PENANG INSTITUTE MONOGRAPHS

#02

19 DEC 2019

Using Carbon Pricing to Support Sustainable Development in Malaysia

By ***Darshan Joshi***

PENANG INSTITUTE
making ideas work

10, Brown Road, 10350 George Town
Penang, Malaysia
T +604 228 3306 **F** +604 226 7042
E enquiry@penanginstitute.org

Using Carbon Pricing to Support Sustainable Development in Malaysia

Darshan Joshi*, Research Analyst at Penang Institute

*darshanjoshi@penanginstitute.org

Executive Summary

The pricing of carbon is widely considered to be a fundamental component of effective climate action, and represents an efficient economic solution to the two market failures which continue to exacerbate the problem of climate change. Such price-based regulation serves to mitigate emissions by incentivising the adoption of low-carbon means of production, encouraging economic actors to invest in and employ emissions abatement technologies, and curbing aggregate demand for emissions-intensive goods and services. Given the growing need for Malaysia to significantly decarbonise its economy, enforcing a price on carbon by taxing emissions arising from the electricity, transport, and oil and gas sectors would place downward pressure on over 70% of national emissions, and spur the growth of competing domestic clean energy and low-carbon industries. Commencing at a rate of RM35/tCO_2e in 2020 and peaking at RM150/tCO_2e in 2028, this tax would raise RM21.8-24.6bil in average annual revenues until 2030, adding approximately 18% to federal direct tax collections over this period. Carbon taxation can play an important role in determining whether Malaysia is able to exceed even its most ambitious climate scenario, which will still see emissions increase by 46% within these three sectors between 2020 and 2030. With the pricing of carbon, for instance, it is projected that parity in the levelised costs of generating electricity through coal and large-scale solar can be achieved by 2020/21, and the gap between the levelised costs of ultra-supercritical coal plants against those of combined-cycle natural gas will be reduced from approximately 50.8% at present to just 14.2% by 2028, assuming no changes to fuel input prices. Across sectors and economic activities, carbon pricing will strengthen the economic competitiveness of low-carbon technologies.

While consumers will be affected by rising prices as a result of carbon taxation, this paper shows that the absolute magnitude of these negative effects are relatively muted. It is estimated that fully compensating the nation's bottom 40% (B40) for the increases in their electricity and transport costs through carbon "rebates" would only consume 29.2-44.5% of total revenue collections over the first four years of the policy – a percentage which shrinks as the price of carbon is gradually raised over time. It is recommended that a significant proportion of residual revenues be utilised to propel further climate change mitigation and adaptation efforts, for which MESTECC cites a present funding gap of over RM20bil, and in the long-run it can play a role mitigating inequality by financing and forming a crucial component of progressive tax system reform, while residual proceeds can be used to stabilise the nation's fiscal outlook. Carbon pricing has the potential to put Malaysia on the path towards long-term sustainability with few consequential costs in the near future and monumental benefits in the long-run.

Table of Contents

1 Introduction

Revelations in 2018 that Malaysia's national debt[1] has exceeded RM1tril sent shockwaves through the domestic economy and almost all levels of government. Efforts have since been made to engage in both cost-cutting and revenue-raising measures, with the 2019 Budget introducing soda and digital taxes, and a departure levy, as well as increases in both real property gains taxes and stamp duties. Members of Parliament agreed, shortly after the 14th General Election, to salary cuts, while extravagant budgetary expenditure items have been pared back, deferred, or cancelled entirely. A fund set up by the incumbent Pakatan Harapan (PH) government, through which citizens contributed to public finances, raised over RM200mil before its closure at the end of 2018. At the same time, the abolition of the Goods and Services tax (GST) will cost the government over RM40bil in foregone revenue annually,[2] with the reinstatement of the Sales and Services Tax (SST) making up less than half of this shortfall. More impactful measures are still required.

Beyond this immediate landscape lies an existential threat to the planet in the form of climate change, and the economic damages that come with it. The need is urgent for nations to decarbonise. The Intergovernmental Panel on Climate Change (IPCC, 2018) announced that unprecedented reductions in emissions are necessary within the next decade in order to prevent an average global surface temperature increase of more than 1.5°C over preindustrial times. Such an increase would exacerbate sea-level rise, render more common extreme weather events – such as storms, floods, droughts, hurricanes and tsunamis – and adversely affect health and mortality, ecosystems and biodiversity, as well as agricultural yield. Consequential policy action on the part of national governments to combat this threat, including in Malaysia, is imperative.

One particular policy mechanism that has the potential to play an important role in addressing both these issues, and more, is the enforcement of a tax on greenhouse gas (GHG) emissions.[3] Such a policy would directly and significantly boost public finances, enhance the competitiveness of low-carbon technology, spur the growth of the local green industry, and contribute to Malaysia meeting its international climate goals.[4] Finally, the redistribution of carbon revenues can directly offset any immediate regressive effects of the tax and indirectly assist in the achievement of other economic policy goals, particularly as they pertain to climate change.

Against this backdrop, this paper lays out a proposal for a carbon taxation policy in Malaysia which covers over 70% of annual national emissions which arise from electricity generation, transport, and oil and gas production, and places an emphasis on the redistribution of carbon revenues which would allow the government to fulfil four key objectives:[5]

i. **Address the regressive direct effects of carbon pricing on citizens**, particularly the B40 group, as the costs of electricity and transport fuels rise as a result of the imposition of such a tax;

ii. **Further decarbonisation efforts**, including increased investment in the research, development and deployment of renewable energy (RE) and energy efficiency (EE) measures; climate change adaptation efforts; improvements in emissions monitoring systems; the modernisation of Malaysia's energy infrastructure in building toward a future of decentralised and distributed electricity generation; and expenditure on improvements to public transport networks and services;

---

[1] Inclusive of contingent liabilities and off-budget government guarantees, which at present amount to around RM400bil of the over RM1tril in total federal financial obligations.

[2] This figure is calculated based on data provided by Malaysia. Ministry of Finance (2017).

[3] Throughout this paper, the terms "carbon price", "carbon tax", "emissions tax", and "carbon fee", or any variant of these terms, are used interchangeably. A carbon tax is considered throughout as the mechanism of choice through which to *enforce* a price on GHG emissions, inclusive of carbon dioxide, methane, and nitrous oxide.

[4] This refers to the government's Intended Nationally Determined Contribution (INDC) to climate change mitigation by reducing the emissions intensity of GDP by 45% by 2030, relative to base year 2005.

[5] While all these measures would have desirable outcomes, elaborating upon the latter two is beyond the immediate scope of this paper. A forthcoming, separate paper will cover the role of this carbon tax policy in progressive tax reform for Malaysia, which also includes broad revisions to income tax codes, reductions to corporate taxes, particularly for small- and medium-sized enterprises (SMEs), and the longer-run abolishment of the SST, amongst other measures. The decision on how best to manage and reduce the size of the country's financial obligations, meanwhile, is a task best left to the Ministry of Finance itself.

iii. **Progressive tax reform**, which effectively addresses the growing income and wealth disparities across socio-economic groups in Malaysia; and,

iv. **Alleviate the existing fiscal burden** faced by the federal government.

2 Reviewing Existing Carbon Pricing Efforts

The issue of climate change is caused largely by the staggering increase in the atmospheric concentration of GHGs since the Industrial Revolution (United States. National Oceanic & Atmospheric Administration, 2018), and is the result of two prominent market failures.[6] In many countries across the world, including Malaysia, markets do not incorporate the cost of emissions that are the externalities of otherwise productive economic activity. When such "negative externalities" are not priced, they are theorised to be oversupplied – as is and has been the case with GHG emissions. Scientific evidence has made clear over recent decades that these emissions will cause significant current and future economic damage through the role they play in intensifying climate change (IPCC, 2018). The price of carbon should therefore be strictly greater than zero, and it is the pricing of carbon which creates a market for emissions where none existed before. Such a price can be subsequently utilised as a means through which to enforce policy measures which directly target the externality, be it through the imposition of a carbon tax, the creation of a cap-and-trade market for emissions, or use in the cost-benefit analyses of regulatory rulemaking.

A growing body of academic literature is devoted toward the determination of an accurate "Social Cost of Carbon" (SCC), a measurement of the economic value of the damage caused by each incremental tonne of CO_2e emitted into the atmosphere. During the Obama administration, the US government developed what is widely considered to be one of the most comprehensive estimates of the global SCC,[7] currently of around US\$42/tCO_2e, or RM170/tCO_2e (United States. Interagency Working Group on the Social Cost of Carbon, 2016). A full list of these estimates is provided in Table 1.

[6] The first of these refers to emissions as a "negative externality", and the second the atmosphere as a "public good", the latter of which is described in detail in Section 3b.

[7] Section 3b highlights the importance of a uniform, global SCC in fully addressing the public goods problem inherent to the atmosphere.

Table 1: SCC Estimates at Varying Discount Rates (US$)

Year	Central Estimates			High Impact Estimate
	r = 5%	***r = 3%***	*r = 2.5%*	*r = 3%*
2010	10	**31**	50	86
2015	11	**36**	56	105
2020	12	**42**	62	123
2025	14	**46**	68	138
2030	16	**50**	73	152
2035	18	**55**	78	168
2040	21	**60**	84	183
2045	23	**64**	89	197
2050	26	**69**	95	212

Source: *US IAWG-SCC (2016)*

Note: *MYR/US$ exchange rate – RM4.05/$1*

The immediate adoption of such a steep price on carbon in the Malaysian context would likely prove politically contentious and even economically damaging. Given the general nascency of carbon pricing strategies within the international context, early-adopters tend to implement carbon pricing schemes which feature gradually rising values of the SCC. These include, but are not limited to, the existing and planned carbon taxation frameworks in the Canadian states of Alberta (rising from C$20 in 2017 to C$30/$t$$CO_2$e in 2018) and British Columbia (rising by C$5 annually until peaking at C$50/$t$$CO_2$e in 2021); France (rising by €10.40 annually until peaking at €86.20 in 2022); the Netherlands (the floor price on carbon will rise from €18 in 2020 to €43/$t$$CO_2$ in 2030); and Singapore (rising from S$5/$t$$CO_2$e between 2019 and 2023, to S$10–15/$t$$CO_2$e by 2030). It is proposed that Malaysia embraces a similarly gradualist approach in pricing carbon.

As of 2018, a total of 45 national and 25 subnational carbon pricing schemes had been either implemented, or scheduled for implementation, across the world, covering around a fifth of total global emissions (World Bank, 2018). The SCCs utilised across these schemes vary tremendously, ranging from as low as under US$1/$t$$CO_2$e in Mexico, Poland, and Ukraine, to as high as US$139/$t$$CO_2$e in Sweden. Crucially, however, most of the prices used across these 70 schemes are considerably lower than the rates of between US$40–80/$t$$CO_2$e by 2020 cited by the World Bank's High-Level Commission on Carbon Prices (World Bank, 2017) as necessary for emissions reductions outcomes to be consistent with the temperature goals set within the Paris Agreement. At present, only Finland, France, Liechtenstein, Sweden, and Switzerland meet these recommended rates. An outsized risk associated with the selection of an excessively-low SCC is that it is unlikely to stimulate lasting decarbonisation. It is thus imperative that in the long-run, there is uniformity in the carbon price used in policy schemes across jurisdictions, and this price has to be set at a rate reflective of a comprehensive and scientifically-accurate SCC.

There also exist variations in the scope of carbon pricing mechanisms enforced across jurisdictions, in both the economic sectors and GHGs that are subject to pricing. British Columbia's carbon tax covers GHG emissions arising from the use of all fossil fuels, amounting to roughly 70% of the state's total emissions), while that in Singapore targets polluters in the power and industry sectors emitting more than 25$kt$$CO_2$e annually, accounting for four-fifths of national emissions.[8] In general, given the outsize influence of electricity and transport on global emissions, an effective and efficient carbon pricing scheme would do well to encompass the emissions arising from these two key sectors; to that end, the majority of the 70 national and subnational policies do impose varying degrees of levies on such polluters.

3 The Economics of Carbon Pricing

The enforcement of a price on carbon emissions represents an efficient manner through which to correct two significant market failures: carbon emissions as a negative externality, and the atmosphere as a global "public good". These market failures are the drivers of climate change, primarily through the multifaceted impacts of the growing atmospheric concentration of carbon. Pricing carbon addresses these issues by ensuring only appropriate, and not excessive, levels of emissions would be released into the atmosphere in any given year.

At present, however, excessive emissions are both causing, and are expected to continue to cause in the future, significant economic damage across the planet. Malaysia will not be spared these troubling impacts; Rasiah et al (2016) find that without improvements to existing mitigation efforts, annual climate change-related damages in Malaysia are projected to rise from RM11.9bil in 2020 to RM456.3bil in 2050, and up to between RM4.7 and RM6.7tril annually within the first decade of the twenty-second century. In this century to 2110, cumulative damages are predicted to reach RM40tril. In contrast, strong mitigation action which sees Malaysia meet its emissions reductions pledge to the United Nations Framework Convention on Climate Change (UNFCCC) of reducing the emissions intensity of GDP by 45% by 2030 would truncate total damages by 87.5%, to a total of RM5.3tril by 2110.

Compounding the problem of emissions as a negative externality is the fact that the Earth's atmosphere is a shared global resource: it is the quintessential public good. Public goods, which by nature exhibit the qualities of nonrivalry and nonexcludability, are in the absence of regulatory action or policy theorised to be overexploited. The conservation of public goods is in no one individual's rational private interest should they derive a benefit from using it, since there are no costs associated with transferring carbon content to the atmosphere. Both the increase in emissions and the subsequent increase in the concentration of carbon in the atmosphere are entirely unsurprising when analysed through the lens of market failures; without the appropriate measures in place to correct them, individual actors do not face the true costs of their contribution to the mix of pollutants in the atmosphere.

The most efficient policy prescription through which to eliminate these market failures is the pricing of carbon. Should GHG emissions be priced in a manner which reflects their full societal cost through their impact on climate change, emitters and consumers alike would be forced to re-optimise profit- and utility-maximising behaviour by embedding the full cost of carbon into decision-making.[9] Such internalisation would serve to depress overall emissions by strengthening the relative fiscal attractiveness of the adoption of emissions mitigating options and processes.

The pricing of carbon is a manner through which to remove a large, inherent subsidy that presently exists for carbon-intensive technology. The failure to do so has two major implications: it implies that the damages caused through the burning of fossil fuels is costless, and entirely disregards the environmental benefits of utilising RE technologies over more polluting alternatives. This is a poor approach in the face of scientific evidence which projects with alarming consequence the climate impacts that would arise from business-as-usual economic practices. Pricing carbon represents a critical step towards the optimisation between carbon-driven economic productivity and carbon-driven environmental degradation – a process which will necessitate shifts in anthropogenic behaviour.

[8] For a detailed but concise overview of both the scope and reach of the various emissions tax and trading schemes in operation across the world, refer to Figure 10 of World Bank (2018).
[9] Or, in other words, by embedding the social costs of their actions into private decision-making.

3.1 Using the Social Cost of Carbon to Address Negative Externalities

Given the generally high level of uncertainty around aspects of climate change and its effects on various economic variables, calculating the SCC involves several extremely complex steps. The first of these requires modelling trajectories of numerous socio-economic factors, including – but not limited to – population, GDP and energy use, in order to estimate emissions over a selected time horizon. These emissions, and consequent changes in the atmospheric concentration of GHGs, are used to infer changes in temperatures across regions. Temperature changes are then translated into estimates of economic damage over time. Finally, such future damage is discounted to reflect their present value in any given year.[10]

Within the context of Malaysia, further research is still required in order to measure with any accuracy the extent to which decisions and actions taken until today will cause damages for current and future life in the country. A better understanding of the localised effects of temperature increases on different components of the economy is required, and these must be translated into measurements of economic damages over time. To achieve this, much of economic and human life in Malaysia must be studied, and their values monetised. Further research into the relationship between climate change and economic damages through the effects of changing weather patterns and extreme weather events; crop yields and agricultural production; mortality and health outcomes; economic productivity; sea-level rise in coastal areas and issues related to flooding and saltwater intrusion; and vector-borne diseases – among many others – is necessary. This would put policymakers in a strong position to enact pre-emptive measures which serve to mitigate future damages effectively, and assist adaptation efforts within areas of life predicted to be hardest hit by climate change.

While these research gaps will take time to be filled, there are no justifiable reasons to put off the implementation of a policy which prices emissions. Scientists and economists have repeatedly called for such a measure, from before the conception of the IPCC in 1990.[11] In 1997 over 2,500 economists, including eight Nobel laureates, in an unprecedented move co-signed the "Economists' Statement on Climate Change", suggesting that "the most efficient approach to slowing climate change is through market-based policies […] nations can most efficiently implement their climate policies through market mechanisms, such as carbon taxes […] revenues generated from such policies can effectively be used to reduce the deficit or to lower existing taxes".[12] The economic theory is unequivocal, and unchanging: IPCC (2018) makes numerous references to the need to enforce a price on carbon emissions, and early in 2019 over 3,500 economists, including 27 Nobel laureates, supported the "Economists' Statement on Carbon Dividends", which calls directly for a robust and gradually rising carbon tax, complete with border adjustments to prevent cross-national carbon leakage, as well as lump-sum rebates to the public to maximise the fairness and political feasibility of such a proposal.[13]

In the US, the SCC, currently of around US$42/tCO2e, was developed primarily for use in domestic environmental legislation. It was utilised to perform cost-benefit analyses for a wide range of environmental- and energy-related regulatory measures implemented during Barack Obama's two terms as President.[14] This includes, among others, updates to national light-duty vehicle emissions standards and corporate average fuel economy standards, as well as Obama's climate policy centrepiece, the Clean Power Plan. The use of the SCC in such command-and-control regulatory action allows for the monetisation and inclusion of environmental considerations into policymakers' cost-benefit analyses, but is still considered inefficient and inflexible from an economic perspective relative to the imposition of blanket policies such as a carbon tax or emissions trading scheme. This is largely due to the very varied nature of emissions abatement opportunities across sectors and industries; imposing specific targeted regulation and abatement options across industries is an exercise both infeasible and impracticably costly.

[10] The discount rate is perhaps the most contentiously debated aspect of the SCC as it is typically determined by a combination of quantifiable (economic) and moral (not easily quantifiable) variables. See Council of Economic Advisers (2017) for a general discussion on the need to employ discount rates in regulatory analysis, while for discounting within the context of calculating the SCC specifically, see Arrow et al (1996); Nordhaus (2007); Stern (2008); and Weitzman (2013).
[11] See Hudson (2015, Aug 13).
[12] Refer to DeCanio (1997).
[13] See Climate Leadership Council (2019).
[14] The rate for the SCC used in US federal policymaking has since been "zeroised" by President Donald Trump; while it still technically exists, it simply takes no weight under the current administration.

Yet, in the case of the US and other nations across the world, it is political constraints that have forced climate policy to take this command-and-control route, rather than follow a first- or even second-best response to the climate crisis. As a result, an insufficient and insignificant proportion of carbon externality is being addressed. Part of the problem stems directly from the designation of the solution as a carbon "tax". Taxes are associated with a deeply negative stigma, but economic fundamentals clearly demonstrate that the pricing and taxing of carbon emissions amounts to more of a carbon correction. It involves creating a market for carbon emissions, where none existed before, and in doing so *corrects* existing market failures. Owing to a lack of political palatability, alternative nomenclatures to the term "tax" have been increasingly adopted, including carbon "prices", "fees", and "dividends".

Exogenous factors can hinder the development and deployment of efficient and effective policymaking, and this is particularly important to keep note of as this paper digs deeper into the prospect of enforcing a price on GHG emissions in Malaysia. It is a key reason why a gradualist approach to the implementation of carbon pricing is preferred, in terms of both the rate and scope of the policy. The immediate imposition of a \$42/$t$$CO_2$e (RM175/$t$$CO_2$e) price on all carbon emissions, while consistent with scientific evidence, would still be politically contentious. That the majority of carbon pricing schemes worldwide fall short of this mark at present is testament to this concern. These are still the early stages of the global adoption of carbon pricing mechanisms, and limiting their introductory rates ensures that any significant short-term adjustment costs to local economies can be efficiently managed.

A politically attainable early-stage carbon price for Malaysia can be drawn from Ricke et al (2018), who estimate country-level social costs of carbon (CSCCs), suggesting that a "world-level approach obscures the heterogeneous geography of climate damage and vast differences in country-level contributions" to the issue of climate change. This approach creates a wide range of SCC estimates for countries across the world, reflective of variations in projected climate damages, as well as that of social and economic factors, across different countries and regions. For instance, the CSCCs estimated for India and the US – both of which are highly populated, near the top in aggregate national GDP rankings and, most crucially, are expected to incur significant damages as temperatures rise – are at US\$85.40 and US\$47.80/$t$$CO_2$e, respectively. In contrast, the CSCC for Malaysia is estimated by Ricke et al at US\$7.90/$t$$CO_2$e (~RM32/$t$$CO_2$e), and offers a pragmatic starting point for introductory carbon pricing rates in the country. It must be kept in mind that in the longer-run, however, differentiated carbon prices across jurisdictions risks the occurrence of issues related to cross-country emissions arbitrage, in addition to such arrangements constituting an inadequate addressing of the "global public good" nature of the atmosphere.

3.2 Using the Social Cost of Carbon to Address the Public Goods Dilemma

This very nature of the atmosphere as a shared global resource means the discussion of a policy measure that transcends national boundaries is important and inevitable. There is a need to account for the fact that regardless of the location of origin of a tonne of CO_2, both its destination (the atmosphere) and its impact on temperatures remains the same. If the imposition of a carbon price within a particular jurisdiction merely shifts emissions-intensive activity to another without such a policy framework, the unilateral policy has not achieved anything beneficial in the context of mitigating global climate change. The borderless nature of the atmosphere requires a borderless policy as a counterweight. The most efficient manner through which to achieve this is a harmonised *global* price on carbon equivalent to a *global* social cost of carbon. While a near impossibility at present, this must be seen as an end-goal of international climate negotiations. Although Malaysia will be only the 71st jurisdiction to employ such a measure, the nation will benefit tremendously from future-proofing its economy by encouraging and stimulating the growth of local companies involved in the green economy, as well as by gaining soft power and moral authority on the issue of climate change within the international context.

This heightens the importance of national explorations into carbon pricing mechanisms. Ultimately, national-level policies must develop into regional frameworks, and these in turn need to over time evolve into a global policy framework for the pricing of carbon – or, in other words, a necessarily global solution to a global market failure. It is imperative that in the near future carbon pricing mechanisms obtain a significant degree of proof-of-concept; it must be shown that carbon pricing creates tangible, net social benefits (for instance, through the progressive redistribution of carbon revenue), and delivers results in line with theoretical predictions. In terms of aiding the achievement of sustainability goals, it is almost unequivocal that the imposition of an enforced carbon pricing mechanism will lower emissions, as clean energy sources, such as solar, wind, small hydro and biomass, become more financially competitive with the new, socially conscious prices of coal and natural gas. Further, tax revenues may be used to funnel funds towards the research and development of RE technologies and policies themselves.[15] These actions will have the knock-on effect of driving further RE cost reductions over time, ultimately boosting the prospects of decarbonisation. As the scope of the carbon tax expands and rates increase over time, proceeds will be large enough to allow the government to realise its other policy ambitions, including a reform of the Malaysian tax system and addressing national debt.

4 An Outline for Carbon Pricing in Malaysia

Carbon pricing measures typically exhibit variation by rate, scope and incidence, in addition to the choice of enforcement mechanism.[16] Almost all existing and mooted schemes explicitly target power generation, given its outsized influence on emissions globally as well as the availability of renewable sources as alternatives to fossil fuels. Most cover industrial processes, manufacturing and transport, to some degree. Still others do not discriminate by economic sector, and enforce a blanket carbon price over the use of solid or liquid fossil fuels, or both.

One of the major results of employing a carbon pricing framework is the elimination of competitive concerns between low-cost, high-carbon technology (which under such a scenario faces an additional overhead in the form of carbon payments) and higher-cost, low-carbon technology. Carbon pricing indirectly places a tangible value on the environmental benefits provided by clean technologies, and through enhancing the fiscal competitiveness of low-carbon technology, it encourages decarbonisation through technology-switching. Options for emissions abatement, however, vary across sectors and industries; it may be straightforward to significantly decarbonise the power sector, by switching from coal to natural gas or, better still, to renewables, but less straightforward within the manufacture of cement, steel or iron, all of which emit CO_2 during their production processes. With limited short-term options to employ technology which reduces the carbon intensity of certain industrial processes, most crucially in this context of carbon capture-and-sequestration (CCS), a carbon price may only serve to dampen particular industries' short- to medium-term prospects in exchange for little, if any, environmental benefit. Prudent selection of the scope of a carbon pricing scheme should therefore remain mindful of the "decarbonisation potential" of particular sectors and industries.

4.1 Determining the Scope of Carbon Pricing in Malaysia

It is still imperative, however, that any carbon pricing scheme encompasses a significant enough share of emissions within a particular jurisdiction in order to engender as many private actors as possible to engage in actions which result in tangible aggregate environmental returns. A list of major sources of national emissions in Malaysia is provided in Table 2, along with the environmental costs associated with these emissions assuming a carbon price of RM35/$t$$CO_2$e, a figure roughly in line with Malaysia's present "country-level" SCC (Ricke et al, 2018). In 2014[17] over

[15] This is especially crucial in Malaysia, given the fact that, for instance, the feed-in tariff (FiT) policy – once our cornerstone RE policy – and the Sustainable Energy Development Authority (SEDA), the agency which runs it, have been consistently plagued by deficient levels of funding (Joshi, 2018a).

[16] These can take the form of a carbon tax or an emissions trading (or cap-and-trade) scheme. This paper proposes a tax scheme for two key reasons: first, its implementation is more straightforward than that of a trading scheme and second, it provides economic actors with long-run assurance on the price(s) of carbon, whereas a trading scheme inherently features carbon prices which fluctuate with the supply and demand of emissions permits.

[17] This is the most recent year for which a detailed breakdown of subsectoral emissions has been published by the Malaysian government. Further efforts should be made on the part of the relevant ministries to regularly provide up-to-date national emissions data to aid the formulation of new

half of emissions came from just two subsectors of the economy: electricity generation and transport,[18] while oil and gas production operations were responsible for slightly under a fifth of all emissions. A carbon pricing policy with this initial coverage would therefore place over 70% of Malaysia's GHG emissions under a single policy framework, and incentivise decarbonisation across the very industries which are contributing in an outsized manner to the issue of climate change within the national context.

Table 2: Major Sources of GHG Emissions in Malaysia, 2014

Activity	Gas	Emissions *in tCO_2e*	Share of Total GHG Emissions	Environmental Costs, *SCC: RM35 (all in RM)*
Electricity and Heat Production	CO_2	98,963,480	31.16%	3,463,721,800
	CH_4	41,200	0.01%	1,442,000
	N_2O	293,030	0.09%	10,256,050
Transport	CO_2	63,019,560	19.84%	2,205,684,600
	CH_4	493,320	0.16%	17,266,200
	N_2O	871,800	0.27%	30,513,000
Petroleum Refining	CO_2	8,624,040	2.72%	301,841,400
	CH_4	8,820	0.00%	308,700
	N_2O	21,040	0.01%	736,400
Manufacture of Solid Fuels and Other Energy Industries	CO_2	25,509,630	8.03%	892,837,050
	CH_4	11,370	0.00%	397,950
	N_2O	13,550	0.00%	474,250
Fugitive Emissions from Fuels[19]	CO_2	1,728,930	0.54%	60,512,550
	CH_4	23,194,370	7.30%	811,802,950
Total	**Aggregate GHGs**	**222,794,140**	**70.14%**	**7,797,794,900**

Source: MESTECC (2018)

Notes: GHG – greenhouse gas; SCC – social cost of carbon; environmental costs assume all emissions in 2014 are priced at an SCC of RM35, in line with Malaysia's country-level SCC (Ricke et al, 2018).

climate policies and the evaluation and potential modification of existing ones. For more details on Malaysia's GHG inventory, see MESTECC (2018).

[18] Conveniently, there is great potential for decarbonisation within power generation, even in the short-run, through the adoption of RE technology. At the same time, reducing emissions associated with electricity generation has positive environmental repercussions for electric vehicles, whether private or shared, whose global emissions impact is determined by the sources of electricity from which they are powered. The important point is that if existing technologies are adopted and utilised to a greater extent, almost half of Malaysia's emissions will be influenced by downward pressures.

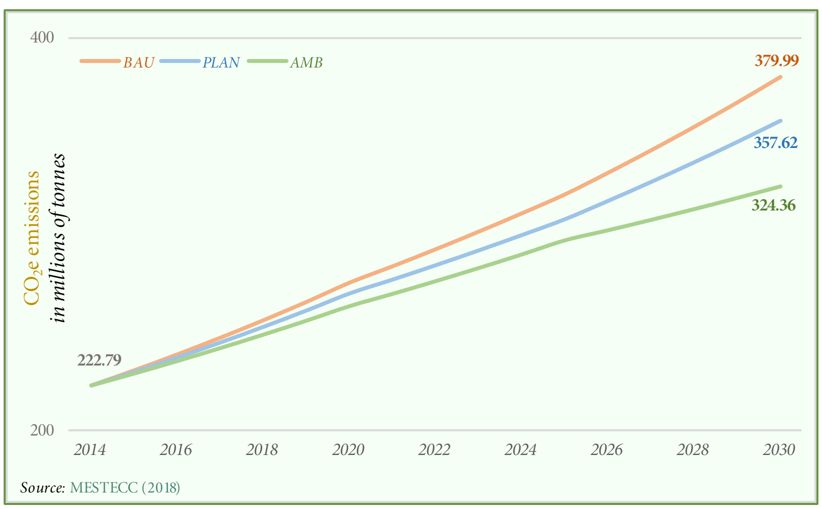
[19] In total, 99.86% of fugitive methane emissions arise from oil and natural gas production, with the remaining 0.14% from solid fuel sources. Natural gas alone is responsible for 96.56% of total fugitive methane emissions (MESTECC, 2018).

The pricing of these emissions at their source, or the downstream implementation of carbon regulation, has the advantage of allowing economic actors within the relevant sectors to select from a wider range of emissions abatement options than would generally be the case under an upstream carbon policy. Firms subjected to pricing in turn minimise costs by reducing pollution levels to the point where marginal costs of adopting abatement measures are equivalent to the cost of carbon. As the carbon price increases over time, a greater number of abatement options fall under this category, adding further momentum to the process of emissions reductions.

Projections of national emissions through 2030 are also provided within MESTECC (2018); those pertinent to the scope of the potential carbon pricing policy highlighted in Table 2 are depicted in Figure 1. For reference, BAU[20] projections assume zero climate policy intervention post-2015; PLAN[21] projections take into account existing climate policy mechanisms through 2030; and AMB[22] assumes the implementation of further emissions mitigation measures in addition to those already planned.

Under PLAN (AMB), the emissions intensity of GDP is projected to fall by 23.2% (25.5%) by 2020, 31.2% (33.8%) by 2025 and 35.3% (40.6%) by 2030, relative to 2005 levels. The disparity in emissions subject to pricing over time peaks in 2030, at roughly 55.63 million tCO_2e. Carbon pricing will have an impact in determining whether Malaysia meets its "ambitious" scenario goals, or even exceeds them, because polluters would be incentivised to reduce emissions as long as it is cheaper to do so than paying the additional carbon fee. This would be a welcome development; even under its ambitious proposal, total emissions within electricity, transport, and oil and gas production in Malaysia are projected to grow by almost 46% between 2020 and 2030. With total emissions ultimately the most important factor to consider in the context of climate change mitigation, such growth suggests that existing and planned policy proposals in Malaysia are strictly insufficient in curbing the issue. Carbon pricing can play an important role in altering this landscape, and in the longer-run, a broader scope of sectors should be subject to pricing. Future candidates include the manufacturing and construction industries, responsible for 7.24% of national GHG emissions in 2014, and waste, at 8.88%.

Figure 1: Aggregate Emissions Projections for Electricity, Transport, and Oil and Gas Production in Malaysia, 2014 to 2030[23]



[20] BAU: business-as-usual.

[21] PLAN: planned.

[22] AMB: ambitious.

[23] The achievement of various emissions scenarios is dependent on the extent of mitigation action undertaken within the relevant sectors. A wider range of mitigation actions are incentivised as the price of carbon increases; consequently, it is the pricing of carbon which can play a role in ensuring long-run emissions reductions in Malaysia meet, or even exceed, MESTECC's more ambitious projections.

4.2 Determining Carbon Rates in Malaysia

Determining the precise rate at which carbon emissions are priced should be an entirely scientific endeavour free of political interference; a long-run global carbon price would ideally be reflective of the true global social cost of carbon. Until such a point, individual nations (and even regions, such as South-east Asia) have the flexibility to implement carbon pricing frameworks featuring rates which gradually trend towards this global social cost of carbon, currently calculated by the World Bank to be between US$40-80/$t$$CO_2$e and rising to between US$50-100/$t$$CO_2$e by 2030. While strictly not a first-best policy response to climate change, introducing an initially-modest carbon pricing scheme does offer valuable benefits in largely assuaging concerns over political feasibility and economic harm, although the selected pricing schedule must not be too insignificant that it does not sufficiently incentivise shifts towards lower-carbon practices. In the longer-run, as economies get accustomed to functioning efficiently in the presence of carbon pricing, the necessary shift to a presumably higher, harmonised global price will prove a smoother process.

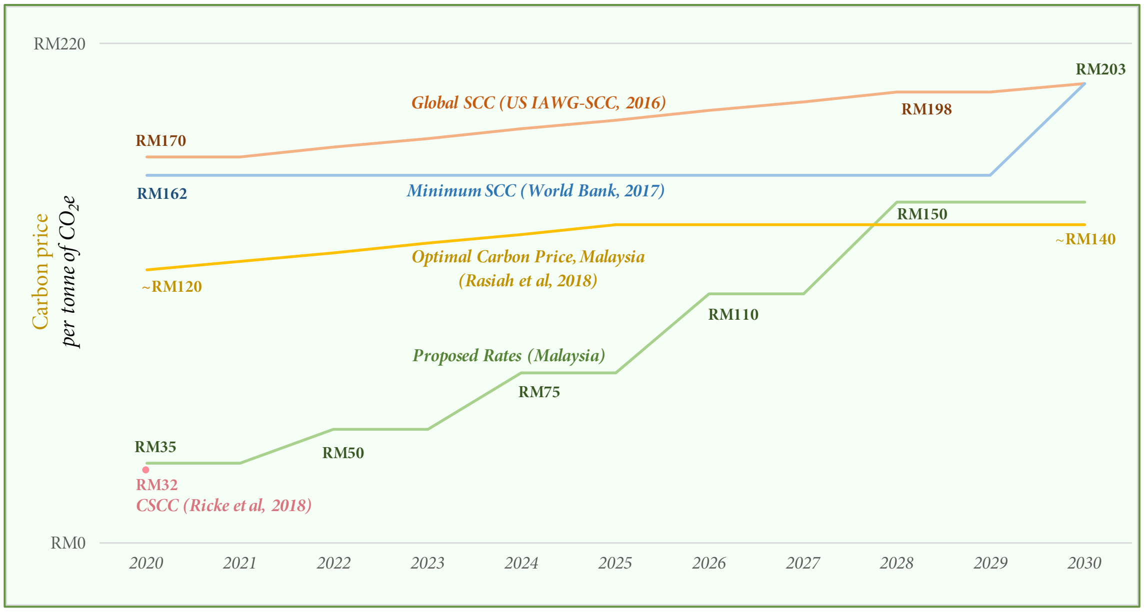
With already over 70 national and subnational jurisdictions having employed carbon pricing schemes worldwide, a figure likely to grow – possibly at an accelerated rate – over the coming decade, regional carbon pricing frameworks will soon become a distinct possibility. Nations under the umbrella of the Association of Southeast Asian Nations (ASEAN) should swiftly follow Singapore's example in enforcing a domestic price on carbon and allow local economies time to adjust to a new economic reality where the market failures of carbon emissions are addressed, with the view of adopting a regional pricing measure by 2030. Beyond this time horizon, attention should turn to the cultivation of new international agreements on the harmonised global pricing of carbon. A rough template for carbon pricing in Malaysia would consequently see prices approach a figure of around RM200/$t$$CO_2$e post-2030, in line with the SCC estimates of the US Government and the World Bank, and in the ballpark of estimates provided by Rasiah et al (2015) and Wong et al (2016). With this in mind, Figure 2 illustrates a carbon rate schedule for Malaysia covering the next decade, and this schedule is used to inform projections of the effects of carbon pricing on the relevant economic sectors throughout this analysis.

Under this proposal, carbon prices are revised every two years, commencing at a rate of RM35/$t$$CO_2$e in 2020. This figure is reflective of Malaysia's aforementioned country-level SCC and falls within the lower end of the range of carbon prices implemented in numerous other nations at present; it is, for instance, roughly equivalent to the cost of carbon under the Portuguese carbon tax and Beijing's emissions trading scheme. The predetermined biennial revision of rates,[24] meanwhile, mitigates policy uncertainty and allows economic actors the ability to project and make longer-run business decisions in the presence of a transparent and predictable carbon pricing scheme. It is recommended that this price be increased gradually over the course of the next decade before peaking at RM150/$t$$CO_2$e in 2028; a figure roughly 25% lower than the social cost of carbon estimates of the US Government and the World Bank, both of whom suggest a price of RM203/$t$$CO_2$e by 2030, and in line with the optimal carbon price computed by Rasiah et al (2015). This would put Malaysia in a strong position to adapt efficiently to an eventual global pricing regime at rates consistent with scientific evidence.[25] Only under such a framework would both market failures contributing to the worsening of climate change would be properly addressed.

[24] Consideration has been given to alternative carbon rate schedules, such as raising the rate (by a larger magnitude) once every three, or five, years. Ultimately, biennial revisions have been chosen as this best allows the Malaysian economy to *gradually* adjust to the implementation of a carbon pricing mechanism while minimising the economic shocks that may arise at the point of rate changes relative to a structure where, say, rates jump from RM35/$t$$CO_2$e between 2020 and 2024 to RM150/$t$$CO_2$e in 2025. Another benefit of regularly increasing the carbon price is drawn from the fact that each rate hike enhances the competitiveness of abatement technologies; as a result, economic actors would face persistent pressure to continuously employ the next-cheapest abatement option.

[25] Worth noting is a study conducted by Wong et al (2016) who, upon calibrating the PAGE09 integrated assessment model (IAM) to Malaysia, finds an optimal carbon tax of US$68.40/$t$$CO_2$ (~RM277/$t$$CO_2$) in 2020, rising to $105.80/$t$$CO_2$ (~RM428/$t$$CO_2$) in 2030. Given that these rates are far higher than the aforementioned estimates of the SCC, as well as the lack of political palatability of an immediate imposition of a high tax on emissions, it is not recommended in this proposal that these rates be adhered to. Regardless, their study issues a reminder that emissions are far from costless, and future updates to the carbon rate structure in Malaysia would do well to take into greater consideration these recommendations.

Figure 2: Proposed Carbon Rates in Malaysia, 2020 to 2030



5 Sectoral Effects of Carbon Pricing

The implementation of a price on carbon will have significant impacts on the Malaysian economy. Recognising emissions as a tangible economic cost has direct negative repercussions for emissions-intensive industry players and in turn provides benefits to low-carbon industries.[26] These price effects are theorised to propel changes in the production and consumption behaviour of economic actors by incentivising the adoption of sustainable practices and technologies. Investigating the impact of carbon pricing within the electricity, transport, and oil and gas industries is the first aim of Section 5. Projections are made for annual revenue generation over the course of the next decade, setting the stage for Section 6 which recommends options for effective redistribution of these revenues.

In pricing emissions at their source, the immediate cost incidence of a carbon tax falls on emitters. This gives polluters a price-based incentive to adopt a variety of abatement measures, of which options currently exist for a wide range of cross-sectoral applications. From the point of pricing, market forces should be left to determine the magnitude of subsequent pass-through in costs.[27] Rising consumer prices in particular expenditure categories, in modifying behaviour and dampening aggregate demand, should add further downward pressure to total emissions.

The electricity sector succinctly illustrates these processes. The pricing of carbon sets in motion a cycle where power producers, in facing higher levelised costs of electricity (LCOE) for the use of carbon-intensive fuels, have several options to minimise carbon payments. For coal-fired power generators, for example, choices include but are not limited to the utilisation of ultra-supercritical technology;[28] investment in flue gas desulfurisation equipment and

---

[26] Perhaps the most important immediate effect is the boosting of the competitiveness of low-carbon industry players and technologies relative to high-carbon incumbents.
[27] Economic literature estimates a wide range of cost pass-through across, and even within, sectors. Of particular interest in the context of carbon pricing are its effects on electricity prices faced by consumer. To this end, a comprehensive analysis conducted by Fabra and Reguant (2014) estimates a pass-through range of 77-86% in their work focusing on Spanish electricity markets after the implementation of the European Union's emissions trading scheme. This point is returned to later on in this section.
[28] Two such plants are relevant within the context of Malaysia, the second of which has yet to achieve commercial operations:
1) Manjung 5, operated by Tenaga Nasional Berhad (TNB), with a capacity 1GW;
2) Jimah East, operated by TNB (70% share), Mitsui & Co. and Chugoku Electric Power (15% each), with a total capacity of 2GW.

other pollution-control technologies; the adoption of integrated gasification combined-cycle technology; and the furthering of CCS efforts. All aforementioned options – and inaction – would squeeze the profitability of using carbon-intensive sources of power generation and render the use of lower-carbon energy sources as input more attractive, including combined-cycle natural gas (CCGT) and RE technologies. This should, in inflating the average electricity tariff, spur reductions in aggregate electricity usage and encourage consumers to invest in energy-efficient technology and RE systems.

5.1 Electricity

Within-sector Effects

The importance of the role of the electricity industry in climate change mitigation cannot be understated. First, it is the single-largest contributor to national emissions, accounting for just under a third of the total. Second, RE technologies are increasingly able to replace fossil fuels as the predominant incumbent sources of energy, from both technical and economic standpoints. On the demand-side, the application of energy efficiency measures, the use of smart technology, as well as the liberalisation of electricity markets, lend themselves to the possibility of further reductions in emissions. The pricing of carbon hastens the process of electricity sector disruption by immediately enhancing the economic competitiveness of lower-carbon technologies, simply by placing a tangible value on the environmental costs associated with the use of fossil fuels.

This idea is summarised in Table 3, which details the impact of the proposed prices on per-tonne carbon emissions on the LCOE of coal and natural gas. An emphasis is placed here on these particular fuel inputs as they have accounted for a combined share of 96.5% of Malaysia's electricity generation mix thus far in 2019. For the typical, ultra-supercritical coal power plant, a levy of approximately 2.87 sen would be imposed per kWh of electricity generated at a carbon price of RM35/tCO_2e; this figure rises to 4.03 sen/kWh for older, less-efficient plants. The levies on natural gas power production would be smaller, ranging from 1.48 to 1.75 sen/kWh for typical CCGT plants, and 1.98 to 2.31 sen/kWh for open-cycle (OCGT) power plants. At a carbon price of RM150, marginal effects are significantly larger in magnitude: between 12.3 and 17.28 sen/kWh for coal, 6.33 and 7.49 sen/kWh for CCGT, and 8.49 and 9.92 sen/kWh for OCGT.[29] These estimates confirm the notion that carbon pricing imposes a heavier burden on emissions-intensive technologies.

[29] In reality, it is highly unlikely that many, if any, existing OCGT plants will still be operational by the end of the next decade.

Table 3: Carbon Taxes Imposed on Electricity Generated by Coal and Natural Gas Power Plants (sen per kWh)

Carbon Price *per tCO₂e*		Coal	Natural Gas (CCGT)	Natural Gas (OCGT)
RM35 (2020/21)	Min	2.87	1.48	1.98
	Max	4.03	1.75	2.31
RM50 (2022/23)	Min	4.1	2.11	2.83
	Max	5.76	2.5	3.31
RM75 (2024/25)	Min	6.15	3.17	4.25
	Max	8.64	3.74	4.96
RM110 (2026/27)	Min	9.02	4.64	6.23
	Max	12.67	5.49	7.27
RM150 (2028-30)	Min	12.3	6.33	8.49
	Max	17.28	7.49	9.92

Note: LCOE – levelised cost of electricity; CCGT – combined-cycle gas turbine; OCGT – open-cycle gas turbine. Minimum and maximum emission intensities of the fossil fuel technologies listed are reported in Appendix **Equation (1)**.

Methodology: See **Equation (1)** of the Appendix.

To put the relative magnitude of these price effects into perspective, Table 4 models the LCOE of two ultra-supercritical coal plants (Manjung 5 and Jimah East), and two CCGT plants (Seberang Prai and Pasir Gudang) in Malaysia, at varying carbon rates. Without a price on carbon, the average LCOE for these CCGT plants, at 35.85 sen/kWh, is over 50% higher than that of coal (23.78 sen/kWh). Carbon pricing minimises this differential: at a rate of RM35/$t$$CO_2$e, the differential falls to around 39%; and at RM150/$t$$CO_2$e, the LCOE of CCGT plants would be only 14.2% higher than coal-fired alternatives – assuming no changes to fuel input costs. This highlights the fact that, *ceteris paribus*, carbon pricing enhances the importance of the emissions intensity of energy sources by eliminating the cost advantages held by cheap, carbon-intensive fossil fuels.

Table 4: Estimated LCOE[30] of Selected Power Plants in Malaysia (sen per kWh)

	Power Plants	Manjung 5 *Coal, 1GW*	Jimah East *Coal, 2GW*	Seberang Prai *CCGT, 1.07GW*	Pasir Gudang *CCGT, 1.44GW*	Average Cost Differential, CCGT *vs* Coal
	Estimated LCOE, ***no carbon price***	**22.77**	**24.79**	**34.7**	**37**	**50.8%**
Carbon Price *per* *tCO_2e*	**RM 35** (2020/21)	25.77	27.94	36.19	38.46	39%
	RM 50 (2022/23)	27.05	29.29	36.83	39.09	34.7%
	RM 75 (2024/25)	29.19	31.54	37.89	40.14	28.5%
	RM 110 (2026/27)	32.19	34.69	39.38	41.6	21.1%
	RM 150 (2028/29/30)	35.62	38.29	41.08	43.27	14.2%

Note: LCOE – levelised cost of electricity; CCGT – combined-cycle gas turbine (natural gas).

Methodology and Sources: See Footnote 28.

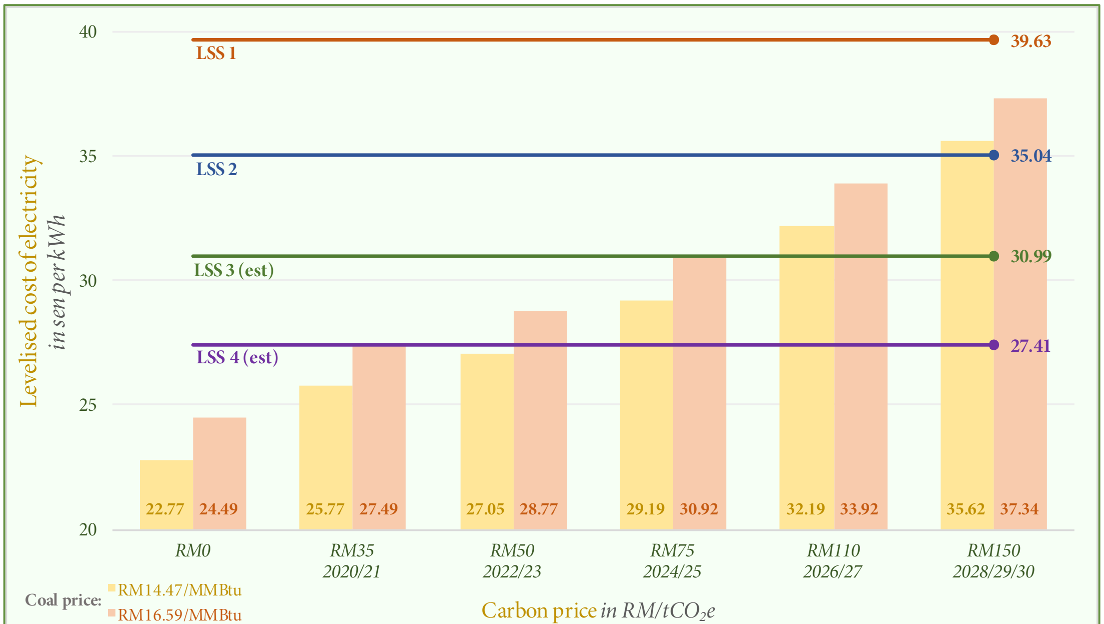
[30] Several assumptions are made in the LCOE modelling for Manjung 5 and Jimah East, both of which are ultra-supercritical coal power plants. These are summarised as follows:

Variable	Manjung 5	Jimah East
Capacity	1000 MW	2000 MW
Nominal capex, per kW	RM5,000	RM6,000
Capacity factor	90%	90%
Estimated efficiency	42%	40%
Heat rate, per kWh	8124 Btu	8530 Btu
Lifetime	25 years	25 years
Fixed O&M, per kW per year	RM130	RM130
Coal price, per MMBtu	RM14.47	RM14.47
Variable O&M per MWh	RM17.37	RM17.37
CO_2 intensity per kWh	857.06 grams	899.92 grams

For comparison, Tenaga Nasional (2015) cites levelised tariffs of 22.78 sen/kWh for Manjung 5 and 25.33 sen/kWh for Jimah East, the former of which is within 0.01 sen of that calculated in Table 4 and the latter within 0.6 sen. For the two CCGT plants, located in Seberang Perai and Pasir Gudang, LCOE figures have been drawn directly from reported levelised tariff rates; see Tenaga Nasional (2015) and Lim (2017).

The picture is brighter still for RE. Figure 3 contrasts the costs of Manjung 5, among the most advanced and efficient coal power plants in South-east Asia, with those of large-scale solar (LSS) plants under varying carbon rates, and at two distinct price points for coal. The first of these is RM14.47/MMBtu, reflective of the official coal price under Regulatory Period 2 (RP2) of the Incentive-Based Regulation (IBR) mechanism (Malaysia. Suruhanjaya Tenaga, 2018c). The second figure, of RM16.59/MMBtu, assumes a growth rate in the price of coal equivalent to that between RP1 (RM12.43/MMBtu) and RP2. Ultimately, this change in price equates to roughly a 1.72 sen increase in the levelised cost of power generation, across carbon prices, and is illustrative of the effects of a small change in the input price of coal on LCOE comparisons. The horizontal lines, meanwhile, reflect an average of the five lowest-cost bids in each LSS auction (Malaysia. Suruhanjaya Tenaga, 2016 and 2017); the estimates for LSS 3 and 4 take into consideration projections of LSS capital expenditure costs through 2030,[31] as well as the magnitude of cost reductions observed between LSS 1 and 2. More so than it does with natural gas, the pricing of carbon greatly enhances the economic competitiveness of solar; at a carbon price of RM35/tCO_2e in 2020 and 2021, LSS 4 is projected to invite bids whose levelised costs, as low as 27.41 sen/kWh, closely resemble those of Manjung 5. A realisation of the long-theorised erosion of the cost benefits of coal-fired electricity through technological development is nearing, and this process is hastened by the pricing of emissions.

Figure 3: LCOE Comparisons, TNB Manjung 5 and Large-Scale Solar at Varying Carbon Rates



Note: Figures for LSS 1 and LSS 2 represent an average of the five lowest-cost approved bids in each auction. See Suruhanjaya Tenaga (2016) and Suruhanjaya Tenaga (2017). Estimations for LSS 3 and LSS 4 are based on projections of future LSS costs. See IRENA (2018) and EIA (2019).

An important side-note is that technologically-driven cost reductions aside, cheaper access to financing has been repeatedly found to enhance a firm's ability to charge lower levelised tariffs. Azhgaliyeva et al (2018) find that improved access to loans strictly increases rates of private investment in RE projects, which are typically capital-intensive, while Ondraczek et al (2015) determine that variations in the weighted average cost of capital (WACC)

[31] The average global per unit costs of utility-scale solar power generation in 2017 were almost three-quarters lower than in 2010, falling from US$0.36/kWh to $0.10/kWh, and are projected to reach as low as $0.065/kWh (RM0.26/kWh) by 2020. See IRENA (2018) and EIA (2019) for more detailed information on the projected costs of electricity generation from renewable sources between 2010 and 2050.

across countries is a significant driver of differences in the LCOE of solar technologies across countries.[32] Finally, Monnin (2015) concludes that low interest rate environments make the adoption of green technologies more attractive, and that the levelised costs of RE are more reactive to interest rate changes than are traditional fossil fuels.[33] This evidence accentuates the importance of a comprehensive national green financing framework which allows prospective private sector actors favourable and stable access to funding for RE projects. This, combined with Malaysia's endowment of high levels of solar irradiation and the fact that the nation is among the leading global producers of photovoltaic panels, means there is tremendous potential for Malaysia to become one of the cheapest countries in which to generate solar-powered electricity should the appropriate measures be put in place.

Within this landscape of large-scale power generation are the possibilities afforded by ongoing disruptions in the traditional electricity supply model, under the umbrella of decentralisation and democratisation. The falling costs and performance improvements of residential solar and energy storage are opening up the possibility of a future proliferation of microgrids. It is becoming increasingly compelling for households and businesses to self-generate through rooftop PV technology, and through the net energy metering (NEM) scheme can export any excess electricity to the grid. At the same time, improvements in the energy efficiency of devices and appliances and their increasing connectedness have the potential to reduce residential and commercial demand for electricity over time. Ultimately, these serve as additional channels through which reductions in national emissions may be realised.

A crucial point of concern within the electricity sector pertains to the effects of carbon pricing on consumer electricity costs, particularly those faced by the B40. Some degree of cost pass-through is to be expected; the economic literature estimates a range of pass-through rates which vary across sectors, levels of firm market power, and demand elasticities. Studies investigating the effects of the pricing of emissions on output prices in electricity markets are particularly informative. Fabra and Reguant (2014) estimate both cost and price pass-through rates within the Spanish electricity market following the implementation of the European Union's emissions trading scheme. Under the conditions of inelastic demand and under the exercise of market power, which, conveniently, are reflective of the Malaysian context, the authors estimate pass-through rates of 77-86%. These results are largely consistent with others in the literature,[34] although it must be noted that the nascency of carbon pricing schemes as a whole means empirical evidence on the issue runs thin, for the time being at least. This situation will change with time given the recent proliferation of carbon tax and cap-and-trade mechanisms.

In determining the effects of carbon taxation on electricity prices, as a result, a liberal estimate of 90% in pass-through is assumed to illustrate the extent of the worst-case potential effects of the policy on consumers. In Malaysia, electricity tariffs vary across customer category and total monthly consumption, and so the magnitude of the effects of carbon pricing on the end-consumer will vary both across and within sectors.[35] In this report, specific emphasis is placed upon households. Detailed analyses of average electricity consumption in Malaysia are few and far between, and would in any case vary across income, even on a per-occupant basis. Zaid and Graham (2017), in the most comprehensive of such studies, look at residential energy consumption over the period of a year in two low-cost housing projects in Kuala Lumpur, and find per-occupant usage to be between 78 and 140kWh per month. This result is here used to estimate the impact of carbon pricing on the well-being of the nation's B40, particularly if, as is theorised, variations in electricity consumption are explained to a significant degree by income. In order to allay concerns over the lack of reasonably consistent empirical evidence on domestic electricity usage on a broader scale within the context of Malaysia, Figure 4 projects the effects of carbon pricing on illustrative households across a wide spectrum of electricity usage rates. Given a presumed correlation between income level and electricity consumption, this exercise allows for far-ranging estimations of the negative distributional effects of carbon pricing.

Several assumptions have been made in the estimating of these effects. First, the maximum marginal cost impacts of carbon pricing on the LCOE of coal, CCGT and OCGT, as per Table 3, are used. Second, the assumed electricity

[32] In fact, the authors find that financing costs have more of an impact on the LCOE of solar PV than local levels of solar irradiation.

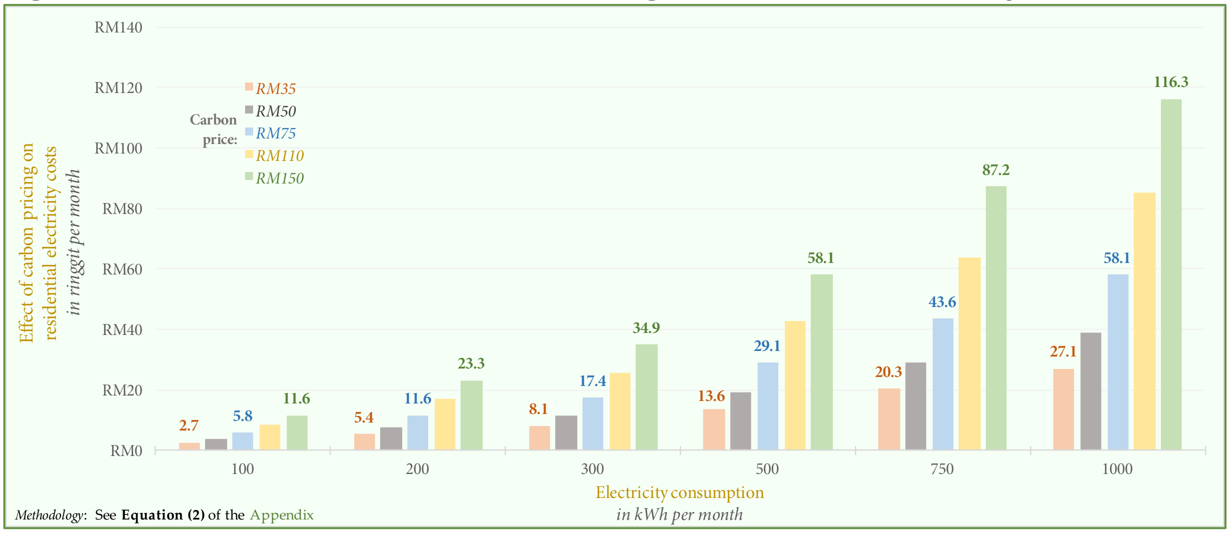
[33] Consequently, Monnin suggests that low and stable interest rate environments are more productive for low-carbon relative to high-carbon energy technology. Classes of loans, aimed at green technologies, which encompass such characteristics and make it easier for prospective clean energy investors to obtain financing for their projects would have a positive influence on the achievement of lower levelised costs of low-carbon electricity generation.

[34] See Sijm et al (2006) and Hintermann (2014).

[35] TNB's customer categories include residential, commercial, industrial, mining, street lighting and agriculture.

generation mix comprises 56.5% coal, 34.6% CCGT and 5.7% OCGT,[36] with the remainder either supplied by technologies unaffected by carbon pricing or those whose contributions to total electricity generation are relatively insignificant. Together with the assumptions on pass-through rates, these ensure that the effects detailed in Figure 4 represent the worst-case scenario for marginal electricity price increases as a result of carbon pricing.

Figure 4: Worst-case Effects of Carbon Pricing on Residential Electricity Costs



Along the horizontal axis are six households with varying rates of monthly electricity consumption, and the coloured bars are reflective of different carbon pricing levels organised in increasing order. At a price of RM35/tCO$_2$e, additional monthly costs range from RM5.40 for households that consume an average of 200kWh of electricity per month, to RM27.10 for those consuming 1000kWh. These figures rise to RM11.60 and RM58.10, and RM23.30 and RM116.30 at carbon prices of RM75/tCO$_2$e and RM150/tCO$_2$e respectively. For a household of two in the B40 that consumes an average of 280kWh of electricity per month, the additional burden is estimated at under RM8.10 at the introductory carbon price of RM35/tCO$_2$e, rising to a maximum of RM34.90 per month at RM150/tCO$_2$e in 2028. To assist the B40 – and potentially segments of the middle 40% (M40) – with these additional costs, Section 6 of this paper shows that collected carbon revenues can be used to finance rebates for low-income earners in order to allay the distributional concerns of carbon taxation.

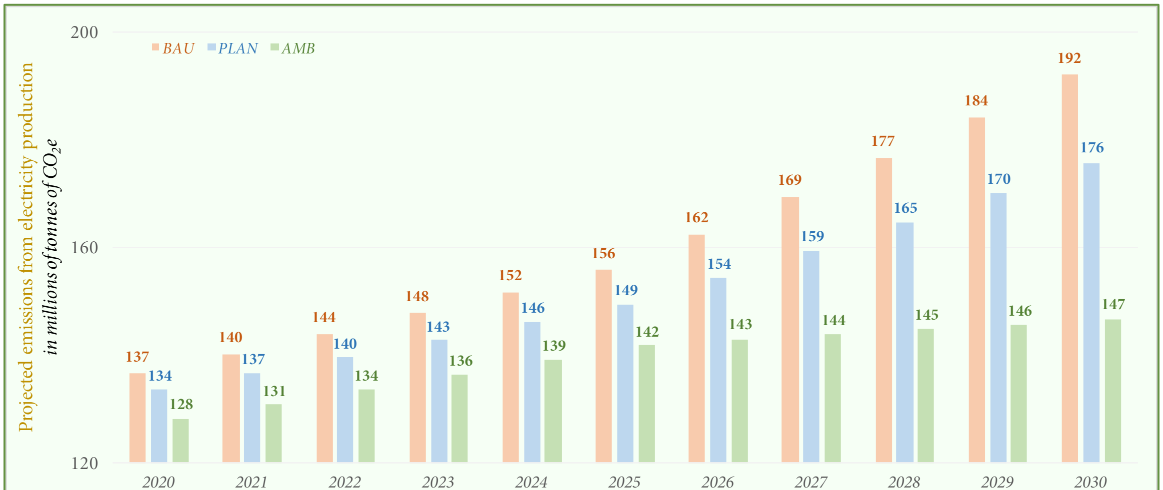
Finally, the effects of carbon taxation on electricity prices are dampened as the share of lower-carbon energy input to electricity generation increases. Should the national RE target of 20% by 2025 be achieved, the marginal effects of carbon pricing on electricity prices are estimated to be approximately 31% lower than under the existing electricity generation mix,[37] a magnitude reflective of the difference in the grid-average emissions intensity between these two compositions. Consequently, as the share of RE in electricity generation increases at the expense of the most emissions-intensive technologies during the course of this carbon pricing regime, its marginal effects on electricity prices over time will likely be progressively smaller than is estimated in Figure 4.[38] Another factor which would serve to mitigate these effects is the increased deployment of self-generation electricity technologies, such as solar panels.

[36] These figures are reflective of those reported by Single Buyer (www.singlebuyer.com.my), the entity charged by the Minister of Energy to manage electricity planning and procurement services within Peninsular Malaysia. In determining the breakdown of natural gas contributions through the twin channels of open- and combined-cycle plants, it is assumed that roughly 14% of natural gas power generation is delivered by OCGTs. This equates to the share of OCGTs in Peninsular Malaysia's total natural gas power generation capacity.
[37] Assuming the remaining share of electricity generation in 2025 is comprised of coal (30%) and CCGT (50%).
[38] This is solely by virtue of the fact that the social cost of carbon, and carbon rates under this proposal, increase with time.

Sectoral Emissions and Carbon Revenue Projections

Figure 5 depicts projections of emissions within the electricity sector, across the three scenarios put forward by MESTECC. Much of the differences between these scenarios are the result of three factors: first, an increase in the share of RE in electricity generation (from 278MW under BAU, to 3.9GW under PLAN and 5.07GW under AMB); second, the utilisation of advanced coal and gas power plant technologies (average efficiencies for coal and natural gas are 33% and 42% respectively under BAU, rising to 37% and 55% under PLAN, and 46% and 60% under AMB); and third, energy efficiency measures on the consumption side (no action under BAU, but 8% in electricity savings through 2025 under PLAN and 10% in savings through 2030 under AMB).[39] Particularly important to keep in mind is the fact that the taxing of carbon will initiate reductions in Malaysia's BAU emissions through these very channels by placing a tangible cost on carbon-intensive means of power generation, and by its general influence on electricity prices. In the longer-run, this policy measure will play a role ensuring emissions within electricity generation track closely to Malaysia's ambitious scenario, and enhance the chances that these targets will be exceeded.

Figure 5: Projected Emissions from Electricity Generation, 2020 to 2030

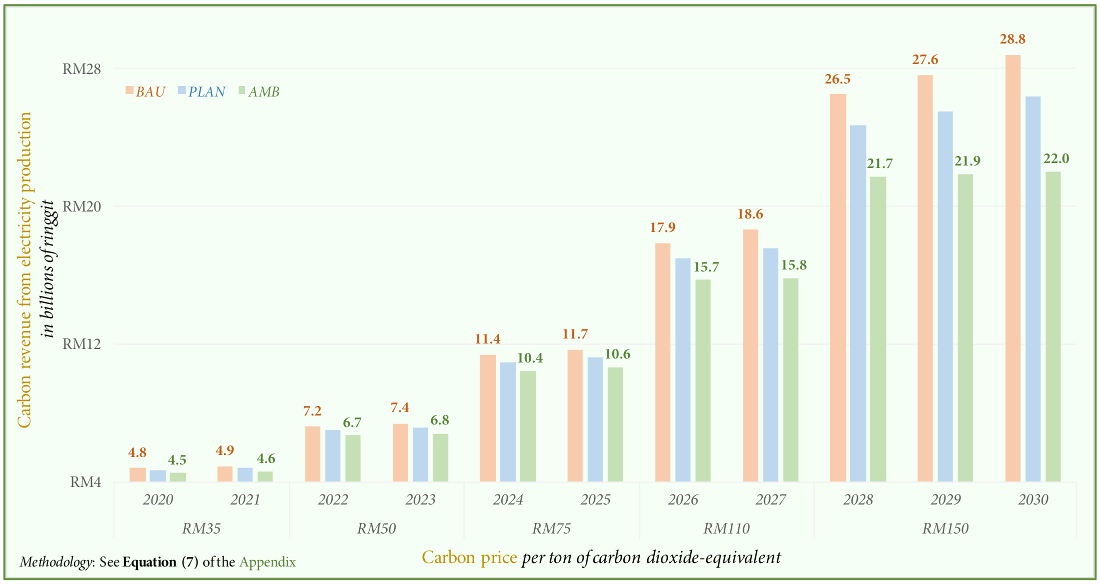


Source: MESTECC (2018)

The disparities in total sectoral emissions between these scenarios are stark; under BAU, emissions are projected to grow by 40.6% between 2020 and 2030, relative to just 14.4% under AMB. Around two-fifths of the *total* increase in Malaysia's BAU emissions in the next decade – across all sectors and industries – are projected to be due to rising emissions within electricity generation alone. The need to curtail this trend and shift the emissions trajectory of electricity downwards justifies the inclusion of this sector under *any* carbon taxation framework. Figure 6, meanwhile, projects total carbon revenues that may be raised from the electricity industry. During the first two years of the policy, with each tonne of CO_2e priced at RM35, revenues are estimated at between RM4.5 and RM4.9bil. This figure rises to between RM6.7bil and RM7.4bil in 2022/23, at a carbon price of RM50/tCO_2e. By the end of the decade, carbon revenues from electricity generation alone could amount to between RM21.7 and RM28.8bil annually, with any variation dependent on the degree of decarbonisation realised over time.

[39] For a review of all potential emissions mitigation measures considered in the development of the various emissions scenarios in Malaysia, refer to Section 3 of MESTECC (2018).

Figure 6: Projected Carbon Revenues from Electricity Generation, 2020 to 2030



5.2 Transport

Within-sector Effects

In Malaysia, prices of petrol and diesel are both heavily subsidised and regulated by the government. This latter fact directly limits the transaction costs associated with downstream implementation of climate regulation within the transport sector. As a result, it would be efficient to impose a carbon levy at the point of refuelling, with a flat tax rate imposed per litre (L) of fuel. Given that combustion emissions vary across transport fuels – most commonly[40] petrol, diesel and jet fuel – tax rates would also vary across fuel type. A summary of emissions intensities and the marginal effects of carbon pricing on transport fuel costs is provided in Table 5, and is based on data gathered from the Energy Information Administration (EIA).[41] At RM35/$t$$CO_2$e, taxing the emissions of petrol would result in an 8.22 sen (3.95% for RON95, and 3.14% for RON97, at current prices) increase in the per-litre pump price, a figure which rises to 35.23 sen/L (16.94%; 13.5%) at RM150/$t$$CO_2$e in 2028. For diesel-powered engines, additional levies range from 9.31 and 39.9 sen/L, owing to higher combustion emissions than those of petrol, and the range for jet fuel is between 8.85 and 37.92 sen/L.

[40] Suruhanjaya Tenaga (2018a) reports that within the transport sector, petrol was the most commonly used fuel at 55.16% of the total, followed by diesel at 31.05%, and a combination of jet fuel and aviation gasoline at 13.77%. Emphasis is therefore placed on the effects of carbon pricing on these four transport fuels.

[41] With the exception of diesel combustion, emissions data for which was sourced from the US Environmental Protection Agency (EPA).

Table 5: Carbon Taxes Imposed on Transport Fuels (sen per litre)

Transport Fuel	Emissions Intensity *in $kgCO_2$ per litre*	Taxes Incurred at Carbon Price of:				
		RM35	***RM50***	***RM75***	***RM110***	***RM150***
		per tCO_2e				
Petrol	2.35	8.22	11.74	17.61	25.83	35.23
Diesel	2.66	9.31	13.30	19.95	29.26	39.90
Jet Fuel	2.53	8.85	12.64	18.96	27.81	37.92
Aviation Gasoline	2.20	7.72	11.02	16.54	24.25	33.07
Methodology: See Equation (3) of the Appendix						

Figures 7 and 8, meanwhile, put into context the relative magnitude of these per-litre increases in the prices of petrol,[42] by estimating additional petrol costs per 100km across gasoline-powered cars of varying fuel efficiency and average additional monthly petrol expenses[43] across these same cars. The results have two important features. First, carbon pricing heightens the importance of vehicular fuel economy. Cars which achieve 10km per litre of petrol would be faced with additional annual costs over vehicles which obtain an average of 22km/L, of RM106.40 at a carbon price of RM35/tCO$_2$e. This figure rises to RM228.02 at RM75/tCO$_2$e, and RM456.04 at RM150/tCO$_2$e. The influence of fuel economy ratings is so stark that vehicles with a fuel economy standard of roughly 28km/L would face only marginally higher additional costs at a carbon price of RM150/tCO$_2$e than a vehicle which obtains 10km/L would at RM50/tCO$_2$e. Carbon pricing provides a consistent fiscal incentive for cost-conscious consumers to divert more attention to fuel efficiency in future vehicular purchase decisions.[44] In playing a role improving average fleet-wide fuel economy, carbon pricing assists in mitigating the contribution of road transport, the most prominent component of sectoral emissions,[45] to total national emissions. For consumers, benefits also extend to reductions in local-level air and noise pollution, particularly through the use of hybrid and electric vehicles (EVs). Enforcing a price on emissions within the transport sector will serve to accelerate awareness and consciousness of energy-efficient vehicles.

[42] Effects on the prices of diesel and jet fuel, while not analysed in detail within this paper, are marginally larger in magnitude than those of petrol given the higher emissions associated with these fuels.
[43] This calculation assumes an annual average of 24,129.1km driven per vehicle (Malaysian Institute of Road Safety Research, 2014).
[44] See Busse et al (2013).
[45] MESTECC (2018) reports that just under 88% of transport-sector emissions arise from road transportation. Within this subgroup, private vehicles are the most polluting segment.

Figure 7: Effects of Carbon Pricing on Petrol Costs per 100km

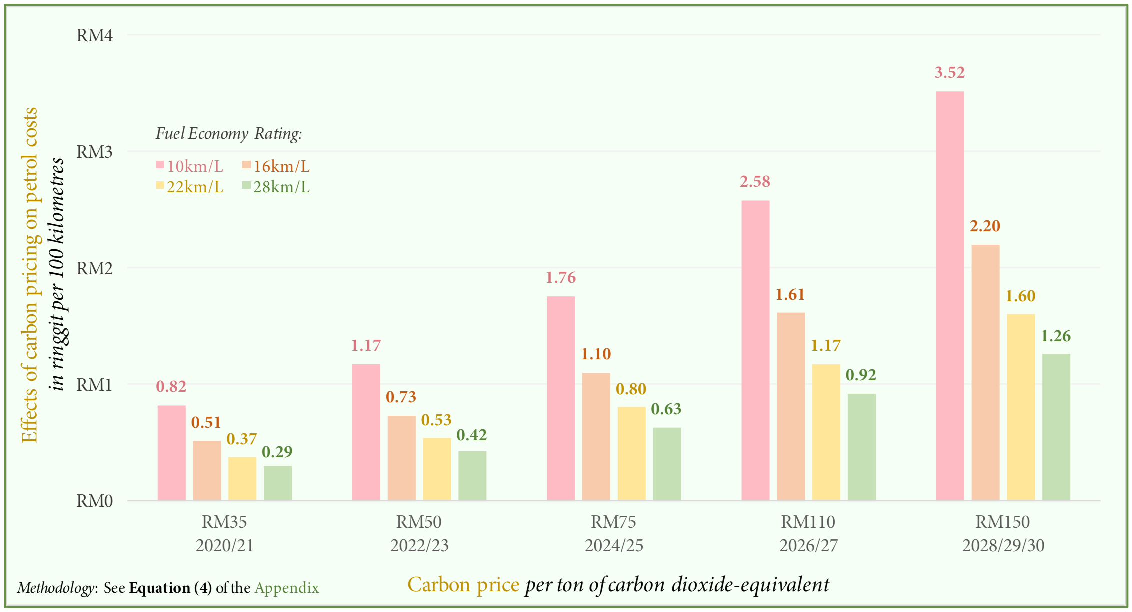
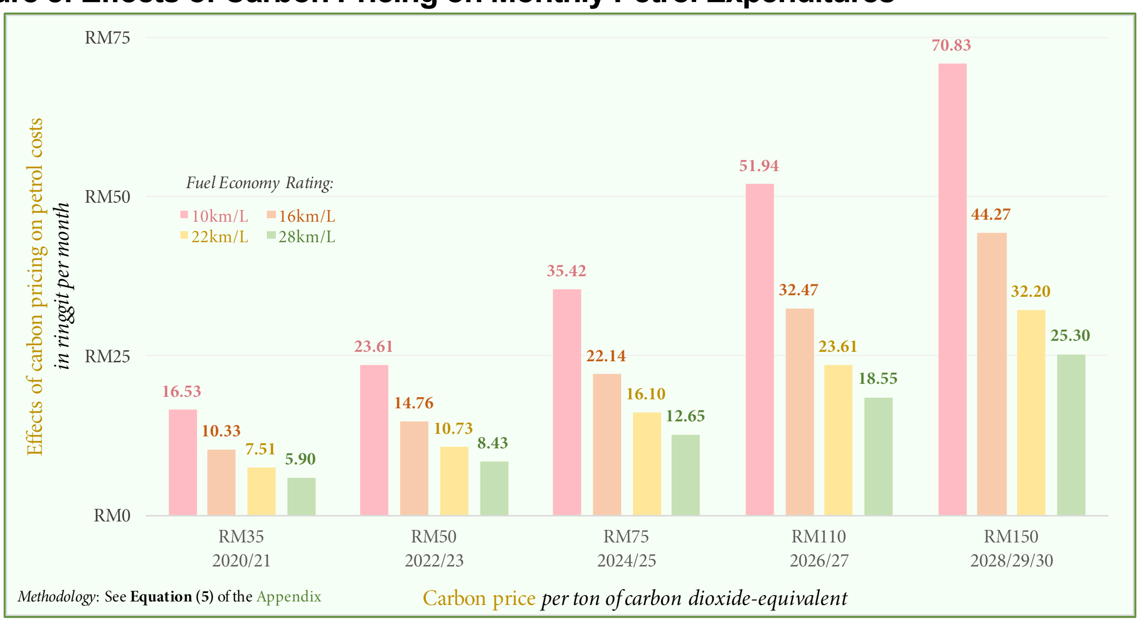


Figure 8: Effects of Carbon Pricing on Monthly Petrol Expenditures



Second, as with electricity prices, the harmful effects of carbon pricing on transport fuel prices are not as large as common belief might suggest, especially in the presence of revenue reallocation.[46] At a modest tax of RM35/tCO$_2$e, most drivers would face additional monthly costs no larger than RM16.53; given that the average fleet-wide fuel economy is closer to 16km/L, additional costs would more likely average approximately RM10 per month. This

[46] Discussions on the redistributive aspects of a holistic carbon pricing framework are left for Section 6a.

figure rises to just under RM15/month at a carbon price of RM50 in 2022/23, and to around RM22 at RM75/tCO_2e in 2024/25. It should be noted that during this period of rising carbon prices, vehicular fuel efficiency is also likely to show improvement. It is plausible that by the time the carbon price rises to RM110/tCO_2e in 2025, the average fuel economy of in-use vehicles would be closer to 22km/L, which in turn translates into additional monthly costs of under RM25.

The carbon pricing-induced rise in the costs of driving across vehicles and fuel types will have the additional effect of driving consumers to move away from cars in favour of public transportation. In addition to incentivising the use of fuel-efficient private vehicles, this is a second avenue through which the pricing of carbon can lead to major emissions reductions within the transport sector.[47] While empirical evidence on the effects of fuel taxes on public transport ridership is limited, literature investigating the more general relationship between gasoline prices and transit ridership are nonetheless informative. Carbon pricing essentially acts as a permanent upward shock in the cost of polluting transport fuels; consequently, any proven effects of the impact of upward gas price shocks on public transit ridership figures would apply to the context of taxes on vehicular fuels. Jung et al (2016) find that in the short-run in South Korea, higher gasoline prices translate into increases in public transport ridership among lower-income groups. These consumers are postulated to be more sensitive to changes in gasoline prices relative to higher-income earners, whose demand for gasoline is more price-inelastic. That a sizeable segment of the population remains committed to driving regardless of changes in gas prices heightens the need for strong policy measures which succeed in improving the average fuel-efficiency of vehicles, whether gasoline, hybrid or electric.[48] These could take the form of incentives for clean vehicles, or fuel economy standards. In examining the cross-elasticity between gasoline prices and transit ridership in Chicago, Nowak & Savage (2013) find that consumers are increasingly likely to switch to public transport the higher the gasoline price rises. This particular finding is corroborated by Iseki and Ali (2014) who, in studying 10 urbanised areas of the US, also establish a positive relationship between gasoline prices and bus ridership in the short-run, and with all major forms of transit in the long-run.

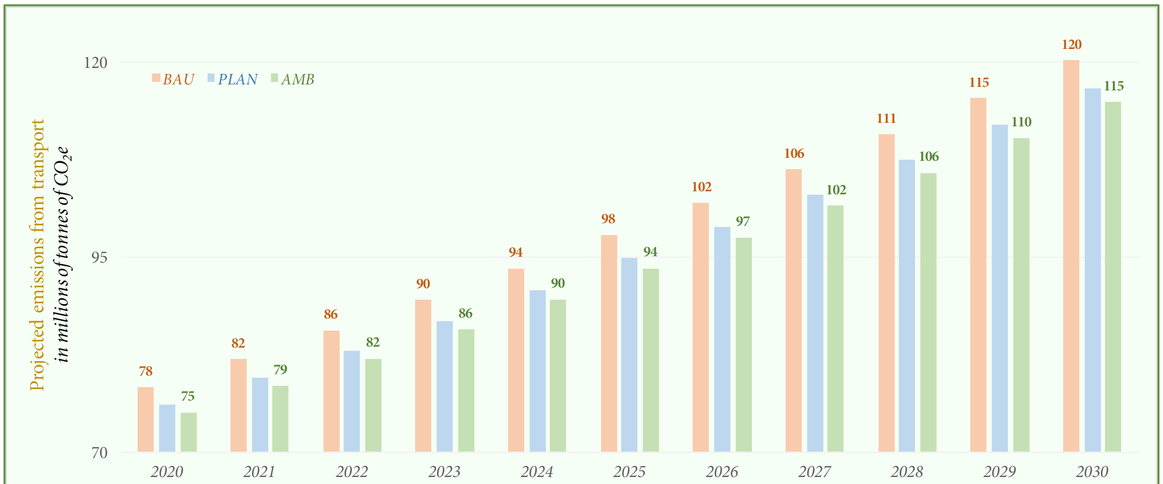
These findings underscore the need to ensure that public transportation networks in Malaysia are prepared to cope with additional demand, as the effects of carbon pricing on fuel prices are felt over time. The following elements are beyond the scope of this paper, and will consequently only be dealt with in a simplified, high-level manner. Within the Klang Valley, emphasis must be placed on enhancements to first- and last-mile connectivity, as well as measures which alleviate capacity issues on popular transit routes during peak periods. Options include building extensive networks of clearly defined pedestrian bridges and walkways, improvements to bus networks and services, and measures which encourage the use of bikes. Traffic congestion is another pertinent problem. While carbon pricing is likely to offer some relief, its absolute effects are, as indicated by Figure 8, muted in the short run. Another measure that would help is the removal of the long-existing fuel subsidy, an argument for which the economics are far more straightforward than the politics. As average fuel economies rise, public transportation networks are improved, and the vehicle fleet electrifies; however, its abolishment will become less problematic a task. The Ministries of Finance and Transportation should set a fixed timeline for this to happen. Beyond Kuala Lumpur, investments should be made in improving bus networks and services across all heavily populated areas of Malaysia, while the development of light-rail or tram services within larger or denser cities such as George Town, Johor Bahru and Melaka is strongly encouraged. In order to generate momentum for a significant downward push in emissions within the transport sector, taking steps to reduce the number of cars on the road is a necessity.[49]

[47] Given that public transport is strictly less emissions-intensive than any private alternatives, any action which induces a shift in demand from the latter to the former would lead to a reduction in aggregate subsectoral emissions.
[48] Joshi (2018a) finds that given Malaysia's current electricity generation mix, most electric vehicles (EVs) today remain more polluting than internal combustion and hybrid vehicles which obtain a fuel economy rating of over 15.8km/L. The outlook for EVs as a tool through which to combat climate change improves as the share of coal in power generation falls in favour of renewables, most prominently, and natural gas.
[49] Until such a point where the electricity grid is clean enough that even a sizable fleet of EVs would reduce emissions within the sector.

Sectoral Emissions and Carbon Revenue Projections

Figure 9 shows that transport sector emissions are projected to increase by over 50% between 2020 and 2030 across all three emissions scenarios, despite each assuming varying levels of increases in the energy efficiency of new vehicles, vehicle fleet electrification, and the use of biofuels in diesel, as well as improvements to public transportation networks, namely through the East Coast Rail Link (ECRL), the Kuala Lumpur-Singapore high speed rail (HSR), a rapid transit system linking Johor and Singapore, as well as new rail infrastructure in Penang.[50] That the disparity in emissions projections between these scenarios, of at most roughly 5.35$MtCO_2e$, is small indicates that existing planned measures make little difference to sectoral emissions. The pricing of carbon, as highlighted earlier in this section, can play a role in Malaysia realising greater emissions reductions by further disincentivising the use of inefficient private road transport; but at the same time, the government must establish improvements to public transport as a key priority for the future.

Figure 9: Projected Emissions from Transport, 2020 to 2030



Source: MESTECC (2018)

Leaving aside the potential longer-run effects of carbon pricing on transport emissions, Figure 10 projects annual revenue collections from the sector between 2020 and 2030. These are projected to average approximately RM2.7bil per year in 2020/21; RM4.3bil in 2022/23; RM7bil in 2024/25; RM11.2bil in 2026/27; and RM16.9bil between 2028 and 2030. These are sizable sums, and would add around 1.5% to 2019 federal tax revenues in 2020/21, and 9.5% between 2028 and 2030. It is likely, however, that in driving further emissions reductions than are planned by MESTECC by increasing the costs associated with driving – particularly less fuel-efficient vehicles – and enhancing the attractiveness of public transport, total revenue generation from taxing emissions from the transport sector will be lower than expected, even under the AMB scenario.[51]

[50] It should be noted that some of these projects may not come to fruition as planned; the ECRL has been delayed and is being re-examined at present, and the idea for a KL-Singapore HSR has been put on hold for the time being. In any case, only one of these proposals satisfies the need for more extensive within-city public transport, and it is on this very front that improved planning and execution is necessary.

[51] This represents an encouraging outcome, as the projected reductions in emissions under the AMB scenario relative to BAU simply are not consequential enough in the context of sustainability and climate change mitigation.

Figure 10: Projected Carbon Revenues from Transport, 2020 to 2030

5.3 Oil and Gas Production

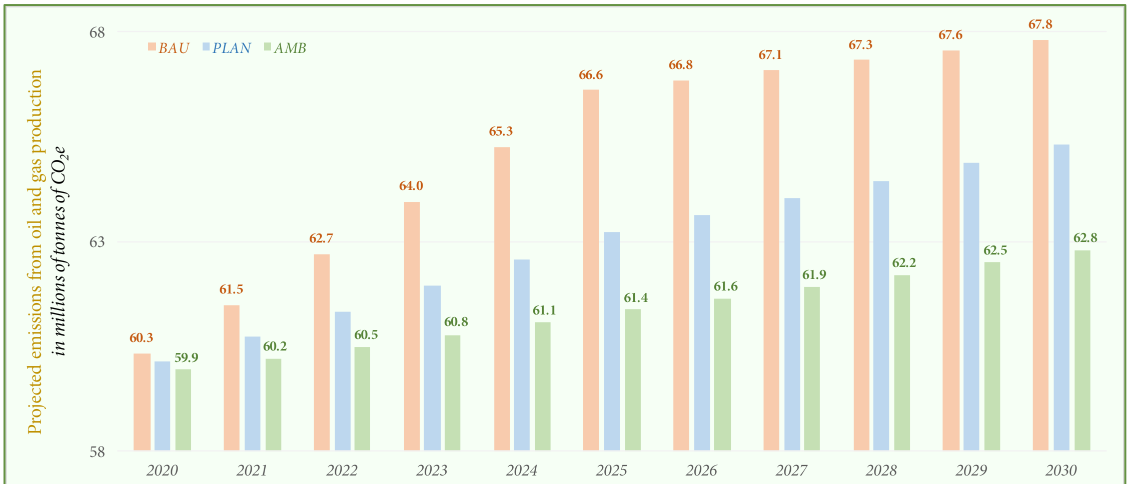
The final component of this proposed carbon pricing framework in Malaysia covers emissions from oil and gas production processes. These fall into three major categories: *i)* emissions from the manufacture of oil, and natural gas transformation; *ii)* emissions at petroleum refineries; and *iii)* fugitive emissions, particularly from venting and flaring of gas in oil production, as well as production, processing, flaring, transmission, storage and distribution emissions associated with natural gas production. The imposition of a carbon tax within oil and gas production essentially amounts to a tax which covers most operations of the state oil-and-gas conglomerate Petroliam Nasional Berhad (Petronas). This situation is complicated by the fact that Petronas has long provided the Malaysian government with special dividends, with the most recent figure amounting to RM30bil (Malaysia. Ministry of Finance, 2018). As far as possible, additional levies imposed on the firm through the pricing of emissions should be treated as distinct to these dividends, which exist for and serve altogether different purposes.

A carbon tax acts as a strong fiscal incentive for all oil and gas industry players to engage in mitigation action within all three major sectoral emissions categories. Table 6 lists the actions cited by Petronas as necessary to achieve an emissions trajectory in line with the AMB scenario depicted in Figure 11. These should not be seen as an exhaustive list of emissions mitigation options within oil and gas operations; over time, further investment must be made in CCS technologies and other carbon-sink strategies, while Petronas should take steps to close some of its more polluting assets. At the same time, it must be encouraged to invest more in its domestic RE generation capacity, and add to its existing 10MW facility in Gebeng, Pahang. While it has applied an internal carbon pricing mechanism in its assessment of investments and operational design (Petronas, 2018), the enforcement of a tangible national-level tax on carbon is needed to drive the adoption of emissions mitigation action and contribute to immediate emissions reductions within the industry.

Table 6: Emissions Mitigation Options in Oil and Gas Production Processes

Oil and Gas Production Process	Mitigation Action(s) Required
Natural Gas Transformation	• Improvements in operations and plant efficiency through fuel consumption optimisation; • Flare reduction and recovery
Oil Refining	• Improvements in plant efficiency through fuel consumption optimisation; • Flare reduction and recovery
Fugitive Emissions	• Zero continuous flaring and venting in all operations
Sources: MESTECC (2018); Petronas (2018)	

Figure 11: Projected Emissions from Oil and Gas Production Processes, 2020 to 2030



Source: MESTECC (2018)

The carbon revenue projections with oil and gas production, visualised in Figure 12, indicate an average of between RM2.1 and RM2.2bil in the first two years of the policy, and culminates at between RM9.3 and RM10.2bil annually at a price of RM150/$t$$CO_2$e between 2028 and 2030. Should Petronas and other domestically based oil and gas industry players wish to minimise these payments, the adoption of emissions abatement technologies is a necessity.

Figure 12: Projected Carbon Revenues from Oil and Gas Production Processes, 2020 to 2030

5.4 Expanding the Future Scope of Carbon Pricing in Malaysia

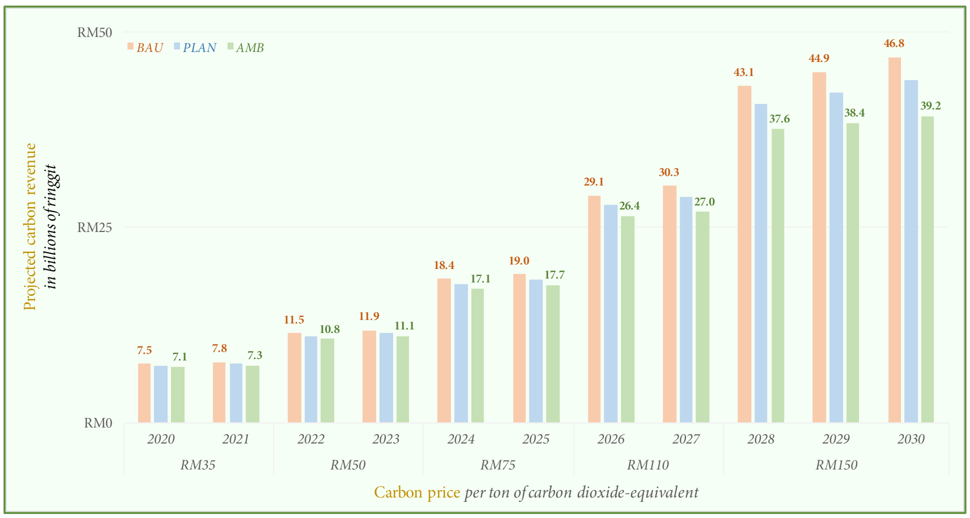
Other sectors which warrant attention are the manufacturing and construction industries, industrial processes, and waste. Combined, these contributed to almost a quarter of Malaysia's emissions in 2014 – a share which will, mathematically speaking, rise should decarbonisation efforts in other emissions-intensive sectors of the economy bear fruit. Given the immediate competitive risks associated with the taxing of industries which are relocatable and subject to the vagaries of international competition, particularly in a region where carbon pricing schemes are lacking, it is proposed that firms operating within these sectors adhere to internal carbon pricing schemes in the shorter-run. Eventually, the scope of the enforced national scheme should be expanded to encompass these emissions. Under such an arrangement, firms would be required to utilise the relevant carbon price in internal decision-making and cost-benefit analyses. This will allow time for firms within these sectors to adapt to the carbon pricing regime, and will in turn serve to minimise any direct adjustment costs relative to an abrupt entrance into the official national policy framework from 2025 onwards.

The trend of firms applying internal prices on carbon is growing; the World Bank (2018) reported that as of 2017, more than 1,300 companies across the world, with revenues totalling around US$7tril (close to 10% of the world's economy) have either adopted or plan to adopt internal carbon pricing mechanisms which inform operational decision-making processes. Particularly given its role as a tool through which firms can manage climate risks and adjust to a lower-carbon economy, as well as prepare for the eventual transition to national carbon taxation framework, it would be beneficial for most, if not all, significant economic actors across the public, private and non-profit sectors in Malaysia to adopt internal carbon pricing frameworks over the coming decade. Ultimately, a full addressing of the carbon externality requires that all emissions be treated equally – not only nationally, but on a global scale. Leaving certain sectors out of a national carbon taxation framework, while effective and politically expedient in the short- and medium-run, should not represent the long-run end-game for internalising the externality costs associated with emissions.

6 On the Redistribution of Carbon Revenues

The redistribution of revenue generated by a carbon pricing mechanism is an integral component of addressing its regressive direct effects, and maximising its indirect benefits, including providing funding for further climate change mitigation and adaptation measures. With a significant carbon revenue stream, policymakers would over time be in a stronger position to address other economic issues and market failures not necessarily relevant to climate change. Figure 13 depicts total annual revenues from the proposed carbon pricing scheme between 2020 and 2030, leaving out the impact of the advocated future inclusion of the manufacturing and construction, industrial processes, and waste sectors.

Figure 13: Aggregate Carbon Revenue Projections, 2020 to 2030[52,53]



With just three sectors covered (electricity, transportation, and oil and gas), the taxing of carbon emissions yields a substantial magnitude of revenue: RM7.5bil in 2020 at a carbon price of RM35/$t$$CO_2$e, rising to RM46.8bil in 2030 at a price of RM150/$t$$CO_2$e.[54] As Table 7 shows, the share of carbon tax revenues to total tax revenues is projected to grow from between 4.04-4.27% in 2020 to 22.27-26.58% in 2030. As a percentage of direct tax revenues, these figures are estimated to be 5.27-5.57% and 29.05-34.67%, respectively. By mid-decade, a carbon tax has the potential add roughly a fifth to direct tax revenues to Malaysia's coffers, and by the end of the decade, revenues from carbon taxation could be the largest single contributor to federal tax income.[55] This would represent an important and significant diversification of government revenue, which at present is heavily dependent on corporate and income tax receipts.

[52] Under BAU emissions, average annual revenues between 2020 and 2030 are estimated at RM24.57bil, with total revenues over the period amounting to RM270.28bil; and under PLAN and AMB emissions, these are RM23.39bil and RM257.69bil, and RM21.8bil and RM239.78bil, respectively.

[53] An important caveat is that two factors may adversely affect actual carbon revenue collections. The first of these are the possibility that economic actors subjected to carbon pricing may understate emissions; this heightens the importance of ensuring a robust and comprehensive ability to monitor emissions within the relevant sectors. Second, any success this carbon pricing policy has in shifting actual emissions to levels even below those projected under MESTECC's AMB plan would also contribute to lower revenue collections. This, however, would be a positive development from the perspective of climate action.

[54] While not recommended owing to the need to adjust to the true scientific value of the SCC over time, even if the decision is taken to implement a carbon pricing scheme which does not see prices reach the heights proposed in this paper, and instead peaks at, say, RM75/tCO_2e, total revenues would still amount to roughly RM20bil per annum.

[55] It can also be argued that a carbon tax would be the only non-distortionary source of tax revenue in the country.

Table 7: Shares of Carbon Tax Revenues to Direct and Total Tax Revenues in Budget 2019

Year	**Carbon Price** *per tCO_2e*	**Share of Total Tax Revenues** *in %*		**Share of Direct Tax Revenues** *in %*	
		BAU	*AMB*	*BAU*	*AMB*
2020	RM35	4.3	4.0	5.6	5.3
2022	RM50	6.5	6.1	8.5	8.0
2024	RM75	10.4	9.7	13.6	12.7
2026	RM110	16.5	15.0	21.5	19.6
2028	RM150	24.5	21.3	31.9	27.8
2030	RM150	26.6	22.3	34.7	29.1

There are four avenues through which carbon tax revenues are recommended be utilised. The first two should be prioritised in the short-run, and the latter two later on during the policy's existence when carbon prices are higher. First, the regressive direct effects of a tax on emissions should be addressed through carbon rebates to the B40; Section 5 provided estimates of the additional monthly burden imposed upon members of the public, and any immediate negative effects on lower-income groups can be managed through such compensation. Second, funding is still required to enable further climate change mitigation and adaptation efforts, particularly in boosting local RE industry development, including grants for R&D; providing a regular source of funding for RE policy initiatives; and investing in public transport infrastructure improvements. Third, carbon taxation should in the longer-run form a crucial component of broader, progressive tax reform, with revenues used to fund a progressive overhaul of personal income taxes, reductions in corporate taxation rates, the longer-run abolishment of the Sales and Services Tax (SST), among other measures. Finally, any residual revenues can be utilised to address Malaysia's existing fiscal issues. The remainder of this section focuses specifically upon the first two of these avenues.

6.1 Addressing the Regressive Direct Effects of Carbon Pricing

Sections 5a and 5b noted the worst-case carbon pricing-induced increases in the monthly electricity and transport costs faced by consumers; Table 8 annualises those figures on both per-individual and aggregate bases in order to quantify the total costs faced by consumers, and total rebate costs faced by the government, during each of the first four years of this policy. Carbon rebates are an essential component of ensuring that carbon pricing aids, rather than hinders, the maximisation of social welfare. While all members of Malaysian society will face the same tax rate on carbon across income levels, rising electricity and transport costs will, in constituting a greater share of their incomes, place a heavier burden on lower-income households. These regressive effects would exacerbate an already-worsening picture of equality in Malaysia,[56] but the utilisation of carbon revenues to compensate members of the B40, and possibly less-well-off members of the middle 40% (M40), would go a long way to mitigating this issue.

[56] See Figures 1.37 and 1.52, in particular, of Khazanah Research Institute (2018).

Table 8: Annual Carbon Rebates at RM35 and RM50/tCO_2e

Carbon Price *per tCO_2e*	**Annual Electricity Rebates** *in RM per individual*		**Annual Transport Rebates** *in RM per individual*		**Total Annual Rebates** *in RM per individual*	
	Mean	Max	Mean	Max	Mean	Max
RM35	48.83	65.10	123.96	198.34	**172.79**	**263.44**
RM50	69.79	93.05	177.08	283.34	**246.87**	**376.39**
	Aggregate Electricity Rebates *in RM bil*		**Aggregate Transport Rebates** *in RM bil*		**Aggregate Annual Rebates** *in RM bil*	
RM35	0.63	0.84	1.60	2.57	**2.24**	**3.41**
RM50	0.90	1.20	2.29	3.67	**3.19**	**4.87**

Assumptions*: i)* mean electricity usage: 150kWh/individual*; ii)* max electricity usage: 200kWh/i*; iii)* mean fuel economy: 16km/L*; iv)* worst-case fuel economy: 10km/L*; v)* Malaysian population: 32.35m*; vi)* B40 population: 12.94m

Methodology: Refer to **Equations (1)** through **(6)**

At RM35/tCO_2e (RM50/tCO_2e), electricity rebates are estimated to range from between RM48.83 (RM69.79) and RM65.10 (RM93.05) per individual within the B40 annually; aggregated across the relevant population subgroup of 12.94m, this equates to federal expenditure of between approximately RM0.63 (RM0.9) and RM0.84bil (RM1.2bil). Transport rebates would be larger still, and on aggregate range from RM1.6 to RM2.57bil annually at a tax of RM35/tCO_2e, and between RM2.29 and RM3.67bil at RM50/tCO_2e. On an individual level, transport rebates are estimated at no more than RM198.34 per year at RM35/tCO_2e, and RM283.34 at RM50/tCO_2e. In total, addressing the regressive direct consequences of carbon taxation would likely consume between RM2.24 and RM3.41bil of federal carbon revenues at RM35/tCO_2e, and between RM3.19 and RM4.87bil at RM50/tCO_2e[57]. This equates to a share of between 29.6% and 46.5% of annual carbon revenues in 2020/21, and 27.8-43.8% in 2022/23.[58] Individuals within the B40 would consequently receive between RM172 and RM264 per annum at a carbon price of RM35/tCO_2e, and between RM246 and RM377 at RM50/tCO_2e.

It is proposed that such carbon rebates be dispersed alongside existing Bantuan Sara Hidup (BSH) payments, under which B40 households are allocated fixed annual grants based on household income subgroup. These are listed in Table 9, which also estimates the marginal impacts of carbon rebates on the magnitude of these grants. Under the introductory carbon price of RM35/tCO_2e, BSH grants inclusive of carbon rebates would rise by 69.1-105.4% for households of four[59] earning under RM2,000 per month, for instance and *ceteris paribus* this figure increases to 98.7-148.7% at the higher carbon price of RM50/tCO_2e. The relative increase in BSH grants are larger for higher-income households within the B40, owing solely to the fact that while the existing grants are progressively distributed, carbon rebates are uniformly distributed to individuals across the three relevant income subgroups. Carbon rebates, in significantly increasing the size of annual grants afforded to the B40, can play a major role improving the social well-being of Malaysia's low-income households, who can profit even further by reducing their individual carbon footprints through investment in and usage of low-carbon technologies.

[57] If steps were taken to mitigate the regressive effects of carbon taxation on the middle 40% (M40) as well, at a rate half that of the B40, aggregate compensation costs would rise by roughly 150% – still enough to ensure leftover funding for other important policy initiatives. Given the rather limited absolute magnitude of the effects on electricity and transport costs, such a move may not even be entirely necessary – if anything, it may be pragmatic to extend some remuneration to only a subset of the M40.

[58] Generally speaking, the proportion of revenues which need to be utilised to compensate the B40 decreases as the price of carbon rises. This, ultimately, leaves more excess revenue though which to address other funding needs the government may have.

[59] Khazanah Research Institute (2018) reports the average household size as approximately 4.1 people.

Table 9: Marginal Impact of Annual Carbon Rebates on "Bantuan Sara Hidup" Grants (per household of 4)

Household Income Group *in RM*	**Existing BSH Grant** *in RM*	**Carbon Price** *per tCO_2e*			
		RM35		RM50	
		Mean	*Max*	*Mean*	*Max*
Under 2,000	1,000	69.1%	105.4%	98.7%	148.7%
2,001 to 3,000	750	92.2%	140.5%	130.1%	198.3%
3,001 to 4,000	500	138.2%	210.7%	197.5%	301.1%

6.2 Funding Further Climate Change Mitigation and Adaptation Efforts

Table 10 provides a summary of the residual carbon revenues from 2020 to 2023, assuming BAU emissions, after the regressive direct effects of the implementation of carbon taxation are addressed. It is estimated that in 2020, for instance, between RM4.11 and RM5.28bil will be available in funding for other initiatives of importance. By 2023, this figure is projected to rise to between RM6.99 and RM8.67bil, owing in part to the anticipated increase in emissions over this time period, but predominantly due to the rise in the price of carbon from RM35 to RM50/tCO_2e. Each increase in the carbon price over the course of the decade will contribute to large hikes in total revenue collections, and this in turn would allow funding for other important economic policies the government may wish to proceed with.

Table 10: Residual Annual Carbon Revenues, 2020 to 2023 (in RM mil, assuming BAU emissions)

Year	**Min**	**Max**
2020	4,111	5,284
2021	4,363	5,536
2022	6,606	8,282
2023	6,992	8,668
Total	**22,073**	**27,771**

As a nation in which there still remains a significant need for continued decarbonisation, the ability to draw on additional financing streams for climate change mitigation measures, such as a greater penetration of RE, the adoption of energy efficiency measures, and forest conservation efforts, is imperative. This need is quoted by MESTECC in its biennial update report to the UNFCCC, alongside the requirements of funding for adaptation measures and improved GHG inventory management systems; in fact, the taxing of carbon will place greater importance on the ability to reliably measure emissions, especially within the policy-relevant sectors. More investment will be necessary to ensure the government's ability to consistently monitor emissions and accurately enforce carbon taxes across firms in the electricity and oil and gas sectors most prominently and later, those involved in manufacturing, construction, industrial processes, and waste. A full list of the climate change-related finance gaps cited by MESTECC is provided in Table 11. Crucially, these gaps can be met in their entirety within the first four years of the carbon pricing framework proposed in this paper, even at carbon rates as low as RM35 and RM50/tCO_2e, and without any foreign financial assistance. This opportunity should be grasped.

Table 11: Malaysia's Climate-Related Funding Gaps (in RM mil)

Area	Funding Requirement
Administrative	
GHG Inventory Management	24.3
Mitigation	
RE Programs[60]	11,907
Energy Efficiency Programs	6,196
REDD+ Initiatives	1,620
Adaptation	
Initial Adaptation Measures	421.2
Development of a *National Adaptation Plan*	
Total	**20,169**

***Source**:* MESTECC (2018)
***Notes**:* MYR/US$ exchange rate – RM4.05/$1; REDD+ – reducing emissions from deforestation and forest degradation

Even then, it is almost certainly the case that sustained climate change mitigation and adaptation efforts continue to require over the longer-run ever larger magnitudes of funding, and partial proceeds from carbon taxation should be in perpetuity used to provide a stable, long-run source of financial support for these initiatives. Such significant investment in the domestic green economy will have strongly positive repercussions for the Malaysian economy at-large, adding momentum to the growth of a group of industries which are, and will continue to be, the centrepieces of sustainable development over the coming decades. As was noted in Section 5, there are numerous other options the government should consider with regard to reducing the emissions intensity of, for instance, the transport sector, through an emphasis on public transportation and the use of energy-efficient vehicles. Successfully carrying out these endeavours would also require large sums of investment, and this illustrates succinctly the fact that MESTECC's cited climate funding needs are far from exhaustive. Malaysia's ability to effectively manage and reduce emissions nationwide is heavily dependent on the ability of the government to raise the requisite funding for all important climate initiatives. In this regard, carbon pricing can play an almost irreplaceable role.

[60] To put this figure into context, average annual collections under the RE Fund, the mechanism used by SEDA to fund the feed-in tariff (FiT) program amounted to only RM447.2mil between 2012 and 2016. For a detailed review of the history of RE policies in Malaysia, refer to Joshi (2018b).

7 Summary and Concluding Comments

With growing concern over the issue of climate change and an unrelenting need to engage in sustained decarbonisation, it is important that Malaysia follows the example of the 70 national and subnational jurisdictions which utilise the pricing of carbon as a critical tool in their climate policy toolbox. A carbon tax applied to the electricity, transport, and oil and gas industries would cover over 70% of annual national emissions and, from the point of view of climate action, can play a major role ensuring Malaysia meets, or even exceeds, its international climate goals. It achieves this particularly through its engendering of emissions reductions within the electricity and transport sectors by incentivising the employment of low-carbon resources and technology and emissions abatement options.

This proposal sees a carbon tax enacted in 2020 of RM35/tCO_2e, a figure reflective of Malaysia's optimal, present-day country-level SCC and which is revised upward on a biennial basis until 2028, when it reaches RM150/tCO_2e. The achievement of this latter figure would see Malaysia applying a carbon price approximately 25% lower than scientific estimates of the SCC; importantly, it would put the country on track to seamlessly adopt any future, global tax on emissions should the need arise as both the effects of climate change become increasingly pronounced and the shift away from fossil fuels grows stronger in necessity. This tax should be applied on downstream actors; within electricity generation this means levying a charge on power plants, within transport a charge on drivers, and within oil and gas at the source of domestic emissions along the production chain. This would enable emitters the opportunity to choose between paying a higher carbon tax or investing in emissions abatement technologies – these options can either directly or indirectly contribute to the mitigation of climate change.

At the introductory carbon tax of RM35/tCO_2e, the levelised cost of electricity from large-scale solar plants is projected to be competitive with those of ultra-supercritical coal power plants, and as the price of carbon increases, the cost differentials between generating electricity from coal and through state-of-the-art combined-cycle natural gas plants is minimised. Within transport, the pricing of carbon incentivises consumers to strongly consider fuel economy ratings when making vehicular purchase decisions, and encourages the use of public transport, and for oil and gas industry players, the adoption of emissions-control measures such as CCS technologies becomes increasingly economical.

The redistribution of carbon revenues, meanwhile, is a crucial component of this policy as it provides a host of external benefits which can assist in the maximisation of social welfare and the effectiveness of domestic action on the climate. Such redistribution includes the provision of carbon rebates for the B40 to compensate for the unintended regressive effects of carbon pricing; addressing the issue of climate change by providing a consistent, long-run source of funding for further climate change mitigation and adaptation efforts; tackling inequality by financing and forming a crucial component of progressive tax system reform; and assisting in the stabilisation the nation's fiscal outlook. The pricing and taxing of carbon, with an emphasis on a redistribution of the policy's revenues, can put Malaysia on the path towards long-term sustainability, with few consequential costs in the near future and monumental benefits in the medium- to long-run.

Appendix

Equation (1): $\mathrm{T}_j = CP_i . \varepsilon_j$

where the carbon tax charge T, in sen per kWh, imposed on electricity generated by each fossil fuel source j, is determined by:

i) carbon prices CP_i, in RM/tCO$_2$e, which take the following values:

$$CP_i \begin{cases} 35 \\ 50 \\ 75 \\ 110 \\ 150 \end{cases}$$

ii) the emissions intensity ε, in gCO$_2$e per kWh, of varying electricity sources j, which take the following values[61]:

$$\varepsilon_j \begin{cases} coal = [820, 1152] \\ CCGT = [422, 499] \\ OCGT = [566, 661] \end{cases}$$

Equation (2): $\mathrm{B}_{em} = u_k \left[\left(CP_i . \frac{9\varepsilon_{j,max}}{10} \right) s_j \right]$

where B_{em} represents the additional burden, in ringgit per month m, faced by households k as a result of the imposition of a carbon tax on electricity generation e, and is determined by:

i) monthly electricity usage u, in kWh, of households k, which takes the following values:

$$u_k \begin{cases} 100 \\ 200 \\ 300 \\ 500 \\ 750 \\ 1000 \end{cases}$$

ii) the function $\left(CP_i . \frac{9\varepsilon_{j,max}}{10} \right)$, which refers to the cost effects of carbon prices CP_i given the maximum emissions intensity ε of electricity sources j, assuming cost pass-through of 90%, with both variables as defined in (**1**);

[61] Data regarding the minimum and maximum emissions intensities of the fuel sources listed are drawn from a combination of the median figures reported by IEA (2012), IPCC (2011), IPCC (2014) and World Nuclear Association (2011).

iii) the generation shares s, of electricity sources j, which take the following values[62]:

$$s_j \begin{cases} coal = 0.565 \\ CCGT = 0.346 \\ OCGT = 0.057 \end{cases}$$

Equation (3): $\mathrm{T}_l = CP_i . \varepsilon_l$

where the carbon tax T, in sen per litre, imposed on transport fuel sources l, is determined by:

i) carbon prices CP_i, which are as defined in **(1)**;
ii) the emissions intensity ε, in $kg$$CO_2$e per litre, of transport fuel sources l, which take the following values:

$$\varepsilon_l \begin{cases} petrol = 2.3485 \\ diesel = 2.6601 \\ jet\ fuel = 2.5283 \\ aviation\ gasoline = 2.2048 \\ marine\ fuel\ oil = 3.1097 \end{cases}$$

Equation (4): $\mathrm{B}_{ph} = \frac{100}{fe_v}(CP_i . \varepsilon_l)$

where B_{ph} represents the additional burden, in ringgit, faced by drivers for each 100km, h, driven in vehicle v as a result of the imposition of a carbon tax on petrol consumption p, and is determined by:

i) the fuel economy fe, of vehicles v, in kilometres per litre of petrol, which take the following values[63]:

$$fe_v \begin{cases} 10 \\ 16 \\ 22 \\ 28 \end{cases}$$

ii) the function $(CP_i . \varepsilon_l)$, which is as defined in **(3)**.

Equation (5): $\mathrm{B}_{pm} = \frac{24{,}129.1}{(100 \times 12)} . \left(\frac{100}{fe_v}(CP_i . \varepsilon_l)\right)$

where B_{pm} represents the additional burden, in ringgit per month m, faced by drivers as a result of the imposition of a carbon tax on petrol consumption p, and is determined by:

[62] Refer to Footnote 34.
[63] Most average vehicular fuel economy ratings typically fall within the 10-28km/L range. Those obtaining 10km/L are taken to be representative of low-efficiency cars; 16km/L is reflective of the average car; 22km/L represents efficient internal combustion cars; and 28km/L the average hybrid vehicle.

i) the function $\left(\frac{100}{fe_v}(CP_i . \varepsilon_l)\right)$, which is as described in **(4)**;

ii) the constant $\frac{24,129.1}{(100 \times 12)}$. This is derived from Malaysian Institute of Road Safety Research (2014), which finds that Malaysians drive an average of 24,129.1km per year, or 2,010.76km per vehicle per month.

Equation (6): $\mathrm{B}_{tm} = \mathrm{B}_{em} + \mathrm{B}_{pm}$

where the total monthly burden of carbon taxation on consumers, B_{tm}, is a combination of its effects on monthly electricity and petrol expenditures, as defined in **(2)** and **(5)**.

Equation (7): $\mathrm{T}_x = \epsilon_x . CP_i$

where T_x represents annual tax collections, in ringgit, from sector x upon which a carbon tax is levied, and is determined by:

i) annual sectoral emissions, represented by ϵ_x;

ii) the prevailing carbon price CP_i which takes in any particular year one of the values listed in **(1)**.

References and Recommended Further Reading

Arrow, K; Cline, W; Mäler, K; Munasinghe, M; Squitieri, R; & Stiglitz, J. 19. *"Intertemporal Equity, Discounting, and Economic Efficiency"*, in *"Climate Change 1995: Economic and Social Dimensions of Climate Change, Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change"*. Cambridge University Press: Cambridge, UK.

Atherton, E; Fougère, C; Lavoie, M; Marshall, A; Minions, C; Risk, D; Werring, J; Williams, J. 2017. *"Mobile Measurement of Methane Emissions from Natural Gas Developments in Northeastern British Columbia, Canada"*. Atmospheric Chemistry and Physics, 17: 12405-12420

Azhgaliyeva, D; Kapsaplyamova, Z; & Low, L. 2018. *"Implications of Fiscal and Financial Policies for Unlocking Green Finance and Green Investment"*. ADBI Working Paper No. 861. Asian Development Bank Institute: Tokyo, JP. Available at www.adb.org/sites/default/files/publication/445076/adbi-wp861.pdf

Bonney, K; Joshi, D; & Strain, M. 2018. *"It Starts With a Social Cost of Carbon"*. Energy Policy Practicum, Booth School of Business at the University of Chicago: Chicago, IL, USA. Available at www.epic.uchicago.edu/research/publications/energy-policy-practicum-it-starts-social-cost-carbon

Bordoff, J & Larsen, J. 2018. *"US Carbon Tax Design: Options and Implications"*. Center on Global Energy Policy, School of International and Public Affairs at Columbia University: New York, NY, USA.

Bowen, A. 2015. *"Carbon Pricing: How Best to Use the Revenue?"*. Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science (LSE) & Global Green Growth Institute (GGGI). LSE: London, UK & GGGI: Seoul, KR. Available at www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/11/Bowen-policy-brief-2015.pdf

Brandt, A & Masnadi, M, et al. 2018. *"Global Carbon Intensity of Crude Oil Production"*. Science, 361 (6405): 851-853.

Broekhoff, D; Down, A; & Lazarus, M. 2017. *"Using Carbon Tax Revenues to Help Attain Climate Goals: Insights for Washington State from Existing Programs"*. SEI Working Paper No. 2017-05. Stockholm Environmental Institute: Stockholm, SE. Available at www.mediamanager.sei.org/documents/Publications/Climate/SEI-WP-2017-05-Using-carbon-tax-revenues-to-achieve-climate-goals.pdf

Busse, M; Knittel, C; & Zettelmeyer, F. 2013. *"Are Consumers Myopic? Evidence from New and Used Car Purchases"*. American Economic Review, 103 (1): 220-256.

Carl, J & Fedor, D. 2016. *"Tracking Global Carbon Revenues: A Survey of Carbon Taxes versus Cap-and-Trade in the Real World"*. Energy Policy, 96 (9): 50-77.

Chao, M-C; Huang, W-H; & Jou, R-C. 2015. *"The Asymmetric Effects of Gasoline Prices on Public Transportation Use in Taiwan"*.

Transportation Research Part D: Transport and Environment, 41: 75-87.

Climate Leadership Council. 2019. *"Economists' Statement on Carbon Dividends"*. Available at www.clcouncil.org/economists-statement/

Council of Economic Advisers. 2017. *"Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate"*. Council of Economic Advisers Issue Brief, Executive Office of the President: Washington, D.C., USA.

DeCanio, S. 1997. *"The Economics of Climate Change"*. Redefining Progress: San Francisco, CA, USA. Available at citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.131.3255&rep=rep1&type=pdf

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. 2012. *"Reducing Carbon Emissions through Transport Demand Management Strategies: A Review of International Examples"*. GIZ China: Beijing, CN. Available at www.sutp.org/files/contents/documents/resources/B_Technical-Documents/GIZ_SUTP_TD_Reducing-Carbon-Emissions-through-TDM-Strategies_EN.pdf

Diamond, J & Zodrow, G. 2018. *"The Effects of Carbon Tax Policies on the US Economy and the Welfare of Households"*. Center on Global Energy Policy, School of International and Public Affairs at Columbia University: New York, NY, USA.

Diamond, P & Saez, E. 2011. *"The Case for a Progressive Tax: From Basic Research to Policy Recommendations"*. Journal of Economic Perspectives, 25 (4): 165-190.

Fabra, N & Reguant, M. 2014. *"Pass-Through of Emissions Costs in Electricity Markets"*. American Economic Review, American Economic Association: 104 (9), 2872-2899.

Greenstone, M; Kopits, E; & Wolverton, A. 2013. *"Developing a Social Cost of Carbon for US Regulatory Analysis: A Methodology and Interpretation"*. Review of Environmental Economics and Policy, 7 (1): 23–46.

Hicks, M & Faulk, D. 2013. *"The Effect of Gasoline Prices on Public Bus Ridership in Indiana"*. Center for Business and Economic Research at Ball State University: Muncie, IN, USA. Available at www.fwcitilink.com/pdfs/ITA-Gas-Prices.pdf

Hope, C & Johnson, L. 2012. *"The Social Cost of Carbon in U.S Regulatory Impact Analyes: An Introduction and Critique"*. Journal of Environmental Studies and Sciences, 2 (3): 205-221.

Hudson, M. 2015, 13 Aug. *"Tax or Trade, the War on Carbon Pricing has been Raging for Decades"*. The Conversation. Available at www.theconversation.com/tax-or-trade-the-war-on-carbon-pricing-has-been-raging-for-decades-46008

Intergovernmental Panel on Climate Change. 2011. *"Renewable Energy Sources and Climate Change Mitigation"*. IPCC: Geneva, Switzerland. Available at www.ipcc.ch/site/assets/uploads/2018/03/SRREN_Full_Report-1.pdf

Intergovernmental Panel on Climate Change. 2014. *"Annex III: Technology-specific cost and performance parameters"*, in *"Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change"*. Cambridge University Press: Cambridge, UK & New York, NY, USA. Retrieved from www.ipcc.ch

Intergovernmental Panel on Climate Change. 2018. *"Global warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty"*. World Meteorological Organization: Geneva, Switzerland. Retrieved from www.ipcc.ch

International Energy Agency. 2012. *"CO_2 Emissions from Fuel Combustion: Highlights"*. International Energy Agency: Paris, France. Retrieved from http://large.stanford.edu/courses/2013/ph240/rajavi2/docs/co2highlights.pdf

International Renewable Energy Agency. 2018. *"Renewable Power Generation Costs in 2017"*. IRENA: Abu Dhabi, AE. Available at www.irena.org/publications/2018/Jan/Renewable-power-generation-costs-in-2017

Iseki, H & Ali, R. 2014. *"Net Effects of Gasoline Price Changes on Transit Ridership in US Urban Areas"*. Mineta Transportation Institute at the College of Business at San José State University: San José, CA, USA.

Kaufman, N & Gordon, K. 2018. *"The Energy, Economic, and Emissions Impacts of a Federal US Carbon Tax"*. Center on Global Energy Policy, School of International and Public Affairs at Columbia University: New York, NY, USA.

Joshi, D. 2018a. *"Electric Vehicles in Malaysia? Hold Your Horsepower!"*. Penang Institute: Kuala Lumpur, MY. Available at www.penanginstitute.org/wp-content/uploads/2018/08/Electric-Vehicles-in-Malaysia_Darshan-Joshi_Penang-Institute_23August2018.pdf

Joshi, D. 2018b. *"Evaluating the Performance of the Sustainable Energy Development Authority and Renewable Energy Policy in Malaysia"*. Penang Institute: Kuala Lumpur, MY. Available at www.penanginstitute.org/wp-content/uploads/2018/06/Evaluating-the-Performance-of-SEDA-and-RE-Policy-in-Malaysia_PI_Darshan_5-June-2018.pdf

Jung, H; Yu, GJ; & Kwon, KM. 2016. *"Investigating the Effect of Gasoline Prices on Transit Ridership and Unobserved Heterogeneity"*. Journal of Public Transportation, 19 (4): 56-74.

Khazanah Research Institute. 2018. *"The State of Households 2018: Different Realities"*. Khazanah Research Institute: Kuala Lumpur, MY. Available at www.krinstitute.org/assets/contentMS/img/template/editor/FullReport_KRI_SOH_2018.pdf

Larsen, J; Herndon, W; Marsters, P; & Mohan, S. 2018. *"Energy and Environmental Implications of a Carbon Tax in the United States"*. Center on Global Energy Policy, School of International and Public Affairs at Columbia University: New York, NY, USA.

Lim, B. S. 2017. *"TNB to Buy 70% Stake in Track 4A"*. The Edge Malaysia Weekly, April 24, 2017 – April 30, 2017. Available at https://www.theedgemarkets.com/article/tnb-buy-70-stake-track-4a

Litman, T. 2019. *"Transit Price Elasticities and Cross-Elasticities"*. Victoria Transport Policy Institute: Victoria, B.C, Canada. Available at www.vtpi.org/tranelas.pdf

Lu, C; Rosenberg, J; & Toder, E. 2018. *"Distributional Implications of a Carbon Tax"*. Center on Global Energy Policy, School of International and Public Affairs at Columbia University: New York, NY, USA.

Malaysia. Bank Pembangunan Malaysia Berhad. 2012. *"Report on Oil and Gas Exploration and Production"*, in *"Annual Report 2011"*. Available at www.bpmb.com.my/documents/21475/33700/20.pdf/3723eecd-5976-4fd2-9b10-c1375fbdd4cc

Malaysia. Ministry of Energy, Science, Technology, Environment and Climate Change. 2018. *"Malaysia: Third National Communication and Second Biennial Update Report to the UNFCCC"*. Retrieved from www.mestecc.gov.my

Malaysia. Ministry of Finance. 2017. *"Estimates of Federal Government Revenue 2018"*. Available at www.treasury.gov.my/pdf/percukaian/penerbitan/buku_anggaran_hasil_kerajaan_persekutuan_2018.pdf

Malaysia. Ministry of Finance. 2018. *"Fiscal Outlook and Federal Government Revenue Estimates 2019"*. Retrieved from www1.treasury.gov.my/fo_2019.html

Malaysia. Suruhanjaya Tenaga. 2012. *"Results of International Competitive Bidding for New Capacity in Prai and Restricted Tender for Renewal of Operating Licences of First Generation IPP and TNB Plants"*. Available at www.st.gov.my/contents/files/press/2018-02-28/1519805108.pdf

Malaysia. Suruhanjaya Tenaga. 2014a. *"Result of Competitive Bidding Exercise for New Capacity 2x1000MW Coal-fired Power Plants for Commercial Operation in 2018/19"*. Available at www.st.gov.my/contents/files/tender/2013/Press_Release_Project_3B.pdf

Malaysia. Suruhanjaya Tenaga. 2014b. *"Clarifications on the Announcement of the Result of Competitive Bidding Exercise for New Capacity 2x1000MW Coal-fired Power Plants for Commercial Operation in 2018/19"*. Available at www.st.gov.my/contents/highlight/2014/tender/Media_Release_07032014.pdf

Malaysia. Suruhanjaya Tenaga. 2016. *"Submission of Bids – Large Scale Solar (LSS) Photovoltaic Plant for 2017/2018"*. Available at www.st.gov.my/ms/contents/article/industry/2016/Large_Scale_Solar_2017_2018_-_Bid_Opening_Price.pdf

Malaysia. Suruhanjaya Tenaga. 2017. *"Submission of Bids – Large Scale Solar (LSS) Photovoltaic Plant for 2019/2020"*. Available at www.st.gov.my/contents/article/industry/2017/LSS/Large_Scale_Solar_LSS_Photovoltaic_Plant_for_2019-2020_-_Opening_Bid_Price_v1.pdf

Malaysia. Suruhanjaya Tenaga. 2018a. *"2017 Malaysia Energy Statistics Handbook"*. Available at www.st.gov.my/contents/files/download/116/Malaysia_Energy_Statistics_Handbook_2017.pdf

Malaysia. Suruhanjaya Tenaga. 2018b. *"Peninsular Malaysia Electricity Supply Industry Outlook 2017"*. Available at www.st.gov.my/en/contents/publications/outlook/Peninsular%20Malaysia%20Electricity%20Supply%20Outlook%202017.pdf

Malaysia. Suruhanjaya Tenaga. 2018c. *"Electricity Tariff Review in Peninsular Malaysia for Regulatory Period 2 under Incentive-based Regulation Mechanism"*. Available at www.policy.asiapacificenergy.org/sites/default/files/Electricity%20Tariff%20Review%20in%20Peninsular%20Malaysia%20for%20Regulatory%20Period%202%20%28RP2-%202018-2020%29.pdf

Malaysian Institute of Road Safety Research. 2014. *"Car Annual Vehicle Kilometer Travelled Estimated from Car Manufacturer Data – an Improved Method"*. World Research and Innovation Convention on Engineering and Technology 2014: Putrajaya, MY.

Mansur, E. 2012. *"Upstream versus Downstream Implementation of Climate Policy"*, in *"The Design and Implementation of U.S Climate Policy"* [Fullerton, D & Wolfram, C]. University of Chicago Press: Chicago, IL, USA.

Marron, D & Morris, A. 2016. *"How to Use Carbon Tax Revenues"*. Urban-Brookings Tax Policy Center. Urban Institute and Brookings Institution: Washington, D.C., USA. Available at www.brookings.edu/wp-content/uploads/2016/07/howtousecarbontaxrevenuemarronmorris.pdf

Metcalf, G & Weisbach, D. 2009. *"The Design of a Carbon Tax"*. University of Chicago Public Law & Legal Theory Working Paper No. 254. University of Chicago Law School: Chicago, IL, USA.

Monnin, P. 2015. *"The Impact of Interest Rates on Electricity Production Costs"*. Discussion Notes 1503, Council on Economic Policies. Available at www.cepweb.org/wp-content/uploads/CEP_DN_Interest_Rates_Energy_Prices.pdf

Nordhaus, W. 1994. *"Managing the Global Commons: The Economics of Climate Change"*. MIT Press: Cambridge, MA, USA.

Nordhaus, W. 2017. *"Revisiting the Social Cost of Carbon"*. Proceedings of the National Academy of Sciences in the United States of America, 114 (7): 1518-1523.

Nowak, W & Savage, I. 2013. *"The Cross-Elasticity Between Gasoline Prices and Transit Use: Evidence from Chicago"*. Transport Policy, 29 (9): 38-45.

Ondraczek, J; Komendantova, N; & Patt, A. 2015. *"WACC the Dog: The Effect of Financing Costs on the Levelized Cost of Solar PV Power"*. Renewable Energy, 75 (3): 888-898.

Petronas. 2018. *"Moving Forward Together: Sustainability Report 2017"*. Available at www.petronas.com/ws/sites/default/files/2018-07/sustainability-report-2017.pdf

PricewaterhouseCoopers. 2016. *"The Malaysian Oil and Gas Industry: Challenging Times, but Fundamentals Intact"*. PwC Malaysia: Kuala Lumpur, MY. Available at www.pwc.com/my/en/assets/publications/2016-msian-oil-n-gas-industry.pdf

Rasiah, R; Chenayah, S; & Al-Amin, A.Q. 2015. *"Prioritizing Climate Change Mitigation: An Assessment Using Malaysia to Reduce Carbon Emissions in Future"*. Environmental Science and Policy, 50: 24-33.

Rasiah, R; Ahmed, A; Chenayah, S; & Al-Amin, A.Q. 2016. *"Climate Change Mitigation: Comparative Assessment of Malaysian and ASEAN Scenarios"*. Environmental Science and Pollution Research, 24 (3): 2632-2642.

Ricke, K; Drouet, L; Caldeira, K; & Tavoni, M. 2018. *"Country-Level Social Cost of Carbon"*. Nature Climate Change, 8 (10): 895-900. Further data available at https://country-level-scc.github.io

Sijm, J; Neuhoff, K; & Chen, Y. 2006. *"CO_2 Cost Pass-Through and Windfall Profits in the Power Sector"*. Climate Policy, 6: 49-72.

Stern, N. 2008. *"The Economics of Climate Change"*. American Economic Review, 98 (2): 1-37.

Sun, H. 2016. *"Understanding Public Transit Ridership through Gasoline Demand: Case Study in San Francisco Bay Area, CA"*. Diss. Department of Economics at University of California, Berkeley. Available at www.econ.berkeley.edu/sites/default/files/Hansen%20Sun%20-%20thesis_1.pdf

Tenaga Nasional. 2015. *"TNB Handbook 1QFY'15"*. Available at https://www.tnb.com.my/assets/conference_materials/92d0f87f9f301ce831a390d733121d77.pdf

Tenaga Nasional. 2018a. *"Growing Better Together: Integrated Annual Report 2017"*. Available at www.tnb.com.my/assets/annual_report/TNB_Annual_Report_2017.pdf

Tenaga Nasional. 2018b. *"Shaping the Energy Landscape: Integrated Annual Report, 4-Month Period Ended 31 December 2017"*. Available at www.tnb.com.my/assets/annual_report/TNB_AR2017_4MONTH_PERIOD_ENDED_31_DECEMBER_2017.pdf

Tenaga Nasional. 2018c. *"Powering Better Brighter Nations: Sustainability Report 2017"*. Available at www.tnb.com.my/assets/annual_report/Sustainability_Report_2017.pdf

Tenaga Nasional. 2018d. *"Presentation to Analyst: Unaudited Consolidated Result for the 1Q FY2018"*. Available at https://www.tnb.com.my/assets/quarterly_results/Analyst_Briefing_1QFY2018.pdf

Turrentine, T; Heffner, R; & Kurani, K. 2007. *"Fuel Economy: What Drives Consumer Choice?"*. University of California Transportation Center: Berkeley, CA, USA.

United States. Energy Information Administration. *"Annual Energy Outlook 2019 with Projections to 2050"*. EIA at the United States Department of Energy: Washington, D.C., USA. Available at www.eia.gov/outlooks/aeo/pdf/aeo2019.pdf

United States. Forest Service. 2011. *"Emissions Reduction Techniques for Oil and Gas Activities"*. FS at the United States Department of Agriculture: Washington, D.C., USA. Available at www.fs.fed.us/air/documents/EmissionReduction-072011x.pdf

United States. Interagency Working Group on Social Cost of Carbon. 2016. *"Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866"*. Available at www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf

United States. Interagency Working Group on Social Cost of Carbon. 2010. *"Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866"*. Available at www.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf

United States. National Oceanic & Atmospheric Administration Earth System Research Laboratory. 2018. *"The NOAA Annual Greenhouse Gas Index (AGGI)"*. NOAA at the United States Department of Commerce: Washington, D.C., USA. Available at https://www.esrl.noaa.gov/gmd/aggi/aggi.html

Weitzman, M. 2011. *"Fat-Tailed Uncertainty in the Economics of Catastrophic Climate Change"*. Review of Environmental Economics and Policy, 5 (2): 275-292.

Weitzman, M. 2013. *"Tail-Hedge Discounting and the Social Cost of Carbon"*. Journal of Economic Literature, 51 (3): 873-882.

Weitzman, M. 2017. *"On a World Climate Assembly and the Social Cost of Carbon"*. Economica, 84 (336): 559-586.

Wong, KY; Chuah, JH; & Hope, C. 2016. *"Carbon Taxation in Malaysia: Insights from the Enhanced PAGE09 Integrated Assessment Model"*. Carbon Management, 7(5-6): 301-312.

World Bank. 2017. *"Report of the High-Level Commission on Carbon Prices"*. High-Level Commission on Carbon Prices, Carbon Pricing Leadership Coalition. World Bank: Washington, D.C., USA. Available at https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices

World Bank & Ecofys. 2018. *"States and Trends of Carbon Pricing 2018"*. World Bank: Washington, D.C., USA. Available at https://openknowledge.worldbank.org/bitstream/handle/10986/29687/9781464812927.pdf

World Nuclear Association. 2011. *"Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources"*. World Nuclear Association: London, UK. Available at http://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Working_Group_Reports/comparison_of_lifecycle.pdf

Zaid, S & Graham, P. 2017. *"Rising Residential Energy Consumption and GHG Emissions in Malaysia: A Case Study of Public Low-Cost Housing Projects in Kuala Lumpur"*. Indoor and Built Environment, 26 (3): 375-391.