tenaga Nasional Berhad (TNB), the national electricity utility company, being the key industry player. Reforms have been undertaken since 1993 when independent power producers (IPPs) were introduced in the first stages of liberalization (Kumar et al., 2021). The introduction of IPPs was designed to improve the security of electricity supply and address shortages of generation capacity. The subsequent Malaysian Electricity Supply Industry (MESI 1.0) reforms prompted the establishment of the ring-fenced 'Single Buyer' model within TNB. This model refers to the separation of accounts and operations to procure electricity from IPPs and TNB Generation, as well as the execution of a least-cost dispatch scheduling model (Kumar et al., 2021).

Figure 18: Malaysia Electricity Supply Industry Structure (MyPower Corporation, 2019)



To focus specifically on the promotion of RE, the Sustainable Development Authority (SEDA) was established in 2011. Its main functions are to enhance Malaysia's use of sustainable energy technologies through administering instruments promoting their adoption, including the feed-in tariff and net energy metering mechanisms.

Electricity sector stakeholders most likely to be significantly affected by carbon pricing and the desired low-carbon energy transition are those operating at the fuel supply, generation, and procurement levels. This includes the power producers, including TNB Generation and the IPPs. At the procurement level, and under the current structure, this also includes the Single Buyer, described above. However, the impacts of carbon pricing will depend significantly on the various aspects of policy design, and accurately determining a ranking of the most impacted stakeholders requires more information than is currently available. For example, if the incidence of a carbon tax is passed through to end-users as a base generation cost, customers will be among the most impacted. Further, long-term power purchasing agreements (PPAs), typically 21 years for gas-fired power plants and 25 years for coal power plants, add an extra layer of complexity to this picture. This is because the Imbalance Cost Pass Through (ICPT) mechanism, which stipulates that any additional costs (savings) are to be passed through to consumers via surcharge (rebate), is designed to alleviate fuel price risks faced by electricity generators. Nonetheless, as discussed below, the likely point of incidence for a carbon tax will be the 'upstream' level, i.e. at the fuel production or supply level. It is here that ramifications are likely to be most profoundly felt.

Two companies supply coal and gas to power plants in Peninsular Malaysia: TNB Fuel for imported coal, and Petronas Energy & Gas Trading (PEGT) for natural gas (Kumar et al., 2021). Due to its impacts on the costs of generating energy through carbon-intensive technologies, these fuel suppliers will likely be deeply implicated by any carbon pricing mechanism implemented.

At the generation-level, the key impacted stakeholders are the IPPs. Most coal power plants are either fully owned by joint ventures or subsidiaries of TNB. For gas power plants, Kumar et al. (2021) highlight that a third is owned by TNB, with the remainder operated by IPPs such as YTL Power Generation Sdn Bhd, Tanjong Bin Power Sdn Bhd, and Jimah Energy Ventures Sdn Bhd (Yatim et al., 2016). While carbon pricing will affect the generation costs faced by IPPs, the extent of such impacts will depend on the relevant PPAs and the ICPT mechanism. Further, the introduction of Third Party Access (TPA) to the gas network, an initiative highlighted in the National Energy Policy 2022-2040 (NEP), will likely lead to greater competition in the industry moving forward (EPU, 2022). Renewable energy IPPs, including solar providers, may also benefit, though the extent would also be dependent on their existing PPAs. For instance, IPPs under LSS programs already receive priority dispatch.

Despite the complexity and dynamism of the structure of the electricity sector, this chapter has identified several influential stakeholders who would be affected by the implementation of carbon pricing. TNB, in particular, as both a fuel supplier and electricity generator, would likely be most affected, along with Petronas, as a fuel supplier for gas. The other IPPs, particularly those whose PPAs have expired or who operate without PPAs, would also face risks from increased operating costs.[22] Nevertheless, the upstream market is at present highly concentrated among a few key stakeholders. While suppliers and generators would be affected by carbon pricing, the Single Buyer plays a significant role in influencing the procurement of electricity, and in doing so, would have some mitigatory impact on the effects of any CPI put in place.

4.1.3 Forestry and Land-Use

As a mega biodiverse country, Malaysia's land-use, land-use change, and forestry (LULUCF) sector has major implications for national-level carbon emissions (through the exploitation of natural capital, including deforestation) and sequestration (through natural capital conservation and rehabilitation, including afforestation or reforestation). The recent focus, across the public and private sectors, toward achieving net-zero emissions has elevated the importance of the forestry sector within Malaysia's climate response.

The stakeholder ecosystem within the forestry sector is more straightforward to assess than the electricity sector as the most influential stakeholders are easily identifiable. With land considered a state jurisdictional matter, state governments remain the key stakeholders.

The first major conflict arises from the fact that states rely on natural resources and land for a sizeable proportion of their revenues. A key challenge that has long faced the forestry sector is the lack of an equitable revenue-sharing mechanism between federal and state levels of government to enhance incentives for states to conserve and rehabilitate their forests. Attempts to raise conservation funds – such as through the National Conservation Trust Fund for Natural Resources (NCTF), Payments for Ecosystem Services (PES), and Ecological Fiscal Transfers (EFTs) – have thus far proven insufficient as a means to replace the income generated from exploitative activities such as logging, land sales, mining, or other rent-seeking practices such as plantations (typically palm oil).

States also vary significantly in terms of forest cover, geography, topography, and economy, complicating any attempts to develop an optimal federal-state revenue sharing model. As a first step toward addressing this issue, 'fair share contributions' for each state to achieve national targets pertinent to natural capital conservation would need to be established. Beyond this, each state will face varying degrees of impacts from carbon pricing. States with higher quantities of forest cover could potentially benefit from the introduction of higher carbon prices; states with lesser forest cover could – depending on the design of the CPI – be 'penalized', at worst, or just not benefit to any great degree from the sale of carbon credits.

[22] For IPPs without PPAs or expired PPAs, the New Enhanced Dispatch Arrangement was introduced as a supplementary to the Single Buyer Rules in 2015 as a short run (daily) competition mechanism to provide opportunities for non-PPA/SLA generators to sell electricity to the Single Buyer (Kumar et al., 2021; MyPower Corporation, 2019).

4.2 Policy Ecosystem Assessment

The policy ecosystem assessment covers broad policies related to carbon pricing as well as specific policies involving the electricity and forestry sectors.

4.2.1 Carbon Pricing

At present, there remains no overarching carbon pricing policy in Malaysia. The most detailed source of information publicly available regarding Malaysia's plans to implement CPIs is the Twelfth Malaysia Plan (12MP), which highlights the ambition to formulate a national carbon pricing policy by 2025. Beyond announcements within the 12MP, Bursa Malaysia launched the Voluntary Carbon Market (VCM) exchange in late 2022. The VCM aims to enable companies to generate, purchase, and sell voluntary carbon credits, giving firms opportunities to support and engage in low-carbon initiatives and conservational practices in exchange for carbon offsets (KASA, 2021).

While the VCM is voluntary, the compliance market for carbon emissions remains in development. The MNRECC, a new ministry established during the formation of Anwar Ibrahim's government in late 2022 and which represents a merging of KASA and KeTSA,[23] has announced its intentions to launch a Domestic Emissions Trading Scheme (DETS). The VCM can act as a stepping stone for the DETS in various ways (Astro Awani, 2021). Most significantly, it will act as a form of 'bottom-up' carbon price discovery, allowing for a greater understanding of the potential market price for carbon in Malaysia. However, it must be noted that this is a non-scientific approach to price discovery. In particular, it does not relate to the external costs through loss and damages of the impact of a ton of CO_2. Furthermore, without a cap in quantity from sectors, there is no correlation with the amount of CO_2 emissions scientifically required to achieve policy targets such as achieving a 1.5-degree Celsius limit of warming. In this case, it is purely, based on the market price due to internal aspirations of enterprises such as achieving their own net-zero commitments.

Taken together, available evidence suggests that Malaysia will move forward on carbon pricing through the development of carbon emissions trading mechanisms. Yet globally, trends point toward hybrid models of CPIs, which include both a carbon tax and emissions trading scheme. Indeed, some economic activities lend themselves better to an ETS, and others to a carbon tax; this is largely dependent on the diversity of sources of emissions. At present, no decision on carbon taxes is known to have been made, although the Ministry of Finance (MOF) has been cited as exploring the potential for the introduction of a carbon tax (Aziz, 2022).

4.2.2 Energy

Since the late 2000s, several electricity sector policies have been introduced, with the aim of increasing Malaysia's use of renewable energy and aiding the low-carbon energy transition. This sub-section aims to discuss these policies and their relevance to carbon pricing.

The NEP provides the overarching strategy for the energy sector, acting as the key reference point for Malaysia's long-term plans within the electricity industry. Specifically, it aims to future-proof the sector in line with global energy transition trends. This includes an aspiration to become a 'low-carbon nation' by 2040, which encompasses targets to reduce the percentage of coal as a share of Malaysia's installed capacity (from 31.4 percent in 2018 to 18.6 percent in 2040) and increase the share of renewable energy in total primary energy supply (from 7.2 percent in 2018 to 17 percent in 2040) (EPU, 2022). These new targets largely supersede those previously set.

An assessment of Malaysia's use of economic instruments to support its climate policy objectives finds that 11 existing and past economic instruments have had either direct or indirect price effects (Mahadi et al., 2022). Among this group are instruments relevant to the electricity sector, including the feed-in-tariff (FiT) and net energy metering (NEM). Both essentially allow consumers to sell excess electricity generated from RE to the national grid. Large-scale solar, meanwhile, has thus far proven to be the most effective mechanism to increase Malaysia's deployment of solar PV, and therefore, in producing price effects. In 2021, the green electricity tariff (GET) was introduced as a measure to further incentivize RE, allowing residential, industrial, and commercial consumers to purchase low-carbon electricity on a subscription basis, at a rate of 3.7 sen/kWh, in exchange for internationally recognized Malaysian RE Credits (mRECs).

These instruments incentivize the adoption of renewable energy in Malaysia. However, they are 'second-best' policies in the sense that they do not internalize negative externalities or otherwise address the market failures recognized in Chapter 1. In other words, these second-best instruments fail to put a price on carbon equivalent to the negative (externality) costs that their emitting activities produce. They do, however, help strengthen the business case for climate action and their impacts would only be amplified given the existence of a carbon pricing mechanism.

[23] From this point on, the Ministries of Environment and Water (KASA), and Energy and Natural Resources (KeTSA), will be referred to as MNRECC, reflecting the current Cabinet composition.

4.2.3 Forestry

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.

Various policy instruments catered toward the enhancement of the forestry sector's contributions toward climate action, such as the REDD+ financing scheme, are currently in development. But there remains significant potential for improvement in Malaysia; many conservation financing instruments can work in tandem with CPIs. EFTs, for instance, have recently been implemented in Malaysia, with Budgets 2022 and 2023 allocating MYR 70 million and MYR 100 million for this purpose, respectively. EFTs entail transfers of public revenue between various levels of government (such as federal to state, and are, as such, a subset of intergovernmental fiscal transfers) based on a variety of ecological indicators and were introduced to encourage the protection of forests and other Protected Areas (PA) by state governments. Currently, these instruments are at their nascent stage of deployment and are limited in terms of execution. This includes a relatively small allocation as indicated above for EFTs as well as REDD+ being at a readiness stage as opposed to the transaction stage for carbon credits.

Payments for Ecosystem Services (PES) has also generated interest in Malaysia, but while such initiatives are supported by the Malaysian government, including through recommendations made by the Economic Planning Unit, it remains largely a private sector-driven initiative. The 12MP reiterated the government's plan to strengthen PES implementation, citing that the "mechanism will be established to ensure the payment for ecosystem services commensurate with the benefits derived and costs incurred from the services" (EPU, 2021). The idea behind PES is to pay landowners for ecosystem services; doing so gives them incentives to support land protection and conservation in the interest of ensuring the provision of 'services' rendered by nature. These services include but are not limited to clean water, habitats for wildlife, and carbon storage in forests.

These instruments demonstrate the importance of understanding that the business case for the conservation of natural capital goes well beyond just carbon. A focus on developing valuations for these ecosystem services would only further strengthen the business case for conservation and climate action.

4.3 Future Policy Trends and Transition Risks

This section provides an outlook of future policy trends likely to affect the business case for emissions reductions and the conservation of natural capital in Malaysia. Specifically, it looks into domestic policies and instruments as well as international trade and transition risks.

4.3.1 Future Policy Trends and Transition Risks

The mapping conducted in the previous section sets the scene for an assessment of the outlook of domestic policies. The transition toward greater climate action and the provision of price signals catered toward emissions reductions and conserving natural capital is highly dynamic and evidence of these endeavors' integration with sectoral objectives is growing. This section reviews the broader policy landscape related to carbon pricing as well as potential sectoral policies that could have implications for carbon pricing in the future.

A national carbon pricing policy will likely be introduced sometime between 2023 and 2025, which marks the end of the 12MP cycle. A few enabling factors point toward the implementation of carbon pricing policies in Malaysia. First, influential actors such as Petronas and TNB, both of whom would be deeply implicated by CPI implementation, have already committed to achieving net-zero emissions and remain dependent on international investments, the sources of which already face pressures to decarbonize investment portfolios and balance sheets. Additionally, Malaysia's financial sector has also responded positively to such international demands by playing a leading role in facilitating the low-carbon transition across the domestic financial industry. This includes the establishment of the Joint Committee on Climate Change (JC3), chaired by Bank Negara Malaysia (BNM, Malaysia's central bank) and the Securities Commission (SC).

One area of lingering uncertainty relates to the design of any potential CPI in Malaysia. This is expected to be clarified by the forthcoming carbon pricing policy. However, based on developments so far – with MNRECC focusing on developing the DETS and the MOF assessing options including a carbon tax – a hybrid approach entailing the implementation of both an emissions trading scheme and a carbon tax is a likely outcome.

The impacts of these instruments depend on more than just the choice of instrument: there remain various elements of CPI design that must be exposited. This includes establishing the coverage or scope of the policy, i.e. which sectors are likely to be covered, and under which scheme. Emissions-intensive sectors, such as electricity, could be included under any CPI, for instance, but may lend themselves better to an ETS given a finite and known number of electricity-generating facilities. A further design element that will require clarification is the price of carbon itself. Other chapters in this report highlight the differences in the business case for emissions reductions and natural capital conservation across varying carbon prices. The VCM will provide an indicative approach to carbon price discovery, and the implementation of strict, long-term emissions-related targets would also necessitate the use of informed, and likely high, carbon prices. This aspect of CPI design has been discussed in Chapters 1 and 2. A third design element that requires scrutiny is the establishment of quantity 'caps' on the total level of emissions allowed across each sector covered by an emissions trading scheme. The Long-Term Low Emissions Development Strategy (LT-LEDS), currently being formulated by MNRECC, will likely provide clarity on intended actions across each sector, including establishing emissions reduction targets for each sector. Finally, decisions related to the intended incidence of taxation – whether upstream or downstream – will also be crucial to properly understand the varying impacts of CPIs on stakeholders, with upstream carbon taxes largely considered more straightforward to implement and administer. These various design elements indicate the many uncertainties in Malaysia's carbon pricing journey at present. Nevertheless, the previous chapters in this report assume a range of carbon prices informed by international evidence and standards, adding credibility to these assessments.

In the electricity sector, the NEP demonstrates a clear commitment to a long-term, low-carbon energy transition. It highlights many actions aimed at further liberalizing the electricity sector. For example, its initiatives include ensuring third-party access (TPA) for the gas market; facilitating the entry of green, virtual PPAs; and studying the potential to further enhance market reforms through liberalization. This points to a more competitive landscape across the energy value chain in the future. The NEP also reinforces the need to reduce the share of coal significantly by 2040, including a commitment not to build new coal-fired power plants. Given this more competitive landscape and recognition of the importance and urgency of decarbonization, carbon pricing is likely to play a more significant role in facilitating climate action. However, the current structure offers little incentive for a clean energy transition. Furthermore, it remains to be seen whether, and to what extent, additional additional costs from carbon pricing will be passed through to consumers through the ICPT mechanism.

If these costs are passed through fully to consumers, they will feel the direct burden of carbon pricing. On the other hand, if these costs are borne by the Single Buyer, it will impact a GLC rather than consumers. This highlights the importance of the design of CPIs, with a key priority being the need to ensure that they positively influence climate action while minimizing harm to the most vulnerable communities or even the economy as a whole.

In the forestry sector, a key requirement is developing a better understanding of the interactions between carbon sequestration in natural capital and carbon trading. Some major questions and policy choices relate to the scope of the compliance market and whether it will provide for a seamless transition from the VCM, which will focus on domestic carbon trading. Limiting the scope to the domestic arena will likely result in lower carbon prices, relative to international markets which typically entail higher carbon prices. The next question is whether sellers, namely state governments, can then opt to sell generated or traded credits in the voluntary markets instead. The national carbon pricing policy must clarify these uncertainties. The VCM guidelines do provide some clues, in that all trades must be approved by the focal point, the MNRECC. This will ensure that the MNRECC can accurately report Malaysia's emissions to the UNFCCC accounting for 'corresponding adjustments.' Additionally, this may put the MNRECC in charge of the approval of any credits concerning forestry.

However, recent events have demonstrated that state governments are also moving in parallel. Sarawak has enacted legislation to regulate forest carbon activities while Sabah has announced its intention to develop carbon exchange legislation by 2023 (The Borneo Post, 2022; Umpang, 2022). These developments demonstrate the need for greater clarity on the responsibilities of federal and state. governments within the forestry sector. Looking beyond carbon, further enhancements and progress to implement conservation financing instruments such as EFTs and PES are likely to continue.

4.3.2 International Trade and Transition Risks

The international trade landscape is also likely to have implications for the business cases for a broad set of environmental goods, including emissions reductions and natural capital conservation. This includes the climate-focused policies of trading partners that will effectively be extraterritorial in nature, the most directly related and significant of which is the EU's planned carbon border adjustment mechanism (CBAM). As a trade-reliant nation, the implementation of the CBAM – and the signals this sends to other countries or jurisdictions which have already implemented CPIs – will likely impact Malaysia. Under the CBAM, EU importers will need to buy carbon certificates corresponding to the carbon price of goods under the EU's carbon pricing rules (currently of roughly EUR 80/ tCO_2e) and the carbon intensity of their imports. This effectively places a carbon tax on products imported into the EU, requiring proof that a non-EU producer has paid a tax on the carbon emitted during production. While no other country or bloc has officially announced they are following in the footsteps of the EU, 'copycat' policies may be implemented by other countries with domestic CPIs moving forward. This is because such carbon border adjustments are an avenue toward protecting the competitiveness of domestic products and services against imports from jurisdictions without carbon pricing, and can enable further decarbonization in the implementing nation(s). While the CBAM will remain in a transitional phase until 2025, it will be fully operational by 2026 and the Malaysian government will need to take steps to address its impacts on covered sectors, which include cement; iron and steel; aluminum; fertilizers; and electricity.

Beyond carbon pricing mechanisms, the EU is also introducing stricter regulations on deforestation. In 2021, the EU introduced a legislative proposal for a regulation on deforestation-free products, which aims to prevent timber, coffee, cocoa, palm oil, beef, soy, and derivative products from entering the EU market if their production has caused deforestation. This will indirectly place downward pressures on revenues for state governments as stricter deforestation regulations are likely to be introduced and enforced in the future.

4.4 Conclusion

This chapter provides an overview of the stakeholder and policy ecosystem related to environmental goods in Malaysia, focusing on carbon pricing and climate action across the energy and forestry sectors. It also discusses some current and future trends across these policy spaces. The dynamic nature of the climate policy transition makes it difficult to predict with certainty how likely policy interventions will play out; indeed, details remain scarce as to how CPIs will be designed and implemented in Malaysia. Nevertheless, the trend is clear of a transition toward stronger climate action, in part through a correction of market failures that increases the costs associated with business-as-usual, carbon-intensive practices. Some of the key findings of this chapter are summarized below:

1. **Electricity market liberalization**
   a. Increased liberalization of the electricity market will result in greater competition across the value chain, including at the generation (IPPs), procurement, and potentially at the retail, stages.
2. **Burden should be identified**
   a. There is a need to model which stage(s) of the value chain will be burdened by any CPI implemented. If an upstream carbon tax is levied, mechanisms must be put in place to ensure that costs are not merely passed to consumers. If this is the case, mechanisms to redistribute tax revenues to the most vulnerable communities must be introduced.

3. **Balancing interests of climate action,state-owned enterprises, and vulnerable communities**

   a. The most influential stakeholders identified in this assessment are the GLCs. This is a double-edged sword. On one hand, it provides a route for policy implementation through government intervention. On the other hand, since GLCs are likely to be the largest hit by carbon pricing, safeguards may have to be put in place to ensure the protection of 'national interests' and economic security. Furthermore, any burdens passed on to the most vulnerable communities should be mitigated. Informed instrument design can play a role in addressing the need for such balance.

4. **Resolving federal-state jurisdiction**

   a. For the forestry sector, there is a need for further clarity on policies allowing states to sell their carbon outside of federal-level instruments or mechanisms.

5. **Take into consideration transition risks and future outlook**

   a. Price discovery and carbon prices should not take a short-term view. Future risks, including those related to climate (worsening of climate change), trade (introduction of the EU's CBAM and other similar policies), investment (increasingly trending toward low-carbon technology and away from fossil fuels), and regulation (including those aimed at disincentivizing deforestation) will likely further increase carbon prices moving forward.

5. POLICY RECOMMENDATIONS

Darshan Joshi

Malaysia is likely to take a hybrid approach to the implementation of CPIs, evidenced by the focus of the MNRECC on the DETS and MOF on carbon taxation (Aziz, 2021). This 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 axxnalysis has shed light on other important factors in the context of electricity-sector emissions reductions and natural capital conservation. Together, this gives rise to the policy recommendations discussed below.

5.1 Carbon Pricing Policy Recommendations

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). (Aldy et al., 2021; Roughgarden & Schneider, 1999; Braunschweig & Nordås, 2021)

This enables the full internalization of the externality costs of GHGs. In practice, however, economic and political constraints tend to hinder a first-best approach to internalizing the negative externality costs of GHG emissions. This is an especially pertinent issue for carbon-intensive economies, where the imposition of stringent carbon costs, or emissions caps, in the absence of economically feasible, low-carbon technologies can have negative repercussions on industrial growth that may outweigh the monetary value of any environmental benefits (Carlin et al., 2022). Assessments of carbon pricing points – or emissions reduction pathways, which inform the allocation of emission allowances – that can assist the achievement of emissions reductions targets (including net-zero by 2050) can act as a starting point to determine prices best suited to support Malaysia's climate ambitions (Kaufman et al., 2020). Other industry-specific policy instruments, such as clean energy incentivization programs or subsidies, can be used complementarily to carbon pricing to reinforce momentum toward decarbonization and even indirectly or artificially raise the price of carbon (Jenkins & Karplus, 2017).

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 and the atmosphere (Nordhaus, 2019; Weitzman, 2015; Weitzman, 2017). Only a global solution can fully account for the global nature of climate change. However, this remains a distant prospect. To at least set a price of carbon that is commensurate with scientific estimates of the impact of Malaysia would 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 the likely economy-wide damages Malaysia faces as a result of climate change (Rasiah et al., 2016; Ricke et al., 2018; Sarkar et al., 2019). Filling the existing knowledge gaps would allow for the estimation of a robust set of science-based estimates for the MY-SCC that can be used to inform prices under compliance market instruments such as the CT and even the DETS, for instance, by allowing prices to fluctuate only within a predetermined range above and below the MY-SCC (see Chapter 5.1, E).

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 reduction outcomes of the DETS depend heavily on the ambition of Malaysia's emissions reduction targets. In contrast to the approach of carbon taxes, which entails setting a price on carbon, ETS sets quantity 'caps' on emissions. This means the price of carbon can fluctuate, and in doing so price signals incentivizing decarbonization are themselves variable and 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).

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 signaling to industries and sectors to engage in decarbonization (Chen & Hafsted, 2016; Macaluso et al., 2018). This is particularly pertinent given the complexity and cross-sectoral nature of contemporary supply chains. Nevertheless, the implementation of CPIs within industries where technology-switching is costly or infeasible risks generating costs that can be detrimental to industrial growth and the achievement of broader economic objectives with little environmental benefit in return (Cuervo & Gandhi, 1998; Smulders & Vollebergh, 2001; Stavins, 2022). Instead, to begin with, CPI scope should be limited to activities where there is potential for cost-effective low-carbon transitions and, following the gradualist approach prescribed for carbon prices, expand over time to cover a broader set of economic activities (ADB, 2021; OECD, 2016).

E. Implement safeguards to ensure similarity, if not uniformity, in carbon prices across CPIs to create consistent price signals for decarbonization across industries.

Such safeguards can come in the form of price floors on ETS prices based on the prevailing carbon tax rate, or allowances for ETS prices to vary within a set percentage band of the tax rate, with these variations dependent on supply and demand for emissions allowances (Parry et al., 2021; WEF, 2021).

F. Develop an understanding of the incidence of regulation on the varying impacts of CPIs on sector-level stakeholders and decarbonization pressures.

Upstream taxes are typically more straightforward to administer, applying at the point of extraction or import of fossil fuels (Foramitti et al., 2021; Mansur, 2012; Metcalf & Weisbach, 2009). In Malaysia, this implicates stakeholders such as TNB Fuel and PEGT. Downstream taxes, applied at the point of fossil fuel combustion, would implicate TNB Generation and IPPs (Kumar et al, 2021). Given the centralized nature of fossil fuel-fired electricity generation in Malaysia, featuring a set number of power producers, downstream taxation need not necessarily engender significant administrative complexities and can entice power producers to abate emissions through technology-switching or GHG capture technologies (Mansur, 2012; Parry et al., 2022).

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

Regardless of the intended or initial incidence, the additional costs imposed by CPIs may be passed down the value chain, possibly affecting end-user prices with adverse effects on households (Fabra & Reguant, 2014; Neuhoff & Ritz, 2019). Safeguards can be put in place to limit the extent of such cost pass-through, in addition to reinvesting a portion of carbon revenues toward reconciling any cost-of-living increases faced by low-income and vulnerable communities and households (CBO, 2012; Marron & Morris, 2016).

H. Develop a well-communicated and ambitious long-term timeline for carbon prices, emissions caps, and sectoral CPI coverages to ensure delivery of the requisite emissions reductions.

This analysis has shown that an aggressive expansion of Malaysia's RE capacity, coupled with the gradual removal of coal from electricity generation, is needed to reduce annual sectoral emissions by over a third by 2050, relative to 2021 levels. In contrast, a less aggressive RE expansion coupled with the continued use of coal would see annual sectoral emissions reduce by just 11 percent between 2021 and 2050. Carbon pricing can assist in this process of technology-switching, especially in the presence of other policy support for low-carbon technology (Abrell & Kosch, 2022; Andersson, 2019; Borghesi et al., 2015; Lin & Li, 2011; Rivers & Schaufele, 2015). Higher carbon prices will also generate stronger incentives to conserve carbon sinks and can create a stronger business case for conservation ahead of the exploitation of natural resources (Austin et al., 2020; Kindermann et al., 2006; Kindermann et al., 2008; Ministry for Primary Industries, 2019).

5.2 Sectoral Policy Recommendations

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

Carbon pricing is considered a fundamental and necessary component of the policy response to climate change but is not the sole solution (ADB, 2021; Baranzini et al., 2017; Dorband et al., 2022; Rosenbloom et al., 2020). A greater understanding of the interactions between CPIs and other economic and financial instruments catered toward enabling the low-carbon transition, such as subsidies and the provision of financing for low-carbon electricity, can ensure that CPIs work efficiently in tandem with them. As CPIs are implemented and practical evidence of their effects is assessed, other policy instruments, such as the FiT, NEM, and GTFS can be revised to ensure their renewed effectiveness and efficiency.

J. 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 or renewable energy sources (IPCC, 2014). Our analysis shows that replacing coal largely with natural gas contributes to a decrease in the emissions intensity of electricity generation of only 25 percent 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 necessary. 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 in ensuring the security aspect of the energy trilemma until then, but phasing it out in the longer run must be considered.

K. Establish benchmark studies of investible carbon in Malaysia.

One of the key factors behind the long-term underinvestment in conservation and the 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 use of resources. Collecting data on the value of stored carbon across major forested areas across states in Malaysia can be a precursor toward enabling carbon projects across a wide geographical spectrum and encourage conservation and the sustainable management of natural capital across the country (Runting et al., 2020). Importantly, it can play a role in diverting conservation to areas where it is most profitable, and exploitation where it remains economically viable.

L. 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 not necessarily measured in terms of GHG impacts (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, the conservation of biodiversity, flood mitigation, erosion prevention efforts, and other beneficial environmental actions. A suite of region-specific, impact-based approaches and policy instruments can address the various externalities causing the undersupply of environmental 'goods' and oversupply of environmental 'bads' and can be more effective than a universal carbon pricing system.

M. Explore the development of carbon projects that can provide an alternative source of revenue to logging.

This is particularly appealing as an avenue to enhance conservation and generate revenue in states with large tracts of investible carbon, especially Sabah and Sarawak (Koh et al., 2021), and its benefits increase with a greater understanding of the location and extent of investible carbon inherent to natural capital across Malaysia.

N. 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 understanding of the key tradeoffs in energy policy, including ensuring affordability, security, and sustainability. More importantly, ensuring open data will allow researchers to continuously monitor and assess the efficacy of policy instruments to meet 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.

6. APPENDIX

Table 15: Scenarios and Assumptions for Electricity Generation in Malaysia

	Assumption	Generation Scenario 1 (G-1) *(High RE, no coal from 2045)*	Generation Scenario 2 (G-2) *(Moderate RE, minimal coal from 2045)*
1	Fixed data points	• 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.	
2	Total generation growth from 2025 to 2035	• Total electricity generation growth (in GWh) was interpolated linearly at 1.6% per year with anchor points of 2025 and 2035.	
3	Total generation growth post-2035	• Total electricity generation growth (in GWh) was assumed to be similar to Assumption #2, with 2035 as the anchor point.	
4	Trend of all electricity sources between 2025 and 2035	• 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%.	
5	Contribution of coal to the electricity mix	• 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.[24]	• 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.
6	Trend of coal post-2035	• Coal GWh was interpolated linearly at -10% per year between anchor points of 2035 and 2045.	• Coal GWh was calculated based on Assumption #5. • Coal capacity factor was 82% based on the MyRER average.
7	Contribution of hydro to the electricity mix [25]	• 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.	• Hydro reaches full installed capacity potential in P. Malaysia and Sabah, and existing capacity doubles in Sarawak by 2050, totaling 10,619 MW. • Hydro capacity factor was 54% based on MyRER average. • Excess Sarawak hydro exported to Sabah and P. Malaysia.
8	Trend of hydro post-2035	• Hydro GWh was interpolated linearly at 4.3% per year between anchor points of 2035 and 2050.	• Hydro GWh was interpolated linearly at 1.9% per year between anchor points of 2035 and 2050.
9	Trend of other[26] sources post-2035	• Contribution of other energy sources was assumed to comprise 0.1% of total generation based on the MyRER average for 2025 and 2035	
10	Trend of renewable[27] 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.	

[24] 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).

[25] 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).

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

[27] It is assumed that the fuels under 'Renewables' or 'RE' include biogas, biomass, and solar in NEB. Although biomass and biogas are combustible with appreciable emissions intensities (Table 6), 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.

Table 16: Electricity Generation and GHG Emissions, Scenario G-1

Scenario G-1	2021	2025	2030	2035	2040	2045	2050
ANNUAL ELECTRICITY GENERATION (GWh)							
Coal	92,603	95,488	76,146	56,804	28,402	0	0
Gas	40,101	40,131	67,705	95,279	127,205	157,668	157,954
Hydro	26,852	29,916	34,463	39,010	47,481	55,952	64,423
Renewables	6,068	14,724	16,474	18,223	23,258	29,683	37,884
Others	211	122	202	282	227	244	261
TOTAL	**165,835**	**180,381**	**194,990**	**209,598**	**226,573**	**243,547**	**260,522**
ANNUAL GHG EMISSIONS (ktCO_2e)							
Coal	97,363	100,396	80,060	59,724	29,862	0	0
Gas	19,337	19,351	32,647	45,943	61,338	76,027	76,165
Hydro	0	0	0	0	0	0	0
Renewables	0	0	0	0	0	0	0
Others	281	163	269	376	302	325	347
TOTAL	**116,981**	**119,910**	**112,976**	**106,043**	**91,502**	**76,352**	**76,512**
CUMULATIVE GHG EMISSIONS (ktCO_2e)							
Cumulative Emissions	116,981	592,228	1,170,978	1,715,061	2,201,766	2,614,127	2,966,752
EMISSIONS INTENSITY (tCO_2e/GWh)							
Emissions Intensity	705	676	584	506	405	316	298

Table 17: Electricity Generation and GHG Emissions, Scenario G-2

Scenario G-2	2021	2025	2030	2035	2040	2045	2050
ANNUAL ELECTRICITY GENERATION (GWh)							
Coal	92,603	95,488	76,146	56,804	55,268	26,535	26,535
Gas	40,101	40,131	67,705	95,279	107,710	146,951	157,102
Hydro	26,852	29,916	34,463	39,010	42,751	46,491	50,232
Renewables	6,068	14,724	16,474	18,223	20,618	23,327	26,392
Others	211	122	202	282	227	244	261
TOTAL	**165,835**	**180,381**	**194,990**	**209,598**	**226,573**	**243,547**	**260,522**
ANNUAL GHG EMISSIONS (ktCO_2e)							
Coal	97,363	100,396	80,060	59,724	58,108	27,899	27,899
Gas	19,337	19,351	32,647	45,943	51,937	70,859	75,754
Hydro	0	0	0	0	0	0	0
Renewables	0	0	0	0	0	0	0
Others	281	163	269	376	302	325	347
TOTAL	**116,981**	**119,910**	**112,976**	**106,043**	**110,348**	**99,082**	**104,000**
CUMULATIVE GHG EMISSIONS (ktCO_2e)							
Cumulative Emissions	116,981	592,228	1,170,978	1,715,061	2,270,032	2,783,951	3,294,190
EMISSIONS INTENSITY (tCO_2e/GWh)							
Emissions Intensity	705	665	579	506	487	407	399

7. 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

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.

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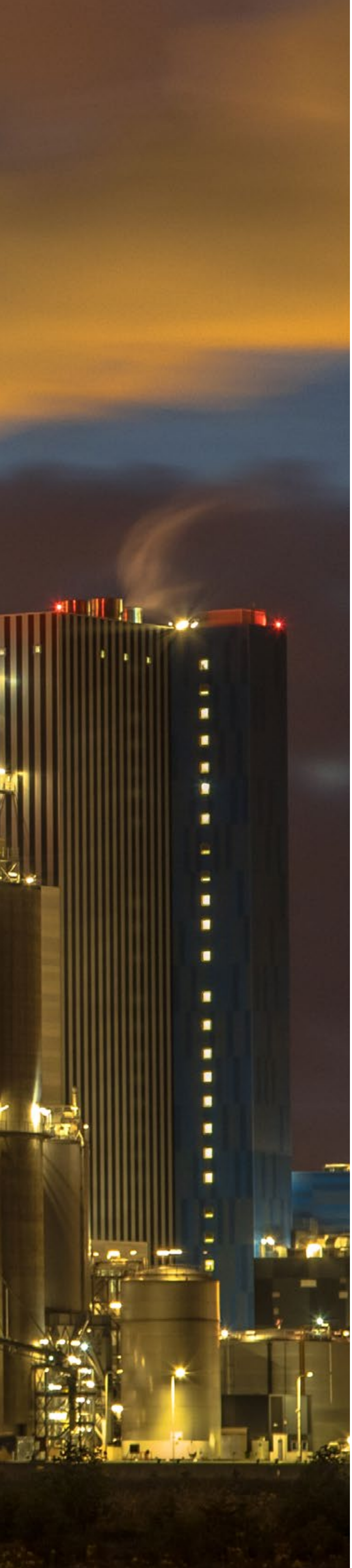

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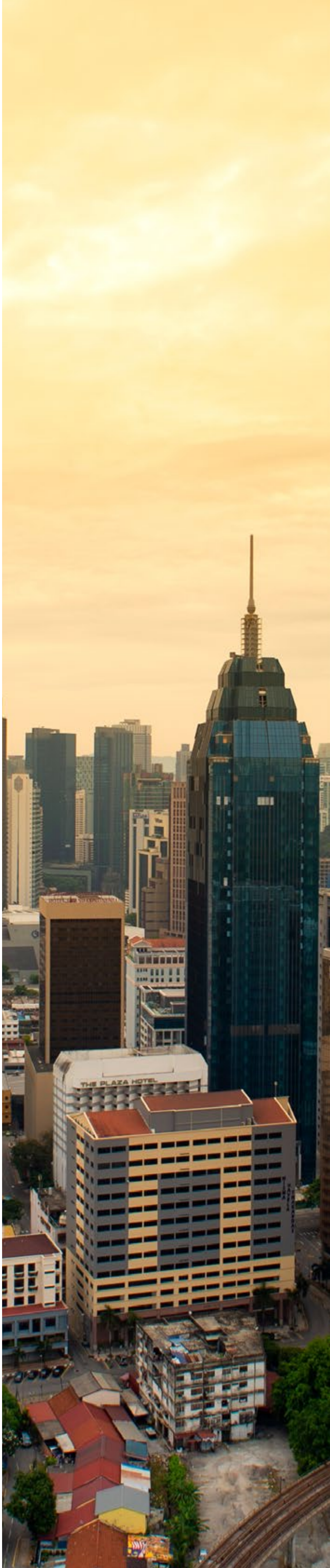

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