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Climate Policy: An Equitable Approach

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Executive summary

The challenge of climate change for national governments lies not only in driving climate action but also in determining an equitable share of climate action in a multilateral context. This paper argues that an equity-informed approach can help governments of developing countries navigate the twin prerogatives of solving for climate change and achieving development, thus achieving climate-resilient development. This paper explores: (1) the equity implications of climate burden sharing; (2) the equity risks imposed by climate mitigation as implied in low-carbon transition; and, (3) enabling conditions as implied in formal climate legislation. This paper uses the Climate Equity Reference Framework for the analysis of climate burden sharing. This paper also compares ten developed and developing countries' Long-term Low-Emission Development Strategies and National Climate Change Acts to examine the equity implications. Discussions of policy implications are situated in the Malaysian context.

This paper finds that:

1. Indonesia and Thailand have set mitigation goals that are higher than or appropriate to their fair share, whereas the United States' goals are far lower than their fair share. The United States ought to significantly ramp up mitigation actions. Malaysia's climate goal remains slightly above its fair share if we consider carbon sink removals, Malaysia should pursue balanced mitigation action subject to fair burden sharing according to equity principles.
2. Emerging risks of low-carbon transition are distributed unevenly among developed and developing countries. Transition potentially affects developing countries' source of trade, fiscal space, and employment in key productive industries. Malaysia is exposed to distributional risks associated with transition.
3. Formal institutions of climate legislation provide an avenue to establish institutional arrangements that deepen cross-agency coordination, dedicated oversight bodies for goal management, and financing mechanisms for climate actions. Malaysia can learn from developed and developing country experiences to design a legal framework that ensures balanced mitigation and adaptation outcomes.

Malaysia, as a developing country with middle-to-low climate change responsibility, faces the twin challenge of achieving development under climate constraints and potential macroeconomic and technology risks owing to the country's reliance on fossil fuel resources. Because of the country's climate vulnerability and likelihood to emit more than its fair share without its natural reserves, the country must conserve and maintain its level of carbon sinks and removals, and allocate more emphasis to climate adaptation action, ideally achieving a balance between mitigation and adaptation, as well as climate and other important social goals.

Under international climate agreements such as the Paris Agreement, Malaysia has the right to pursue its developmental aspirations and receive international support in the form of technology, finance and capacity building. In pursuit of low-carbon transition, it is crucial for the government to ensure equitable distribution of costs and benefits, which calls for the close examination of distributional risks associated with many mitigation policies. In the design of formal institutions for climate governance, it is key to put in place mechanisms that improve whole-of-government coordination, secure international support, and careful assessment of policy instruments to avoid adverse distributional outcomes.

Policy implications

1. Malaysia's net emission target surpasses our fair share of emissions reduction. By removing conditionality from its Nationally Determined Contribution (NDC) under Article 3 of the Paris Agreement, Malaysia is effectively contributing more than its means without external support. This situation hinders the country's ability to fulfil its treaty obligations. Adhering to the intended target would subject Malaysia to standards typically applied to developed countries, despite being categorized as a developing nation (Article 4 of the Paris Agreement entitles developing countries to support from developed countries, it recognises support from the latter allows for higher ambition by developing countries).
2. Malaysia's target is framed in terms of economy-wide emission intensity, which presents two distinct challenges. Firstly, the country must continuously improve its GDP-to-emissions ratio. Our target ties GDP growth to emission efficiency, requiring GDP to grow at a faster rate than emissions. This **puts bigger pressure on Malaysia to transition** away from inefficient carbon-intensive energy consumption, facilitated by low-emission energy sources like renewable energy. Secondly, available carbon sinks are inherently crucial for accounting for economy-wide emissions. In the case of higher emission intensity (lower GDP with higher emissions), emission offsets become the primary source of abatement. Therefore, **conserving existing carbon sinks is essential.**
3. **Malaysia's reliance on fossil fuel resources for fiscal revenue poses a constraint.** Fiscal policy plays a critical role in transition financing and achieving other developmental goals. The potential disruption of this revenue stream due to the global transition limits public spending capacity, which is essential for the less bankable but critical transition investments. Hence, strengthening fiscal sources, particularly a wider tax base, is paramount for the government. This expansion is contingent on improved household income.
4. Past income growth woes have restricted the purchasing power of Malaysian workers, particularly those in lower income brackets. Household energy spending as a share of income is higher for poorer households and lower for richer households. A price hike in energy products, whether through carbon pricing mechanisms or power market price fluctuations, can disproportionately impact vulnerable groups. The government can implement targeted subsidies to mitigate the impact of inflation on energy products and a wide range of goods and services. However, the extent of inflation stopgap relies on monetary policy. Revenue recycling from carbon tax, if implemented, can partially replace lost fiscal revenue from fossil fuel sources, however, fiscal reform is needed as carbon tax receipts will decline overtime.
5. The economic opportunities of transition ought to be strategically captured. Malaysia's participation in the global green value chain and the promotion of local green energy are expected to generate employment. The **displacement of high-skill, high-productivity jobs should be counterbalanced by equivalent job gains** in the new sector. This could be challenging due to the diverse range of jobs within the green sector. Malaysia's position within the green value chain determines the types of jobs created. Low-productivity, labour-intensive, and low-wage jobs may dominate new job gains. Creation of high-skill, high-income jobs has been difficult in the past decade due to deeper structural challenges.
6. In addition to transition risks, Malaysia is also vulnerable to the physical impacts of climate change, necessitating a balanced approach to planning and investment. Public spending is crucial due to the low commercial viability of these projects.

Policy recommendations

1. **Align all policies with a fair climate mitigation and adaptation goal consistent with the principles of Common but Differentiated Responsibilities and Respective Capabilities (CBDR).** This approach addresses the issue of international equity. Sub-sector targets should collectively contribute upwards to the national goal, as represented by the NDC, through practical means, considering national circumstances and development needs.
2. **Balance the distributional risks of the transition to a low-emission economy.** This requires identifying the risks and groups at risk, such as those vulnerable to inflationary pressure, energy insecurity, and climate impacts. Scenario modelling is helpful for this purpose, with emphasis on cost-benefit balancing across groups. The government can design policies to mitigate inequitable outcomes by implementing cross-subsidization mechanisms or redistributing carbon tax or windfall tax to social programs. Additionally, the government can support the transition of vulnerable groups' energy use to low-emission alternatives.
3. **Implement institutional designs that promote effective cross-agency coordination.** A national framework law can: (1) establish general principles of climate policy-making; (2) define clear roles and responsibilities of all levels of government in climate action; (3) strengthen cross-governmental coordination; and (4) establish a dedicated fund to tap into international finance and resources. Currently, the National Climate Change Action Council performs some of these roles; however, transparency and performance monitoring could be improved.
4. **Avoid institutional designs that risk entrenching inequities without offering an exit strategy.** Market-based instruments such as Emissions Trading Schemes (ETS) and carbon pricing can result in inequitable outcomes both internationally and sub-nationally. For instance, carbon pricing instruments implemented domestically under trade pressure may disregard the responsibilities of developed countries and unfairly burden local firms, while regressively impacting low-income households. Therefore, the distributional risks of market-based instruments need to be thoroughly assessed before being established through law.

Contents

1. Introduction

1.1. Background

Climate change has foregrounded many challenges for national governments of developing countries. Among them, rising temperature leads to climate extremes that incur losses in economy and livelihoods. These effects necessitate countries to enact actions that adapt to such impacts, as well as reduce emissions of warming gases to mitigate further warming. However, as most developing countries still need to raise living standards, which warrant some levels of energy use and emissions, they now face the challenge of achieving socio-economic development under the constraints of mounting climate impacts and shrinking climate space for permissible emissions.

Developing countries, therefore, are compelled to progress towards climate-resilient development, or "development trajectories that combine adaptation and mitigation to realize the goal of sustainable development"[1]. This means that socio-economic development cannot pursue the unsustainable pathways of the past, such as those undertaken by developed countries.

Our current global economic system is embedded in energy infrastructure based on fossil fuels, which are a primary source of global warming. Sustainable development in the context of climate change necessarily entails the transformation of socio-economic systems to production and consumption that are low-emissions, using energy sources that emit little or no warming gases as by-products. A climate-resilient development, therefore, must balance the transition of energy-use, which addresses the source of warming, and the adaptation to climate impacts, which protects communities from the ramifications of climate change.

There are risks of inequities associated with transition, which hinder the attainment of sustainable development. Transition is costly; massive investments are needed to expand renewable energy infrastructure in a world where fossil fuel-based energy production is still prevalent. Rapid fossil fuel phase-outs will lead to abrupt decommissioning of fossil assets, disrupting supply chains, costing jobs and livelihoods. There are also benefits associated with transition. Apart from environmental gains from reduced emissions, transition also offers economic opportunities in the low-carbon value chain, driving demand and job creation. However, the costs and benefits of transition, if not balanced-out, are likely to be unevenly distributed between the developed and developing countries.

Second, there are institutional risks that arise from the emergence of "winners and losers" in the transition process. As transition involves a "dramatic renegotiation of the institutions that structure economic and social activity within each economy"[2], and national governments now assume a larger role in climate governance, there is a need to carefully design institutional forms, such as laws and regulations, to ensure redistributive equity and avoid risks of locking-in undesirable outcomes.

Under the Paris Agreement, this onus of making development work within climate constraints has fallen largely upon the shoulders of national governments. Not only now are governments straddled with the tasks of managing the impacts of carbon pollution and climate risks but

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[1] Schipper et al. (2022)

[2] Aklin and Mildenberger (2020)

manoeuvring the changing global economy in pursuit of sustainable development. Developing countries face the constant risk of being swept out by economic, technological, and ecological shifts.

Such challenges invoke the importance of an equity perspective, especially for developing nations. Equity is indispensable in formulating a balanced climate action, where climate goals can be achieved without encroaching on the developing state and its citizens' rights to a dignified life or burdening the state and the economy with undue obligations, which may stifle necessary development, or worse, exacerbate living conditions of those in developing countries.

1.2. Aligning climate actions for Malaysia

Tackling climate change effectively necessitates a unified global effort. Since all countries contribute to greenhouse gas emissions, albeit to varying degrees, meaningful climate action must originate at the international level. International climate treaties serve as the bedrock of global climate change governance. Among the major treaties are the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement (PA). These multilateral agreements lay the groundwork for collaborative global action.

The Paris Agreement establishes the mechanism for collaboration in Article 4, which allows country parties to independently communicate their Nationally Determined Contribution (NDC) or the intended level of climate mitigation and adaptation effort. NDC thus represents a party's obligation to the agreement; observing the commitment is therefore important for effective collective action. In its updated NDC, Malaysia has committed to “reduce its economy-wide carbon intensity (against GDP) of 45% in 2030 compared to 2005 level”[3].

National initiatives were announced within the target period of the updated NDC (2021 to 2030). Among forthcoming initiatives in the 12th Malaysia Plan (RMK-12) were the National Climate Change Act (NCCA), NDC Roadmap, Long-Term Low Emission Development Strategy (LT-LEDS), and National Adaptation Plan (MyNAP). This set of policies informs Malaysia's vision of climate-resilient development and sets forth the country’s strategy for tackling the core issue of development under climate constraints. They also lay the foundation for policy integration by setting the principal direction for local actors to align individual action plans, tailor respective strategies, and consequently arrive at a unitary national goal. Both legislative and non-legislative measures were put forward in the package, but there remains little clarity on the role they play, their alignment, as well as their implications towards society, economy, and above all, equity.

Both public and private actors have taken it upon themselves to implement sector-specific climate-related actions. For example, the Kuala Lumpur Low Carbon Society Blueprint 2030, Low Carbon Society Blueprint Iskandar Malaysia 2025, and PETRONAS' Pathway to Net Zero Carbon Emissions 2050, among others.

These localised policies of sub-national governments and firms inform local actors' decisions, and the absence of interactions among policy silos implies little to no integration among policy domains[4]. Policy integration is widely agreed to be essential in addressing cross-cutting problems such as climate change[5]. Because the nature of the climate problem involves sources and consequences that cascade over segments of the socio-economic system (sectors and

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[3] Malaysia (2021)

[4] Khailani and Perera (2013); Hezri (2016)

[5] IPCC (2022a)

jurisdictions), coordination among governance levels and respective policies is key to ensure alignment for effective implementation and minimise efficiency loss, as well as a balanced strategy that preserves socio-economic development and, at the same time ensure substantive attainment of climate goals.

National climate strategy is crucial for determining a fair level of country climate action, lining up mitigation and adaptation actions with global objectives, and balancing developmental priorities and climate actions. Absent careful consideration of equity, and an understanding of the country's capabilities and obligations, Malaysia risks boxing itself into unfair commitments, constraining developmental space, and consequently producing uneven outcomes that undermine the attainment of overall sustainable development.

This paper intends to study the challenges of climate-resilient development from a climate equity perspective. The paper is organised as follows: Section 2 demonstrates the equity problem of climate burden-sharing by comparing and examining the climate burden fair shares of four selected countries: Indonesia, Thailand, the United States (USA), and Malaysia. Section 3 reviews the literature on the risks associated with low-carbon transition and assesses the Long-term Low Emission Development Strategies (LT-LEDS) of the four previously identified countries. Section 4 discusses the institutional form, focusing on the legal instruments for climate change governance. The section also compares the National Climate Change Acts (NCCA) of six selected countries: the United Kingdom, Australia, Mexico, South Korea, Pakistan, and the Philippines. We end each section with discussions on policy implications for Malaysia.

1.3. Methods

Climate change is a "distributive problem"[6]. The design of climate change policy cannot avoid the task of determining the adequate "distribution of rights and responsibilities for environmental and social impacts" among global and local actors[7]. However, a prevalent trend among policy and decision-makers is an acceptance of "cost-effective" or market-based instruments. Market-based instruments are climate policies where the primary goal is an economically-efficient outcome where the marginal costs of climate stabilization are balanced with marginal benefits[8]. In other words, this set of policies focuses on minimizing the cost by allocating mitigation wherever it is cheapest. However, climate policies left to the whims of the market often bear the hallmarks of inequitable distribution. Where only efficient allocation of cost is considered, actual costs may be incommensurate to the share that ought to be borne by responsible actors, while benefits are allocated away from those who need them.

Economic efficiency in climate policies must be deliberated in tandem with the objectives of (1) global climate stabilization and (2) socio-economic development in developing countries to ensure dignified living. This entails a critical perspective on cost-effective approaches to climate actions. There is, therefore, a need to ground the study of climate policy in an equity perspective. Such a perspective allows us to assess the soundness of actions in delivering effective climate stabilization via equitable sharing of efforts among groups of different responsibilities and capabilities. This section articulates the analytical framework and conceptual definitions used in this study.

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[6] Finnegan (2022); Aklin and Mildenberger (2020)
[7] Schroeder and McDermott (2014)
[8] N. H. Stern (2007)

Climate policy instruments broadly fall into three types: (1) regulatory or formal rules and laws; (2) economic or structured remuneration and deprivation; and (3) information or intellectual and normative appeals[9]. These instruments are enabled by the general toolkit at the disposal of legislative and executive arms of government, i.e., a combination of legislation and executive orders available to make incentives and deterrence towards a defined climate goal.

In this paper, we are interested mainly in the first and the second type. We intend to compare two main types of policy among countries, i.e.:

1. National Climate Change Act (NCCA); and
2. Long-term Low Emissions Development Strategy (LT-LEDS)

The rationale of the scope is as follows:

NCCA or climate change framework legislation often form the basis of national climate governance. The law defines the rules and procedures under which options are structured and enables interventions or non-interventionist arrangements[10]. NCCA offers a view into the institutional foundations on which other climate or related policies can be built. LT-LEDS is one policy tool developed by governments to guide socio-economic actors in the societal transition towards a low-emissions economy. Although not a requirement under the Paris Agreement (Article 6), many countries voluntarily submit LT-LEDS to a unified registry, which makes comparisons possible. LT-LEDS offers a view of the socio-economic pathways under consideration and the general intent of governments in attaining respective climate goals. LT-LEDS is useful for comparisons of policy credibility with respect to national circumstances.

To this end, we adopt an equity framework for the analysis of our comparative results. Borrowing Kasperson and Dow (1991) and McDermott et al. (2013), the equity framework establishes a set of guiding parameters for researchers to frame their analysis of the equity problem and to make explicit the value assumptions from the outset.

Equity is defined in this study as the **quality of fairness in both the process and the associated outcomes of a policy or decision**[11]. We refer to the international legal usage of the concept, as enshrined in the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement (PA). The UNFCCC sets down the principle of **Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC)** for all actions aimed at stabilizing the climate system[12]. This principle provided for differentiation among contracting parties according to differences in "the capability to resolve climate change problems, the vulnerability to climate change, and the responsibility for emissions"[13]. This differentiation is reflected in the types of mitigation targets, obligations on financial transfers, and options on flexible mechanisms[14]. However, the terms of a fair differentiation can be less clear than intended in international agreements. For example, the PA did not specify the weights and relationship between responsibilities and capabilities nor the qualifying criteria for development categories. The content of equity also varies under different contexts, which can refer to access to development

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[9] IPBES secretariat (n.d.); Bemelmans-Videc, Rist, and Vedung (1998)
[10] Bemelmans-Videc, Rist, and Vedung (1998); Averchenkova, Fankhauser, and Nachmany (2017); Rüdinger et al. (2018)
[11] Kasperson and Dow (1991)
[12] 'United Nations Framework Convention on Climate Change' (1992), Article 3.1
[13] Will (2020)
[14] Ibid.

and poverty alleviation, geographical representation, and intergenerational access to stable climate, among others[15].

Ringius and colleagues (2002) referred to the principle of equity as applied in international negotiations as an appropriate distribution of costs and benefits according to some accepted dimensions of importance[16]. Regarding burden sharing, the common notion of fairness is that those who contributed significantly to the climate problem should be accorded proportionate responsibility to "clean up the mess". One common measure used is cumulative or historical greenhouse gas (GHG) emissions. Similarly, those with a higher "ability to pay" should proportionately bear the costs of mitigation action. In this regard, a widely used yardstick in measuring wealth is GDP per capita[17]. This is discussed in detail in Section 2. In terms of the distribution of benefits, which in the climate context may refer to lowered climate impact from temperatures or reduced environmental damage costs, this may be distributed according to the principle of contribution in providing a good or according to needs. This is represented as a matrix in Table 1.1:

Table 1.1: Key principles of equity

Focus on	Object to be distributed	
	Costs (obligations)	Benefits
Cause of the problem	Responsibility (for causing the problem)	Contribution (to solving the problem or providing the good)
Consequences for actors	Capacity (ability to pay)	Need

Source: Adapted from Ringius et al. (2002)

The content of equity can be broken down into three analytical dimensions, namely: (1) distributive, (2) procedural, and (3) contextual. We are interested in the distributive dimension, i.e., the "burdens and benefit-sharing across countries and across time",[18] and the contextual dimension, i.e., the context in which political processes and distributive outcomes are situated[19]. We operationalise the two dimensions with measures as listed in Table 1.2, in which the distributive dimension will be the parameters of assessment while the contextual dimension serves as the basis for selection and normative evaluation.

Table 1.2: Operationalised measures of two equity dimensions

	Distributive	Contextual
Responsibility	fair share allocation; NDC	historical emissions
Capabilities	impact of response measures (GDP change)	socio-economic developmental status by indicators (GDP per capita)

This assessment of national-level climate policies takes into account the respective responsibilities, capabilities, and national circumstances of each country, which considers the historical effects of global inequities, which have led to varying roles and powers of nation-states[20], as opposed to the common practice of comparing countries on an equal benchmark in ahistorical and/or best practice indices[21].

[15] Will and Manger-Nestler (2021)
[16] Ringius, Torvanger, and Underdal (2002)
[17] Ibid., Dooley et al. (2021)
[18] Stavins et al. (2014)
[19] McDermott, Mahanty, and Schreckenberg (2013)
[20] IPCC (2022c)
[21] Dooley et al. (2021)

A fair share of global mitigation efforts refers to the equitable level of emission reduction that ought to be undertaken by a country to achieve the goal of global climate stabilization. Delimiting what an equitable level is a widely debated field. One method of deriving the fair share amount is to account for the responsibility and capability of countries. This analysis uses the Climate Equity Reference Framework (CERF)[22] and its tool, the Climate Equity Reference Calculator (CERc)[23] , to derive the fair share allocation for each selected country. The CERF, developed by the Stockholm Environmental Institute (SEI) and EcoEquity, is a "general framework for burden-sharing for climate change that takes both responsibility and financial capability into account"[24]. The framework allocates the mitigation burdens as a share of the total remaining global carbon budget[25]. CERF develops a Responsibility-Capacity Indicator (RCI), which is used as a weighted sum to allocate emissions share based on the cumulative responsibility and national income. The details of the method and settings are outlined in Section 2.1.

Along with fair share, we also seek to understand the risks of low-carbon transition faced by countries with respect to just transition. Just transition refers to the "set of principles, processes and practices that aim to ensure that no people, workers, places, sectors, countries or regions are left behind in the transition from a high-carbon to a low-carbon economy"[26]. In this paper, we aim to analyse countries' respective statuses in the just transition process, which involves examining their intent, their capacities, and their fair responsibilities in facilitating a just transition.

Second, we outline the low-carbon transition risks facing countries along three dimensions: (1) macroeconomic risk, (2) distributional risk, and (3) technology risk. We review the intranational and international implications on equity under these dimensions, focusing on the effects of labour, income, trade, and technology. We then compare the LT-LEDS of three countries, Indonesia, Thailand, and the United States (USA), against their national capabilities and responsibilities, as well as fair shares of climate effort as derived in the preceding section.

In this comparative exercise, we consider two additional indicators for national capabilities aside from GDP per capita. In the context of transition risks, we also look at the (1) dependency on fossil fuels and (2) state capacity towards low-carbon transition as indicators of national capability. The identified variables under these two indicators are listed below. This considers the importance of affordable energy, primarily supplied by fossil fuels, towards the development of the assessed country. The comparisons also consider the relative capacity of governments to facilitate low-carbon transition in the absence of international support. The detailed rationale for the exercise is explored in the corresponding section.

[22] Christian Holz, Kartha, and Athanasiou (2018)
[23] Ceecee Holz et al. (2019)
[24] Kemp-Benedict et al. (2018)
[25] Friedlingstein et al. (2020)
[26] IPCC (2022b), p. 1806

Table 1.3: Indicators of capabilities

Indicator	Variable
Economic fossil dependence	Economic share of fossil fuel (% of export; % of GDP); Employment share of high-risk sector
State transition capacity	Government energy spending (% of GDP); Fossil fuel rent (% of government revenue)

Third, we compare the national climate change laws of six countries, i.e., the United Kingdom, Australia, South Korea, Mexico, Pakistan, and the Philippines. We analyse the legal provisions in terms of the national circumstances, scope, and utility of the law in light of the capabilities and responsibilities of the country. We then discuss the observations with respect to equity and implementation in Malaysia. Details of the method are discussed in Section 4.1

2. A fair share of climate space

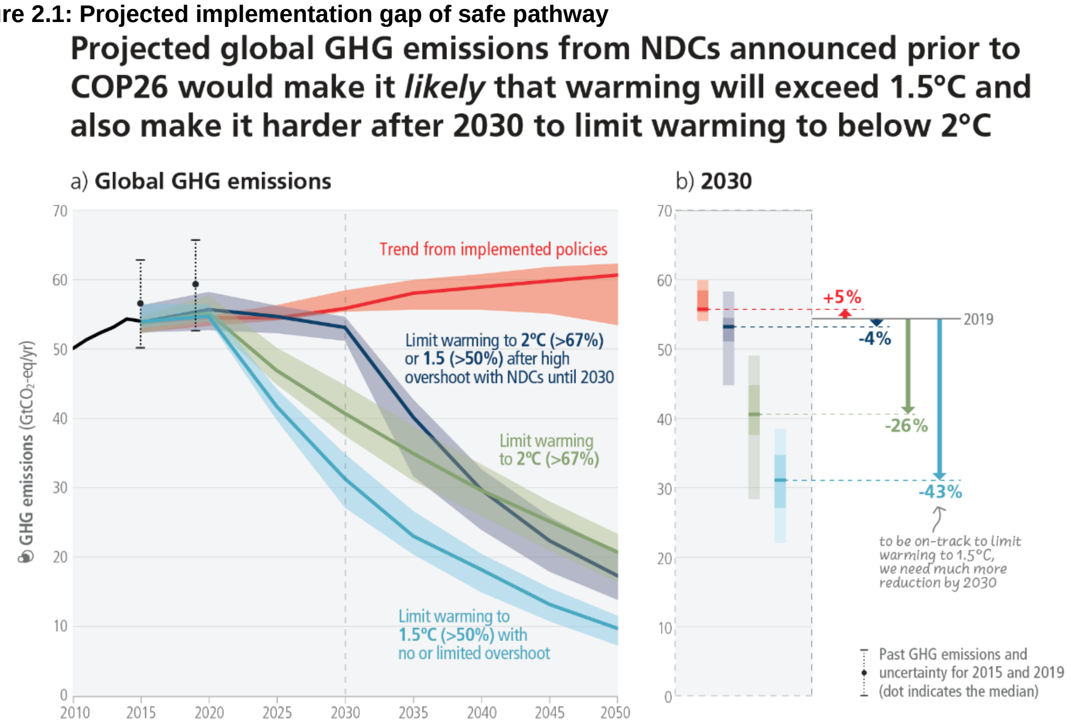
A fact to consider when discussing global climate equity is that

> *There is simply not enough "environmental space" for the still-poor to develop in the same way [...] as that which was taken by the already-rich.*[27]

The global carbon budget of keeping within the 1.5°C pathway is rapidly shrinking, and humanity is on track to overshooting[28]. The remaining permissible amount of carbon emission to keep global temperatures below climate targets **has shrunk by 32 GtC (121 GtCO$_2$)** since the IPCC AR6 assessment based on 2019 data[29]. IPCC (2023) warned that "If the annual CO_2 emissions between 2020 – 2030 stayed, on average, at the same level as 2019, the resulting cumulative emissions would almost exhaust the remaining carbon budget for 1.5°C".

For as long as the emission reduction is deferred, the window of securing a future within a safe pathway will close further, and subsequent efforts needed to recoup will gravely rise. This future will inevitably aggravate inequalities among developed and vulnerable groups.

Figure 2.1: Projected implementation gap of safe pathway



Source: IPCC (2023)

The fast-depleting carbon space points to the need for not just limiting but also rapidly and deeply cutting back on emissions. Because the entire global economic system runs mainly on fossil fuel-based energy, which is the major source of human GHG emissions, a large chunk of that reduction must happen in the energy sector. This can be done in two ways: reduction of energy use and/or

[27] Baer, Athanasiou, and Kartha (2007)

[28] IPCC AR6 (2023) has revised lower the likelihood of limit warming below 1.5°C since its 2018 special report. In keeping with the equitable pathway vulnerable countries need for continual progress, rather than a higher likelihood scenario, this paper analyses fair share at the 1.5°C pathway.

[29] Friedlingstein et al. (2022)

reduction of emission per unit energy use. The first approach includes both absolute reduction of energy use or energy efficiency improvements, and the second approach involves changing the source of energy away from fossil fuels. Both approaches can imply widely unequal consequences for developed and developing groups.

Empirical studies have drawn evidence of the close relationship between energy use and socio-economic development. Limiting energy, especially access to affordable energy can mean constricting developmental space for poorer countries[30], in effect foreclosing their ability to address issues of poverty and to provide the most marginalised group their right to a dignified, productive life. While developed countries may have fewer technical barriers to achieving such reduction, political and economic feasibility have impeded meaningful progress[31].

By shifting to zero or low-emission energy sources, energy transition can theoretically sustain the same growth in energy use on reduced emissions. As discussed in Section 3, an economy-wide transition is costly and costs more for poorer countries than wealthier countries. Energy transition on the global scale has seen sluggish growth compared to the required rate and concentrated in advanced economies[32]. This asymmetry is due to the higher cost associated with the unfavourable position of lower-income countries in the international financial structure, which market forces alone cannot address[33].

While there are pressures at international fora for developing countries to comparably step-up mitigation efforts, the resources transferred to developing countries are insufficient, even by the benchmark set by developed countries[34]. Developing countries must balance other development goals such as poverty eradication, food and energy security, and intra-national inequalities within the constraints imposed by rapidly depleting carbon space and, at the same time, address the climate impacts that aggravate conditions for achieving those social goals.

Behind the glaring distributional predicament are the often-ignored structural inequities that gave rise to the climate crisis as it is currently experienced. The long-term memory of the earth system, i.e., the persistence of GHG in the climate system over a long time scale and the lag in climate response to earth system processes, means that the effect of current warming, apart from being a result of direct forcing, is also influenced by past emissions[35]. Through the extraction of fossil fuels, humans release carbon into the atmosphere at a rate above the natural sequestration rate of the carbon cycle, compounded by large land-use changes such as deforestation, which removes surface carbon storage. The accumulation of GHG in the atmosphere is what gave rise to global warming.

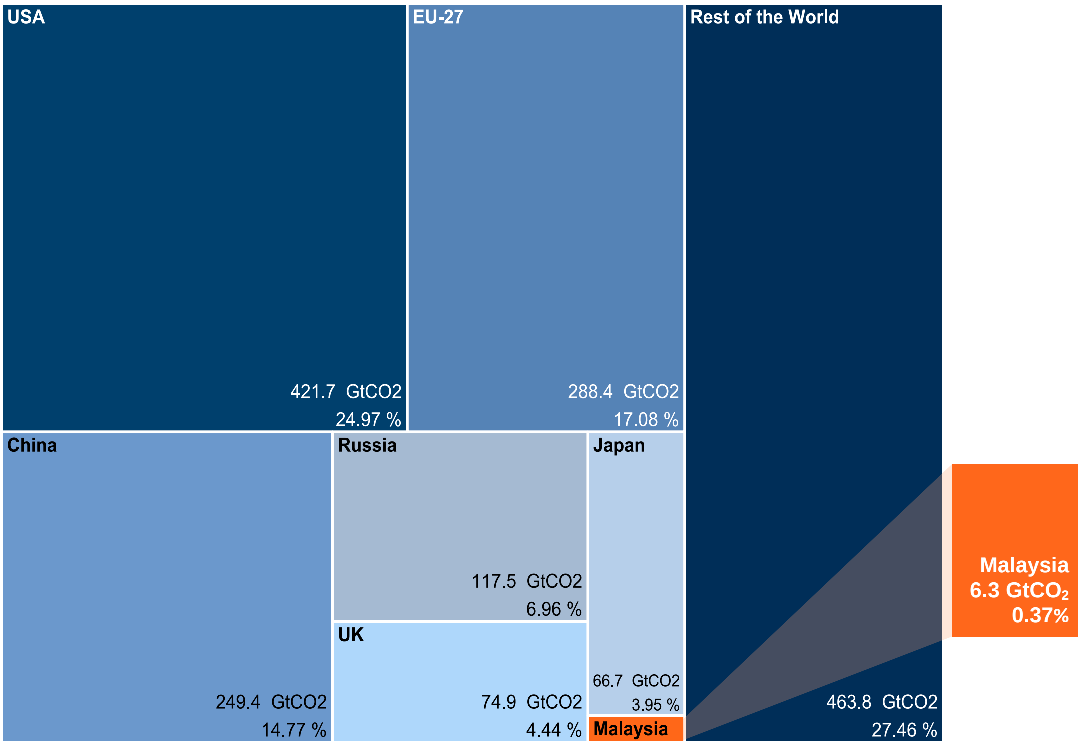
Historically, the high emitters have played the primary role in driving this process. The few developed states have achieved much of their socio-economic status off the back of extraction and unbridled emissions, much of which occurred in the colonies, which build up most of the developing world today. Besides the extractive economic processes that engendered runaway global warming, colonial history also laid down the world system structure that continues to

[30] D. I. Stern, Burke, and Bruns (2017)
[31] Bejar-Garcia (2020)
[32] IEA (2023b)
[33] Avantika Goswami and Ananya Anoop Rao (2023), see Section 3.1
[34] Zagema et al. (2023)
[35] Zickfeld and Herrington (2015); Yuan et al. (2022)

entrench the economic and political power of a few, while depriving the developing world of their capacity to build resilience against adverse climate impact[36].

There is indubitably a deep historical responsibility that the developed countries bear, past what cumulative emissions can account for. The present problem of the climate crisis suggests that as emissions in the developed world slowly taper off, emission reduction should mainly be undertaken in developing countries as annual emissions of countries like China and India have surpassed those of the United States and Europe[37]. However, this argument fails to recognise the culpability of the developed states, their insufficient performance in achieving reduction[38], and their disproportionate power in the international climate legal regime that allowed them to move the goalpost to their advantage.

Figure 2.2: Cumulative carbon emissions of major emitting regions and countries, 2021



Source: Friedlingstein et al. (2022); Author's visualization

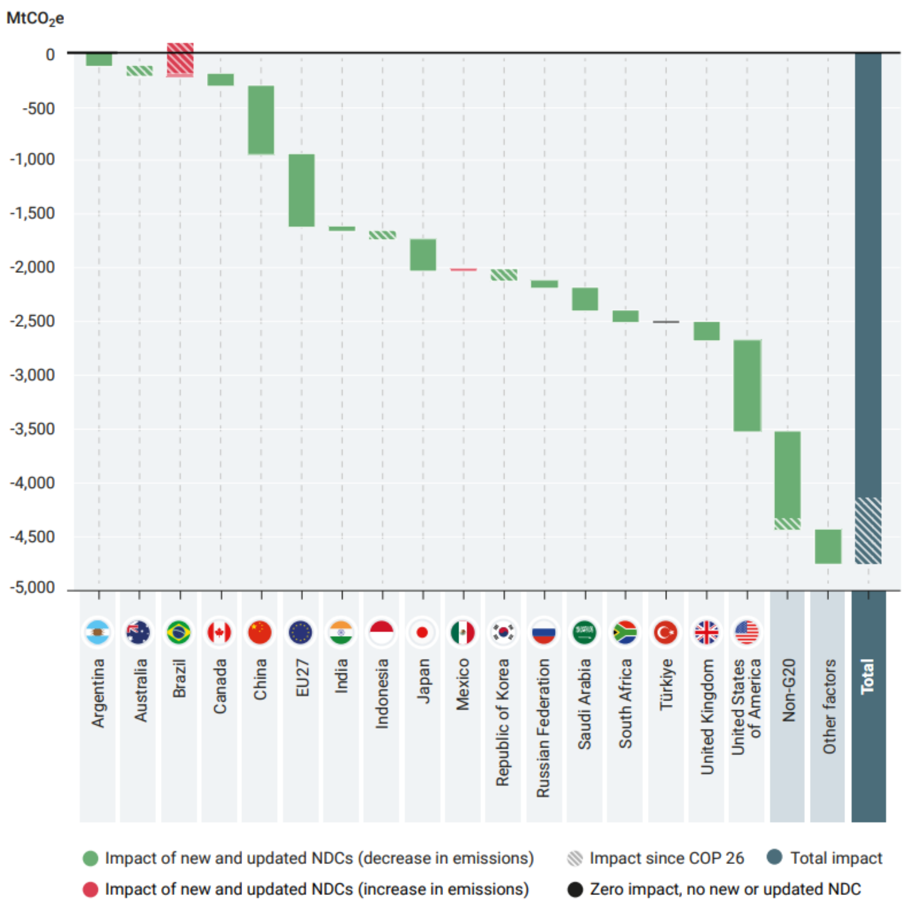
An equity perspective argues that the common effort to stabilise global warming cannot be equally borne by all global actors but ought to follow the principle of CBDR-RC as enshrined in international climate treaties[39]. This means that the onus of mitigation should be fairly allocated to countries proportionate to their responsibilities in causing global warming while considering their respective financial and technological capabilities. The global mitigation effort should also make space for sustainable development in developing countries to address social needs while asserting the obligation of developed countries to provide resources to facilitate sustainable development.

[36] Rodney (2018); Letzing and Sung (2022); IPCC (2022a), B.2
[37] China's emission is in fact so high that the country managed to reach 3rd highest in cumulative CO_2 emissions in the span of five decades from 1950 to 2000.
[38] USA remains the second highest annual emitter and EU-27 the fourth despite driving the highest rate of reduction, pointing to the high absolute emissions.
[39] 'United Nations Framework Convention on Climate Change' (1992); 'Paris Agreement' (2015)

Are the developed countries doing enough?

The United Nations Environment Programme (UNEP) emissions gap report[40] shows, assuming full implementation of all unconditional NDCs as of 2022, which translates to an additional annual reduction of 4.8 $GtCO_2e$ by 2030, a gap of 23 $GtCO_2e$ (19 – 25 $GtCO_2e$) remains of the required emission reduction to meet the IPCC recommended 1.5°C limit of global warming by 2050[41]. Assuming that all conditional and unconditional NDCs are implemented, the gap merely closes to 20 $GtCO_2e$.

Figure 2.3: Impact on global GHG emissions in 2030 of new and updated unconditional NDCs relative to initial NDCs



Source: Adapted from UNEP (2022)

UNEP (2022) found that the combined pledges of the G20 group make up around -3.55 $GtCO_2e$ annual reductions by 2030. Adding on the contributions of the non-G20 group and other factors of reduction, such as international transport, the global figures merely make up to -4.8 $GtCO_2e$ by 2030, which is -23 $GtCO_2e$ away from keeping with the 1.5°C-consistent pathway. For global temperature to stay within the 1.5°C-consistent pathway, global mitigation pledges need to increase almost five-fold. In comparison, the combined pledges of the G7 group, which consists of high-emitting developed states (excluding China), merely amount to -2.08 $GtCO_2e$ by 2030, which

[40] United Nations Environment Programme (2022)

[41] The median estimate of level consistent with 1.5°C was budgeted at around 360 $GtCO_2$ (67%), which means annual global total emissions should fall within 33 $GtCO_2e$ in 2030.

is less than 10% of the annual emission reduction required to reach the 1.5°C-consistent pathway. This is despite the group alone emitted a quarter of the world's total annual emissions in 2019 (22.8%, all GHG, inclusive of EU-27)[42] and 44% of the world's cumulative CO_2 emissions[43].

Nonetheless, NDC pledges only paint a picture of aspirations. UNEP found that under current policy scenarios, the G20 members are projected to fall short of their NDCs by 1.8 $GtCO_2e$. This is half of what the group had pledged. Without aggressively ramping up action, the current policies will widen the gap needed to reach a safe trajectory further.

The use of IPCC scenarios as a benchmark of implementation is not without caveats. The 1.5°C-consistent mitigation pathway is modelled through least-cost scenarios, which assume away real-world economic inefficiencies. Therefore, the resulting emission range does not capture the inequalities of the implied implementation[44]. This may imply a larger latent implementation gap in terms of the distribution of costs and benefits across incomes and regions[45]. For example, mitigation through low-carbon transitions can be much cheaper in some income regions, while the macroeconomic costs of the same climate policies can be far higher in others[46]. The modelling convention also simplifies the burden-sharing regimes, omitting normative assumptions of a fair global common effort[47].

As Dooley and colleagues (2021) noted,

> *Quantified approaches also often implicitly assume that cost optimization is neutral, requiring no ethical justification. Imposing the same least-cost solution in a highly unequal world, however, is inherently unjust. An equal distribution to parties starting out with different capacities, different needs and vulnerabilities or different responsibility for the problem does not yield an equitable result.*[48]

Climate action assessments based on ethically explicit burden-sharing approaches reveal greater inequities between high-capabilities culpable countries and low-capabilities non-culpable countries. This led us to the task of determining an equitable pathway with transparent normative assumptions without losing resolution on the contextual basis of its subject.

Approaches of determining fair share

Following Müller and Mahadeva (2013), the design of an equitable burden-sharing scheme calls for the operationalisation of the CBDR-RC principle in international climate agreements[49]. Measuring responsibility for climate change can be as straightforward as measuring historical cumulative GHG emissions, but complications set in where the starting date is concerned. The first Industrial Revolution is widely accepted to be when anthropogenic climate change was traced, defined by the Global Carbon Project (GCP) as the period between 1750 and 1850[50]. IPCC

[42] Climate Watch data (2022)
[43] Friedlingstein et al. (2022)
[44] Riahi et al. (2022)
[45] Kanitkar, Mythri, and Jayaraman (2022)
[46] Ibid.
[47] Roelfsema et al. (2020)
[48] Dooley et al. (2021)
[49] Müller and Mahadeva (2013)
[50] Friedlingstein et al. (2022)

uses 1850 as the starting date of historical emissions calculations, using 1850 – 1900 as a reference period for pre-industrial temperature when human-induced warming had not taken place[51]. In this paper, we use 1850 as the start date of historical emissions.

Common options of operationalising capability (capacity) use the economic size of a country as an indication of the country's "ability to pay"[52]. Commonly used measures range from gross domestic product or national income (GDP or GNI) to net national income (NNI) or other wealth annuity measures. The use of GDP per capita, which considers the average citizen's level of well-being in terms of monetary value, is often used as a proxy for "ability to pay". This is based on the premise that higher GDP per capita implies greater financial capacity for an average citizen in a country to allocate resources toward climate mitigation efforts. However, what this measure does not reveal is the unequal distribution of wealth in a country. This means that the rich individuals whose lifestyle and activities contributed significantly to global warming can "hide behind the poor" in a relatively poor country, and the poorest individuals in a wealthy country are burdened equally as the rich[53]. Effort sharing scheme, thus, has to cut across both inter- and intranational inequities.

The Oxford Capability Measures, developed by Müller and Mahadeva (2013), measures the economic capacity of a country in terms of average national income, which is progressively scaled and adjusted for an aggregate poverty factor which reflects the "poverty intensity of the national economy". This measurement defines a country's capability in two primary ways: the first, as the country's GDP (referred to as base capability measure, BCM) adapted with a progressivity parameter, and second, as the GDP per capita of a country relative to world average GDP per capita (known as Oxford Gross Capability, OGC), which is further adjusted for the poverty alleviation needs of the country (Poverty Capability Adjustments, PCA). The measure also takes into account intranational inequity by factoring in the "poverty intensity" of an economy, determined based on the headcount of households experiencing multidimensional deprivations. This approach allows countries with similar capacities (GDP per capita) to assume differentiated obligations based on their specific needs in addressing poverty alleviation.

The Climate Equity Reference Framework (CERF)[54], developed by the EcoEquity and Stockholm Environment Institute (SEI), measures fair shares in terms of cumulative emissions reductions. This approach, known as the effort-sharing approach, allocates mitigation responsibilities for each country by first deriving a Responsibility-Capability Indicator (RCI). The RCI is then weighted to the total global mitigation effort. Capability is calculated through a metric called "capable income", defined as the sum of income shares above a set development threshold typically set at USD 7500 – 9000 (PPP adjusted). This income, considered responsible for climate mitigation, is counted towards capability. This method effectively carves out a "development space" for the population below an exempted income level to continue their development without climate obligations. Mitigation obligations are progressively assigned to income groups above the threshold. The capability is then weighted along with the responsibility indicator, defined as the historical emissions up to 2020 (in the latest update). The result is a graphical representation of a fair pathway of allocated emission allowance and corresponding mitigation effort (Figure 2.11 and 2.12, area highlighted in orange) relative to an estimated baseline of projected emissions.

[51] Masson-Delmotte et al. (2018)
[52] Müller and Mahadeva (2013)
[53] Baer, Athanasiou, and Kartha (2007)
[54] Earlier known as Greenhouse Development Rights Framework (GDRF), see Kemp-Benedict (2008).

Some frameworks account for responsibility and capability by giving greater weight to per capita emissions. This perspective was articulated in Anil Agarwal and Sunita Narain's seminal analysis of GHG emissions data, in a critique of the World Resources Institute report[55]. Per capita emissions are based on the principle of treating the atmospheric resource as a global common, which argues that individuals have a right to development which accords them with an equal allocation of emission rights, especially in the case where emissions-decoupled development is implausible[56]. This necessitates the accounting of national emissions responsibility with respect to the size of the national population. For example, Fanning and Hickel (2023) developed an equality-based method to derive a fair amount of compensation for atmospheric appropriation by evenly distributing a given global carbon budget for keeping within a safe warming level, according to a country's population as a share of the global population[57]. Emerged alongside were the concepts of ecological debt and reparation. They argue that, in the context of global warming, the high emitters who contributed disproportionately to climate destabilisation, and in the process gained through excessive emissions, should be limited in their access to further emissions and are obligated to pay for mitigation solutions. Martin Khor (2020) developed a burden-sharing framework by calculating respective carbon debts and credits using per capita emission as a global population share[58]. The framework distributed the remaining global carbon budgets (67% of 2°C and 75% of 2°C scenarios) among Annex I and non-Annex I countries according to the amount of carbon debt and carbon surplus. The analysis concluded that developed Annex I countries are beholden to the carbon debt (568 $GtCO_2$ in 1850-2008), having emitted above their fair share of emissions. Therefore, they are obliged to achieve negative emissions, making space in the remaining carbon budget to recompensate individuals in developing countries.

From the rundown of burden-sharing designs, it is clear that approaches to determining fair share are dependent on ethical assumptions. Quantitative burden-sharing frameworks based on emission accounting are not without flaws. For example, they cannot address the loss-and-damage incurred by climate impacts. Yet, they are useful for sketching out the equity problem and providing a scenario for equitable sharing of the common global effort.

2.1. Fair share allocations for selected countries

This section intends to answer the questions of international climate equity by assessing the fair burden-sharing of global efforts for solving climate change. We do this by comparing the pledged effort of developed and developing countries against an assigned fair share of the global effort. We use the Climate Equity Reference Framework (CERF) for this purpose. The CERF enables us to quantify the responsibility and rights allocation in terms of emission reduction. In CERF, each country is allocated an amount of emission allowance (rights) and emission reduction obligations. This is derived according to historical responsibility and capability.

CERF allocates climate burden as a share of the total emission reduction effort required to keep temperatures below the 1.5°C pathway (50% chance of staying below 1.5°C in 2100). This entails the sharing of global efforts among countries to achieve a climate stabilization goal.

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[55] Agarwal and Narain (2019)

[56] Ibid.

[57] Fanning and Hickel (2023)

[58] The carbon debt, or the surplus emission above the fair amount based on the proportion of emission fairly allocated according to the size of population of a country as a share of the world population, is calculated as the difference between the fair share emissions and the actual emissions. Carbon surplus is the opposite, where countries have emitted less than their fair share.

The CERF develops a Responsibility-Capability Indicator, which is a weighted combination of cumulative GHG emissions and income per capita as a share of the world total.

Equity checks of burden-sharing framework

To ensure the framework we adopt is equitable, we perform an equity assessment of the burden-sharing framework.

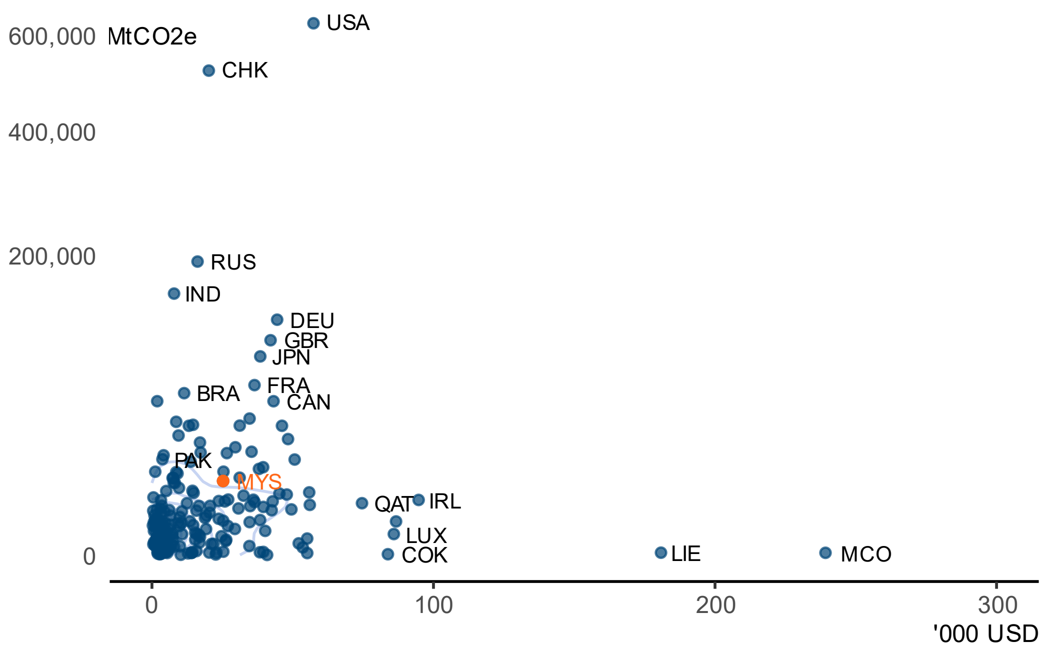
According to Ringius et al. (2002), any climate burden-sharing regime can follow four principles of redistribution. In order to be equitable, the regime needs to redistribute costs and benefits according to responsibility, capability, and needs. In a crude way, we can check the boxes of these criteria by looking at (1) how the framework allocates mitigation burdens, i.e., does it accord burden proportionally to responsibility and capability, and (2) how the framework addresses needs, i.e., does the framework allocate equitable climate space for those in need of an acceptable amount of emission allowance to develop.

To that end, we assess

1. The proportionality of burden allocation and responsibility. A fair regime should avoid grandfathering of emission allowance, i.e., bigger emitters get more allowance, which can crop up in inequitable regimes, and
2. if the framework accommodates the needs of groups to meet their developmental needs. We do this by checking balances of emission allowance for groups, comparing it with the share of population below the defined development threshold.

The CERF framework uses the PRIMAP-hist historical emissions data to derive responsibility and project emissions trends until 2030 and the World Bank's national GDP data for capacity. The distribution of the two measures gives us a picture of the setting of the climate problem.

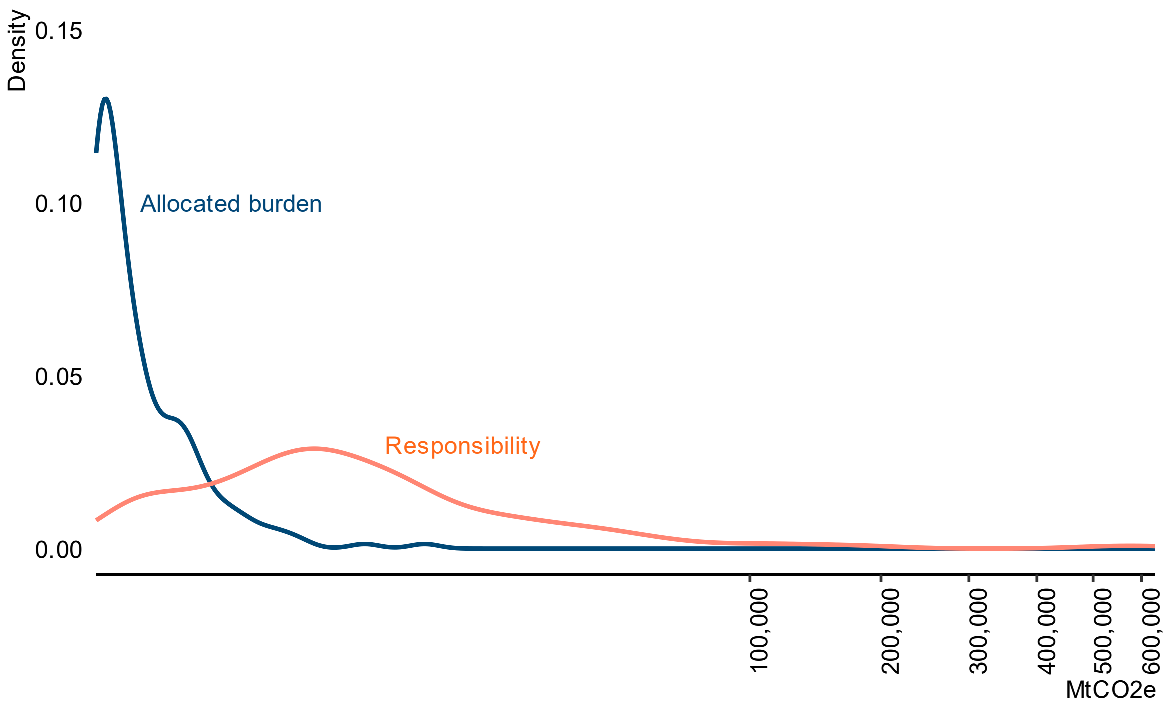
Figure 2.4: Projected cumulative emissions and projected GDP per capita in 2030



Note: Points show projected GDP per capita (x-axis) and cumulative emissions in 2030 (y-axis). The y-axis is modulus transformed.

Figure 2.4 shows the projected cumulative emission level and GDP per capita in 2030 by country. Because of the high responsibility and capacity of a few countries, we assume the distribution of allocated burden will also be skewed. We check if the distribution is positively or negatively skewed. An equitable burden-sharing regime means a higher share of burdens should accrue to the more responsible, which are a few; we expect a fair regime to have a long right tail. We check if the distribution of cumulative emissions is similar to the distribution of allocation.

Figure 2.5: Density curve of allocated burden and cumulative emissions in 2030 ($MtCO_2e$)

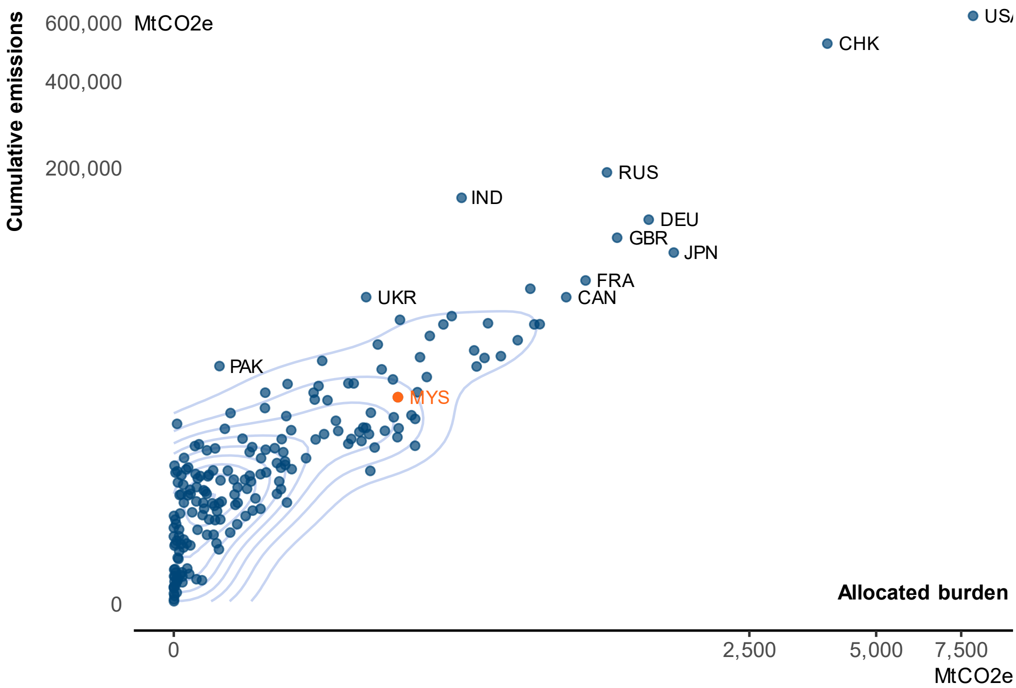


Note: The density curve represents the probability distribution of the set of countries in the burden-sharing regime. A point on the curve represents the probability of a country having a corresponding burden allocation or cumulative emission level. The x-axis is modulus transformed.

Figure 2.5 shows the distribution of countries corresponding to their allocated burdens and their cumulative emissions. The x-axis is the level of emissions in $MtCO_2e$, and the density curve represents the frequency of countries. Both the distribution of allocated burdens (blue density curve) and the distribution of cumulative emissions (orange density curve) exhibit positive skew. This means that higher levels of emission reduction are allocated to very few countries with large cumulative emissions, represented by the long right tail of the curves, while a high number of countries, represented by the peak of the curves, take on less burden. The positively skewed shape of both curves indicates that both actual emission and allocated emission reduction are unequal. However, equality is not a desirable quality in designing a fair burden-sharing regime.

Figure 2.6 demonstrates the bivariate spread of countries corresponding to their burden allocation and cumulative emissions. In the bivariate plot, we can see a correspondence between cumulative emission and allocated burden. Countries such as the United States, China, Germany, Russia, the United Kingdom, and Japan are allocated with higher burdens due to their higher responsibility. Most of the rest of the world is allocated with little burden, either because of low responsibility and/or capability.

Figure 2.6: Bivariate distribution of allocated burden and cumulative emissions ($MtCO_2e$)



Note: The x-axis and y-axis are modulus transformed.

Both distribution plots indicate that a higher share of emission reduction is allocated to high emitters. There are caveats to this approach. First, country-oriented distribution omits the statuses of parties. For example, the EU-27 negotiates as a group in the UNFCCC. Therefore, we must consider them as a collective. Second, the burden of emission reduction can be zero but not negative. This is because the framework calculates the burden as a share of the required total emission reduction to reach the 1.5°C pathway. This may run in contrast to the idea of carbon debt, of which countries with carbon surplus should be allocated the right to emit. Another caveat is that we assess the amount of reduction that is allocated in 2030. It is possible to aggregate the annual reduction cumulatively to give a more complete view of allocation, but we assess only the endpoint for this analysis.

Redistributive power of fair share framework

Emissions distribution is similar to an unequal income distribution, where a small number of countries emit (earn) a lot more than most. We can imagine emissions as an income distribution and mitigation effort allocation as a tax. Like a progressive tax system which operates to redistribute wealth, a fair burden-sharing regime allocates more burden on those who have appropriated more carbon space. We check this by finding the Gini coefficient, wherein a more progressive allocation would align to or be more concave than the normal Lorenz curve[59].

[59] Norregaard (1990)

Figure 2.7: Lorenz curve of allocated mitigation effort and baseline cumulative emissions

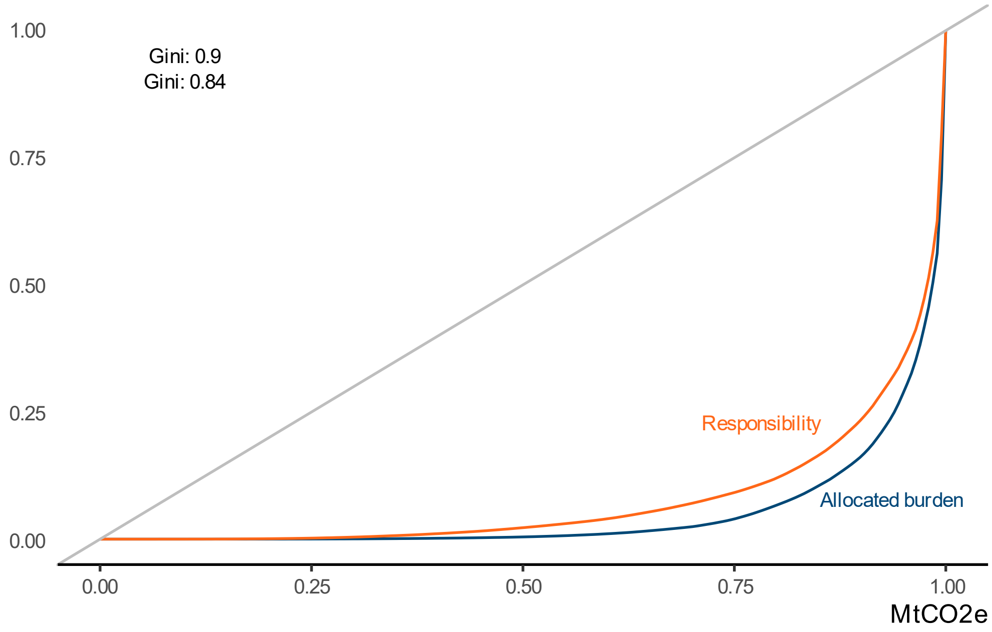
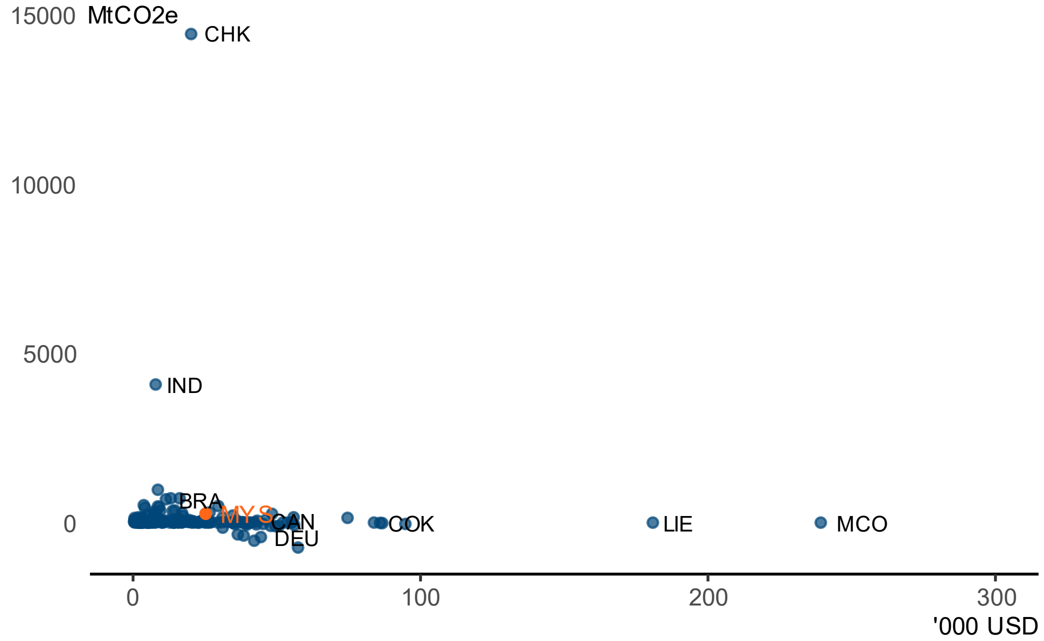


Figure 2.7 shows the Gini coefficient of the allocated mitigation effort (0.9) closely matches the cumulative baseline emissions (0.84). This means the inequality of emissions is matched with a proportionate allocation of burdens that weigh down on the high emitters. This is equally the case for post-allocation emissions where Gini is higher than 1, and a coefficient higher than 1 indicates that some countries must produce negative emissions.

However, in this framework, some high-emission countries may receive higher allowances due to their capabilities.

Unlike a tax system designed to redistribute wealth and equalize social outcomes, a re-compensation may be expected in a burden-sharing system, where emissions of some countries are allowed to grow, while others are required to make room for that growth within the shared climate space to meet developmental needs. The CERF framework determines this based on the capabilities of a country, defined as the income share that is above a set development threshold. In our analysis, we use an annual income of 7500 USD PPP as a static development threshold. We analyse whether the framework accorded climate space or emission allowances equitably according to the needs of a country.

Figure 2.8: Emission allowance and projected GDP per capita in 2030 by countries



Note: The x-axis shows GDP per capita, and the y-axis shows the allocation of emission allowance.

Figure 2.8 shows that more than half of the world will be given room to emit in 2030, wherein China and India are given the most emission space within the constraint of the carbon budget due to their population size and lower GDP per capita. In contrast, countries like the USA and those in the EU-27 are required to produce negative emissions to make room for growth in developing countries.

Figure 2.9 plots the allocation of emission allowance and the proportion of population with income below the development threshold (annual income of 7500 USD PPP) for each country. The distribution of countries' developmental needs (proportion of income below development threshold) is **bimodal** (Figure 2.9). This means that more countries are at the extremes of having most of their population below or above the development threshold while the remaining half of their population needs developmental space. Simply put, the higher the proportion, the higher the development needs of a country. A fair share framework should accord those with more development needs (ratio > 0.5) less burden in the case where emissions decoupled development is either implausible or risk inequitable outcomes.

However, this is not what we observe in the pattern of allowance allocation. Figure 2.9 shows that countries with low capacity are given similar, albeit slightly higher, emission allowance than most high-capacity countries, with the exemption of high emitting northern countries (left bottom of graph: USA, GBR, EU-27), China (CHK) and India (IND). Emissions allowance is the difference between a country's absolute emissions baseline and its reduction obligation. It is a function of the trajectory of current emissions, individual rights to emission space, and population size. If we adjust for per capita allowance, the pattern remains. Figure 2.10 shows the allocation of emission reduction burden per capita and the proportion of population with income below the development threshold. When we look at the per capita burden, the distribution follows a generally progressive pattern, where the higher the country’s development needs, the lower the burden they are obliged to take on. Whereas highly wealthy countries are accorded a high per capita burden.

Figure 2.9: Emission allowance and ratio of population below development threshold

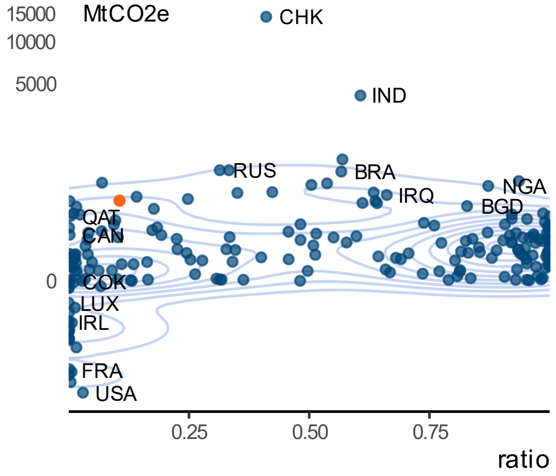
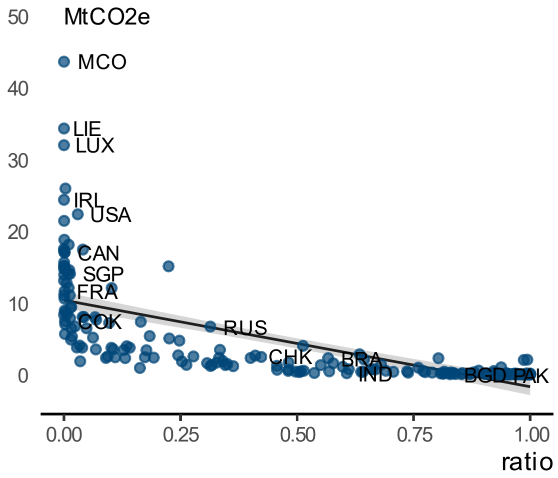


Figure 2.10: Emission reduction per capita against ratio of population below development threshold



Note: The x-axis represents the ratio or proportion of population earning below 7500 USD PPP annually. This is used by CERF as a "development threshold" to indicate the population with development needs and exempted from paying towards solving climate change. The higher the ratio, the larger share of a country's population is below the development threshold. The Y-axis in Figure 2.9 is modulus transformed.

Our assessment of the CERF burden-sharing framework indicates that mitigation efforts align with differentiated responsibilities, capabilities, and needs. Overall, the results show generally equitable allocation, with minor signs of grandfathering observed among middle-capacity countries, particularly when adjusting for per capita figures. However, it is important to note certain caveats in the method, such as low emission allowance assigned to low-emission countries due to their population size. Additionally, our settings also do not account for trade- and consumption-adjusted emissions, which can have implications[60], especially for countries with low territorial emissions.

[60] Trade- and consumption-adjusted emissions represent the emissions that are "off-shored" to other countries as a result of international trade. Developed countries have shifted much of their industrial activity to developing countries since the 1960s, seeking lower production costs. Developed countries now boast lower territorial emissions due to reduced domestic industry, their per capita consumption-based emissions remain higher because their citizens' consumption habits generate significant emissions elsewhere, embodied in imported goods. The developing world, conversely, often house major territorial emitters due to the relocated industries. However, the individuals in these countries, burdened by low income and limited purchasing power, typically possess the lowest consumption-based emissions per capita. These patterns are reflective of the structural inequities of international trade, investment, and financial order that subjugates citizens in developing countries to low income, poor purchasing power, and highly polluted living environments.

Comparing fair shares and NDC targets of selected countries

This section examines the equitable level of effort or commitment to climate mitigation that a country should adopt, considering the different responsibilities, capabilities, and national circumstances.

We compare four countries' NDCs with their fair share using the Climate Equity Reference Framework (CERF). We use the web-based calculator (CERc) to obtain the country's fair share of climate mitigation efforts and compare them with mitigation targets set out in the countries' respective NDCs.

Caveats

It's important to note that NDC targets are often expressed as a quotient of emission reduction relative to a baseline, either based on a projected Business-As-Usual (BAU) emissions scenario in the future or an estimated past emissions level of a defined base year. We also compare targets specifically until 2030. Therefore, net-zero emissions targets (of CO_2 or other GHGs) by 2050 or later are not included. The analysis also does not account for the difference in the scope of GHG covered under respective NDCs[61].

The settings and assumptions of the fair share calculations are shown in Table 2.1.

Table 2.1: CERc settings

Country	Mitigation pathway	Responsibility	Progressivity	
		Start date	Development threshold	Emissions elasticity
IDN	1.5°C	1850	USD PPP 7500	1.0%
THA	1.5°C	1850	USD PPP 7500	1.0%
USA	1.5°C	1850	USD PPP 7500	1.0%
MYS	1.5°C	1850	USD PPP 7500	1.0%

NDCs are based on country-reported emissions baseline[62], either as a quotient of a projected business-as-usual future emission level (such as Indonesia and Thailand) or an estimation of past emission levels (such as the USA and Malaysia). The National Greenhouse Gas Inventory reported by countries in their submitted NDCs differs from the CERF emissions baseline. CERF uses national emissions data from an independently compiled inventory database, the PRIMAP-Hist dataset, to calculate fair shares. A more detailed treatment of this can be found in the Appendix.

Comparing the targeted emission reduction with fair share reduction level relative to different baselines can be misguiding. To address this discrepancy and ensure comparability, we rebase the NDC targets to align with the CERF baseline. The rebased NDC targets can be found in the Appendix. We do not calculate fair share allocations based on country-reported BAU due to the absence of country-reported data on deep historical emissions dating back to 1850.

[61] Most of the NDCs in comparison cover all of Kyoto GHGs (CO_2, CH_4, N_2O, HFCs. PFCs, SF_6, NF_3). except for IDN (only CO_2, CH_4, N_2O). We cover all Kyoto GHGs in our analysis.

[62] See country NDCs "Information for Clarity, Transparency, and Understanding" section.

The CERF method also primarily excludes Land Use, Land-Use Change and Forestry (LULUCF)[63]. However, as all NDCs in our comparison cover economy-wide sectors and categories, which include LULUCF emissions and removals, we compare NDC targets relative to emissions baseline with LULUCF.

Results and Discussion

Table 2.2 and Table 2.3 show each country's mitigation fair share.

Table 2.2: National mitigation fair share, incl. LULUCF

Country	RCI	Baseline emission	mitigation fair share			emission allowance	
			as tonnes below baseline	as tonnes per capita below baseline	as percent below baseline	as tonnes	as tonnes per capita
IDN	0.72%	2,584 $MtCO_2e$	202 $MtCO_2e$	0.7 tCO2e	7.8%	2,382 $MtCO_2e$	8.0 tCO_2e
THA	0.43%	458 $MtCO_2e$	120 $MtCO_2e$	1.7 tCO2e	26%	337 $MtCO_2e$	4.8 tCO_2e
USA	27.9%	6,363 $MtCO_2e$	7,785 $MtCO_2e$	22.1 tCO2e	122 %	-1,422 $MtCO_2e$	-4.0 tCO_2e
MYS	0.47%	313 $MtCO_2e$	131 $MtCO_2e$	3.6 tCO2e	42%	182 $MtCO_2e$	5.0 tCO_2e

Table 2.3: National mitigation fair share, excl. LULUCF

Country	RCI	Baseline emission	mitigation fair share			emission allowance	
			as tonnes below baseline	as tonnes per capita below baseline	as percent below baseline	as tonnes	as tonnes per capita
IDN	0.48%	1,102 $MtCO_2e$	130 $MtCO_2e$	0.4 tCO2e	12%	972 $MtCO_2e$	3.2 tCO_2e
THA	0.38%	450 $MtCO_2e$	103 $MtCO_2e$	1.5 tCO2e	23%	348 $MtCO_2e$	4.9 tCO_2e
USA	29.4%	7,174 $MtCO_2e$	7,912 $MtCO_2e$	22.4 tCO2e	117%	-1,193 $MtCO_2e$	-3.4 tCO_2e
MYS	0.47%	390 $MtCO_2e$	127 $MtCO_2e$	3.5 tCO2e	33%	263 $MtCO_2e$	7.3 tCO_2e

Note: Responsibility-Capability Indicator (RCI) is shown as a percentage of a global total.

[63] CERF uses PRIMAP-hist historical emissions data, which has ceased to publish LULUCF emissions data in 2018. However, the database remains accessible for us to reconstruct the LULUCF inclusive emissions baseline and RCI. For more information, refer to Janssens-Maenhout et al. (2017).

Table 2.4: National fair share compared to NDCs, incl. LULUCF ($MtCO_2e$)

Country	NDC emission reduction		NDC emission level		Fair share	
	Unconditional	Conditional	Unconditional	Conditional	Reduction	Allowance
IDN	915	**1,240**	1954.1	1629.6	**201.7**	2,382
THA	166.5	**222**	388.5	333	**120.5**	337
USA	**3,317.5 – 3,450.2**		3317.5 – 3184.8		**7,784.8**	-1,422
MYS		**217.32**		85.6	**131**	182

Note: Based on 5(e) of the MYS NDC, we include LULUCF removals data from BUR4 into the quantification of NDC.

Table 2.5: National fair share compared to NDCs, excl. LULUCF ($MtCO_2e$)

Country	NDC emission reduction		NDC emission level		Fair share	
	Unconditional	Conditional	Unconditional	Conditional	Reduction	Allowance
IDN	915	**1,240**	1954.1	1629.6	**130.4**	972
THA	166.5	**222**	388.5	333	**103**	348
USA	**3,317.5 – 3,450.2**		3317.5 – 3184.8		**7,912.1**	-1,193
MYS		**126.37**		403.9	**127.1**	263

Note:

1. The BAU baseline for IDN and THA in this table refers to the updated NDCs submitted by respective countries, which are different from the CERF baseline, which is derived from CERF method. Indonesia projected BAU in 2030 is est. 2.869 $GtCO_2e$ (Indonesian Enhanced NDC, 2022); Thailand projected BAU in 2030 is est. 555 $MtCO_2e$ (Thailand 2nd updated NDC, 2021). US baseline (net emissions in 2005) is reported at 6635 $MtCO_2e$, referred to updated NDC (US updated NDC, 2021).
2. MYS NDC is quantified in emission intensity following the reference indicator reported in BUR4.
3. Shaded cells denote NDCs without conditionality. MYS updated NDC in 2021 has removed conditionality, which expanded the 35% unconditional and 10% conditional targets to a target of an unconditional reduction of 45% of economy-wide emissions intensity (MtCO2e/GDP) relative to 2005 levels.

Taking the global mitigation requirement of 26,942 $MtCO_2e$ (excluding LULUCF) and 27,821 $MtCO_2e$ (including LULUCF), the CERF allocate the burden according to the RCI of each country as a share of the global total. Taking this fair share as the baseline, countries with corresponding responsibility should, equitably, contribute a fair amount of effort in emissions reduction.

Tables 2.2 and 2.3 show that the fair amount of emission reduction ought to be taken on by Indonesia, Thailand, and Malaysia are lower than the USA. Conversely, the emission allowance, or the emission permitted for each country to emit until 2030, is the highest for Indonesia and the lowest for the USA. In per capita terms, if LULUCF emission is accounted for, citizens of Indonesia are given the most allowance, followed by Malaysia, Thailand, and the USA. Whereas if LULUCF is excluded, Malaysia is permitted to emit the most. In any case, each citizen in the USA is required to reach negative emissions (-3.4 and 4 tCO_2e) by 2030.

Tables 2.4 and 2.5 compare the countries' fair share to their pledged NDC targets. Both Indonesia and Thailand's conditional and unconditional NDC targets are above their fair share of emission reduction. This means that these countries are, at least by pledged ambitions, contributing a fair amount to solve global warming. We make comparisons for both scenarios, including and excluding LULUCF removals. In both cases, Indonesia's conditional target commits to 6 to 9 times more reduction than it ought to, and Thailand commits around two times more.

Comparison is slightly tricky for Malaysia as Malaysia's NDC target is based on emissions intensity relative to a base year. We can reproduce the NDC target emissions level in 2030, which requires knowledge of base year emissions and GDP as well as future GDP. We project the 2030 GDP based on the IMF World Economic Outlook 2023's forecast of 4.5% annual growth (CAGR for eight years). We use the 2015 constant price GDP for 2005 and 2022 from the IMF's database. For country-reported 2005 emissions, we use the most recent Biennial Update Report (BUR4) updated figures[64]. Malaysia's NDC target is almost 165% above its fair share of emission reduction considering its LULUCF removals but 1% lower than its fair share of reduction if excluding LULUCF removals.

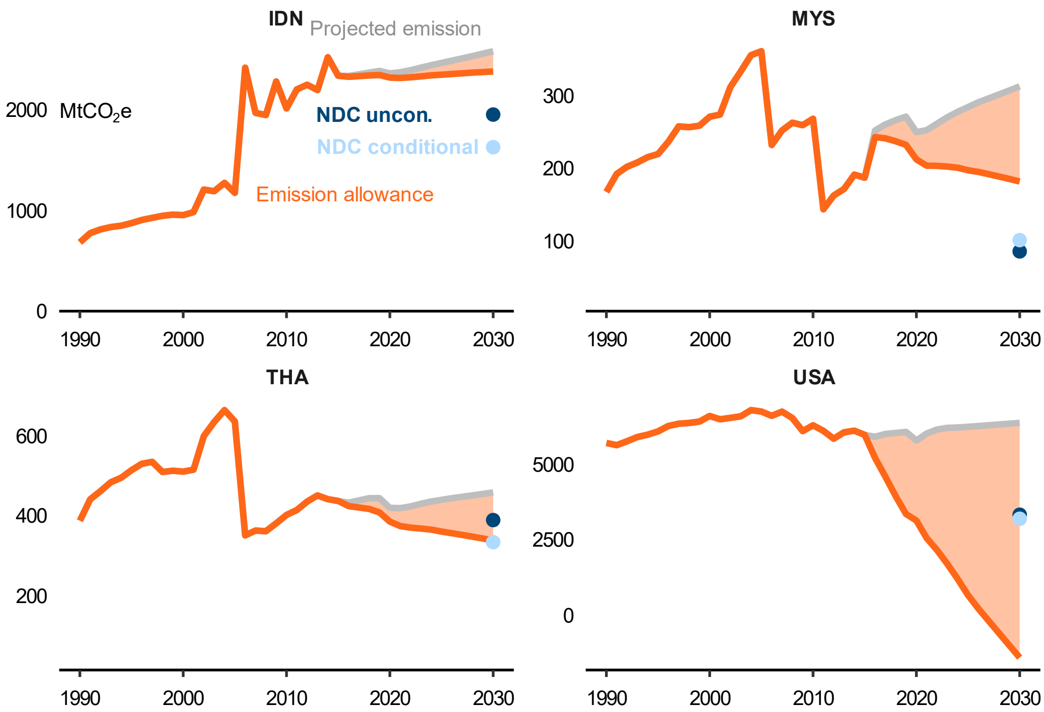
The USA overall aimed far less ambitious than it ought to. The country's NDC targets, both upper and lower bound, are off their fair share mark by more than 4000 $MtCO_2e$ in both scenarios. The NDC target range of 50 – 52% lower emission than the 2005 emission level is more than 40% off the fair share of emission reduction required of the country. This means that the country ought to aggressively ramp up its ambition to equitably recompense for the responsibility it holds over global warming. By virtue of the large historical responsibility and relatively high capacity in terms of GDP per capita, the USA should achieve negative emissions by 2030 through rapid, deep emission cutbacks, much less assuming the role of a net carbon sequester by 2030. This is, however, neither technically nor politically feasible by 2030[65] (Section 3.2). Developing countries will unavoidably take on what is beyond their fair share of emissions reduction. They must, therefore, be compensated with effective finance, technology, and capacity transfer to enable them to achieve low-emissions and climate-resilient development.

It is worth noting that CERF allocates the burden as a share of global needed emission reduction. This results in a projected emission level after reduction or emission allowance. This is different from the country-reported emission level after the NDC target is met, because of the difference between the country-reported BAU projection and CERF projection. This discrepancy is tabulated in Tables 2.4 and 2.5. Indonesia, which reported a much higher BAU, 2869 $MtCO_2e$ in 2030, after a fair reduction, still maintains an emission level higher than the CERF emission allowance due to this discrepancy. To eliminate this, we rebase or take the NDC target quotient of the CERF emission baseline for all countries. The result of this rebase exercise is shown in the Appendix.

Figures 2.11 and 2.12 show the projected Business-as-usual emission (in grey line) and emission allowance (in orange line) until 2030 for all four countries.

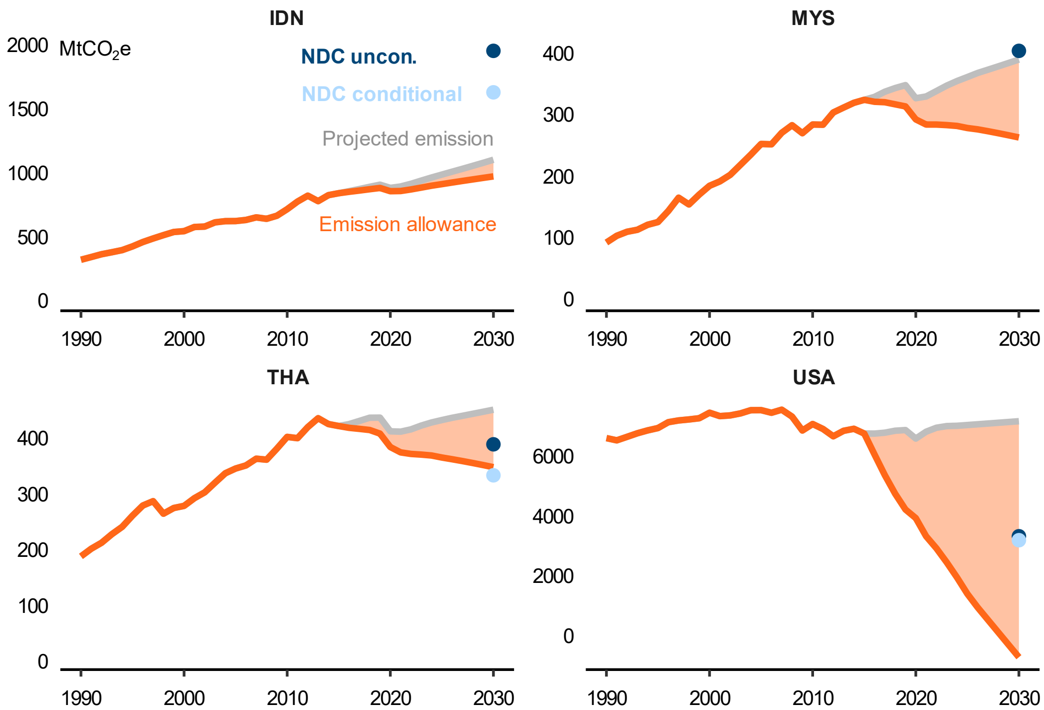
[64] CERc method do not include LULUCF removals. Because Malaysian NDC applies the net-net accounting approach to LULUCF sector GHG inventory, which is included in the sector coverage, we produce a LULUCF-excluded and LULUCF included emissions level at 2030 based on NDC target (see Table 2.3 and 2.4). For more information on CERc, visit https://calculator.climateequityreference.org/.
[65] Basseches et al. (2022)

Figure 2.11: Emission and NDC targets until 2030, incl. LULUCF ($MtCO_2e$)



Source: Author's visualization

Figure 2.12: Emission and NDC targets until 2030, excl. LULUCF ($MtCO_2e$)

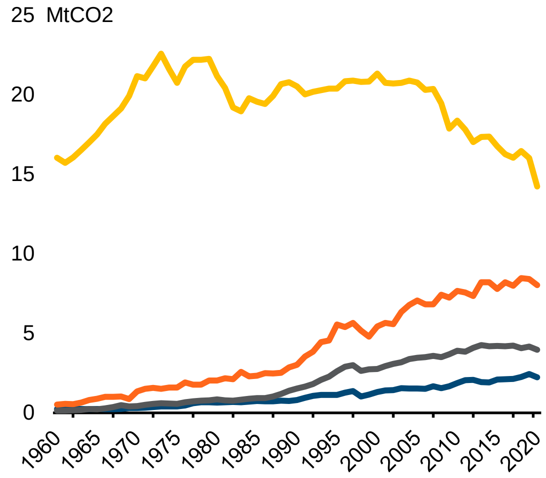


Source: Author's visualization

Note: NDCs are rebased to the CERF baseline for clarity, as the CERF baseline only considers non-LULUCF CO_2 emissions and may differ from the country-reported baseline. The shaded area shows the amount of mitigation effort allocated for countries based on their fair share; NDC figures for MYS and THA were obtained from Meinshausen et al. (2022). NDC emissions figure for MYS derived assumed IMF WEO 5% after 2019.

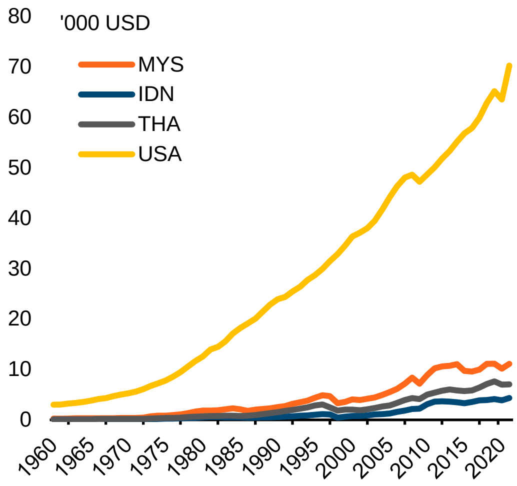
To put things into perspective, the combined historical emissions of Indonesia, Malaysia, and Thailand only make up a little less than 30 $GtCO_2e$, merely 6.6% of what the USA emits throughout history. This striking difference between absolute cumulative emissions, which directly contribute to global warming, points to the need to nest discussions of climate burden-sharing within an equity perspective. Such an approach involves fairly distributing burdens among countries with varying levels of responsibility and capability.

Figure 2.13: Historical CO2 emissions per capita in selected countries, 1960 – 2021



Source: Friedlingstein et al. (2022)

Figure 2.14: GDP per capita in selected countries, 1960 – 2021



Source: World Bank (n.d.)

While economic development, and consequently emissions in all three countries of the Southeast Asia region in our comparison only started to grow recently. It was towards the end of the 1980s that the per capita emissions of Indonesia, Malaysia, and Thailand truly picked up and diverged (Figure 2.13). However, the income levels of all four have yet to equalise, much less converge with the level of developed countries. GDP per capita in all three countries remains significantly lower compared with the USA (see Figure 2.14 and Table 3.1). It is worth noting that income per capita in Indonesia and Thailand is still below the global average, and wide sub-national geographical inequalities can also obscure the disparities in the developmental needs of local communities.

Intranational inequities also need local-level development. Discussions of global development, which treats countries as developmental actors, can reduce the important disparities within countries, which potentially foreclose the developmental needs of underdeveloped groups.

For example, despite Malaysia's high levels of electricity coverage, states such as Sabah still face challenges in power supply and distribution[66]. Many areas in Sabah are covered by off-grid systems or grid extensions due to difficult access[67]. These challenges are compounded by the low-income status of the state and a relatively high incidence of poverty.

Indonesia also faces challenges in closing the gap of geographically unbalanced development, as noted in section 3.1, emissions-intensive extractive industries tend to cluster in regions which rely on the sector to achieve high growth. Coal basins concentrated in Central and Southern Sumatra, as well as Eastern Kalimantan, have brought higher incomes to these regions,

[66] As of 2017, estimated 378 to more than 400 villages of rural Sabah has no access to electricity (77 - 89% coverage, unofficial sources).
[67] Sabah2RE Roadmap (2022)

invigorating the local economy and uplifting many[68]. Meanwhile, low electrification ratios among low-income regions such as Nusa Tenggara Timur and Papua (54.8% and 36.4%) can stymie access to social services and regional development[69]. As of 2022, the poverty rate in both regions remained above the national average[70].

Countries in this group have dire priorities to reach important development goals that are impossible without elevated energy use, and by virtue of their low income, the need for low-cost, widely accessible energy is critical for social development. Currently, the cost of generating electricity from solar and wind has fallen below that of fossil fuels in many cases[71]. While the cost of renewable energy has continued to fall, structural impediments such as international financial and technological order can hinder transition in developing regions through the cost of capital disadvantage and intellectual property regimes[72].

Low-carbon transition, which involves the transformation of socio-technical and socio-ecological systems to decouple economic development from carbon emissions and develop institutions to enable adaptation[73], presents a viable pathway for developing countries to pursue development with sustained energy needs but lower emissions[74]. However, there are multiple barriers to the implementation of the concept. The impedance entails deeper equity issues that play out at international and intra-national scales. A low-carbon transition, therefore, requires a just and equitable burden-sharing regime, much like any proposed mitigation pathways.

While it is undoubtedly important for developing countries to participate in the effort of mitigating global warming, their potential to contribute more to emissions pales in comparison to the scale of harm that developed countries have already exerted and continue to inflict.

A fair, climate-resilient, and sustainable global development agenda should facilitate a shift towards renewable energy sources and equip countries to adapt to climate impacts, all without imposing undue financial burdens. This must be achieved through the effective transfer of technology, financial resources, and capacity-building in line with provisions laid out in international treaties.

[68] Fadhila Achmadi Rosyid and Adachi (2016); Oxford Business Group (2012); Rian Hilmawan, Rizky Yudaruddin, and Yuyun Sri Wahyuni (2016); Muhammad Beni Saputra (2022)
[69] ADB (2016)
[70] 13.83 – 26.03% in the regions compared to 9.36%.
[71] IRENA (2023b)
[72] Avantika Goswami and Ananya Anoop Rao (2023)
[73] Masson-Delmotte et al. (2018)
[74] Schipper et al. (2022)

3. A just low-carbon transition

In this section, we examine low-carbon transition in the context of climate-resilient development, defined as pathways that pursue sustainable development in tandem with "efforts to eradicate poverty and reduce inequalities while promoting fair and cross-scalar adaptation to and resilience in a changing climate"[75]. The concept raises the need to address the ethics, equity, and feasibility aspects of the deep societal transformation required for emissions mitigation and climate stabilization[76].

A key part of achieving sustainable development is switching to a low-emissions development pathway. Low-carbon transition involves the transformation of energy, transport, urban, production, and other subsystems towards lower carbon consumption and emissions[77]. This entails a shift away from fossil fuel-based energy sources, which are tethered to socio-technical systems built around its extraction, production, and conversion.

In the words of Brusseler (2023), the fossil system is

> *physically constituted by fixed stocks of capital equipment and infrastructure, and more broadly composed by complex thickets of relationships between diverse segments of these stocks, inputs, labour, and socio-technical systems, institutions, or arrangements.*[78]

This system creates lock-in effects that reinforce interdependencies and resist fundamental changes[79]. The transition to another energy source necessitates a whole-of-system transformation of the complex interdependencies that compose the fossil system to a system based on renewable energy (RE). This transpires in the phase-outs of older infrastructure made for thermal power production, installation of renewable power plants and battery and energy storage systems, distribution of centralised power production to expanded networks, closure of traditional extractive activities, alienation of land for infrastructure development such as hydropower dams and transmission lines, and other changes to human activities. For developing countries struggling with inadequate energy systems, transition constitutes system transformation that builds new capacity based on renewable and sustainable energy sources.

Changes in the ways in which energy is sourced and flows through the economy imply direct and indirect effects on social variables, such as livelihoods, social and energy security, and consequently the social well-being of people actively employed in or dependent upon the system. In the absence of managed transition, the transition process "runs the risk of further increasing social inequality, exclusion, civil unrest, and less competitive businesses, sectors and markets"[80].

Critics of poorly managed transition point to the coal phase-out experiences in the past, which produced localised effects on economies and incurred costs to households[81]. While unmanaged phase-outs have impacted local economies, it was the displaced workers without reemployment

[75] Masson-Delmotte et al. (2018)
[76] Ibid.
[77] Denton et al. (2022)
[78] Brusseler (2023)
[79] Seto et al. (2016)
[80] UNDP, Lee, and Baumgartner (2022)
[81] Sartor (2018); ILO (2022)

alternatives and social protection that were most affected. These experiences imply what could happen under transition at the scale needed for fossil phase-out.

Inequities can also take form at a scale relevant to national interests and international dynamics. As low-carbon transition entails rapid phase-out of extractive industries integral to the fossil system, developing countries ingrained in fossil fuel extraction face substantial developmental risks. Countries dependent upon carbon-intensive industries or fossil fuel sectors may not be open to halting their activities, not when it means arresting the macroeconomic growth required to close the gap in socio-economic development and uplifting the poorest to meet the basic needs of a dignified life[82].

Low-carbon transition has the potential to engender new forms of inequity while reinforcing pre-existing structures of inequality. This highlights the importance of facilitating a just transition.

World Resource Institute (n.d.) characterised just transition as the process of "equitably distributing the costs and benefits of climate action"[83], which entails the protection of those vulnerable to the process of low-carbon transition. A whole-systems approach conceives such transition as integrating considerations of cost-benefit balances between local and global effects, distribution of risks between labour and capital; sectoral and regional interrelations; energy security; and implementing governance processes[84]. This requires a coordinated effort of managed transition.

Following Muttitt and Kartha (2020), a managed transition that adheres to an equity principle takes into account the developmental needs and fair burden-sharing of the transition process[85]. They argued that in order to address the distributional question, countries ought to assume differing roles in an equitable global phase-out of fossil fuel extraction. The normative principles they suggested dictate that (1) **phase-out should happen the fastest where the social cost of doing so is the least,** and (2) the **largest burden should be borne by those with the greatest ability to pay**.

In this analysis, we consider the comparative transitional challenges of selected developed and developing countries identified in the preceding section. We address the question of who should undergo transition the fastest and who should bear the costs of transition. We identify the transition challenges in two dimensions, i.e., (1) macroeconomy and (2) technology. We explore the distributional impacts incurred by transition on output, fiscal system, labour and income, as well as issues of technological uncertainty and technology transfer with respect to equitable transition.

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[82] Baer, Athanasiou, and Kartha (2007)
[83] WRI (n.d.)
[84] Abram et al. (2022)
[85] Muttitt and Kartha (2020)

3.1. Transition risks

Macroeconomic risks

The discourse on low-carbon transition is laden with techno-optimism. Many alluded to the technological development within the energy and production sector, citing rapid improvements in price-competitiveness of low-carbon energy technology[86] as well as government and corporate buy-in as a source of momentum for driving transition. Market-based climate policies are also mooted by multilateral organisations as the panacea for correcting carbon pollution[87]. Often obfuscated are the unequally distributed macroeconomic impacts that mitigation and transition entail.

Because climate policy involves "an array of regulations, subsidies, incentives, border measures, government expenditures, and taxes", low-carbon transition necessarily entails macroeconomic impacts that are highly uncertain[88]. Nonetheless, the large and complex economic processes that low-carbon transition calls forth can affect macroeconomic stability and growth. Generally, macroeconomic impacts can be felt in (1) potential output decline, (2) public finances, and (3) distributional impact on labour and income.

We discuss in brief each component of the macroeconomic impacts and their equity implications for countries in our analysis.

Output

While modelling studies have supported long-term global economic growth under 1.5°C-consistent pathways, it is important to note that in the near term, climate change mitigation incurs a cost to the world GDP. IMF (2022) estimated annual growth to be dampened by 0.15 – 0.25%[89]. IPCC estimates further indicate potential GDP reductions ranging from 2.6 – 4.2% until 2050 for the 1.5°C-consistent pathway and 1.3 – 2.7% until 2050 for the 2.0°C-consistent pathway. While most country-level models show negative impacts of mitigation policies on local growth, relative levels of decline are unequal across countries, with the brunt of negative impacts on GDP predominantly borne by low- to middle-income countries[90]. IMF (2022) model study found that across indicators of GDP growth, productivity, and headline inflation, regions outside of the USA, EU-27, and China are most impacted, with significant variations in GDP change, particularly impacting oil-dependent Gulf countries[91].

This near-term decline is associated with adjustments to structural transformations under transition. The output loss is explained by two main mechanisms: (1) reduced use of production factor imposed by certain carbon constraints and (2) additional required investment, which crowds out productive investment elsewhere[92]. In any case, output (Y), expressed as the total value added of an economy, will decline due to a shift in total cost.

86 Simon Evans (2020); IRENA (2022b); IEA (2023b)
87 IPCC (2022d), E.4.2; IMF (2020)
88 Pisani-Ferry (2021)
89 IMF (2022)
90 Kanitkar, Mythri, and Jayaraman (2022)
91 IMF (2022), see Annex 3.3
92 Lecocq et al. (2022)

In economic terms, transition is a process that completely substitutes fossil fuel (F) with non-primary energy capital (Ke) in an energy system (E). Because a low-emissions energy system uses freely available renewable energy sources but relies on electricity for transmission, non-primary energy or electricity infrastructure such as transmission and distribution grid assume a heavier weight. This also entails a system-wide replacement of carbon-intensive capital (K_y) and labour (L_y) with carbon-efficient alternatives. We can express this in a nested production set:

$$E = E(Ke, F)$$
$$Y = Y(Ky, Ly, E, F) \quad (1)$$
$$E = E(Ke)$$
$$Y = Y(Ky, Ly, E) \quad (2)$$

There are implications associated with the capital and labour reallocation in this process. A carbon constraint – be it through regulation, carbon pricing, or other means – amounts to "pricing a resource that use to be free, [...] which on the surface bear many similarities to standard oil price shock"[93]. Given full transition to cheaply available and reliable clean energy is yet complete, a price hike in energy prices in the short term can affect the production cost of all productive activities as energy enters the production of all goods[94]. As a result of relative price changes and carbon constraints, a portion of the capital stock will become economically obsolete. Vast quantities of recoverable fossil fuel will be kept underground, and carbon-intensive economic activities and equipment in use will be decommissioned before the end of their economic life. This, along with the effects of labour market rigidities, will temporarily reduce factor productivity. Consequently, output growth in the short term will be inhibited.

Price signal-driven policies such as carbon tax also raise cost pass-through in carbon-intensive sectors, which has an impact on consumer prices[95]. This may lead to inequitable distributional outcomes as lower-income groups spend a larger proportion of their income on energy services. Consequently, these households face more difficulties changing over to alternatives[96]. In markets where price rigidity is significant, the inability to pass on price increases to consumers can lead to reduced output, incurring costs for producers[97].

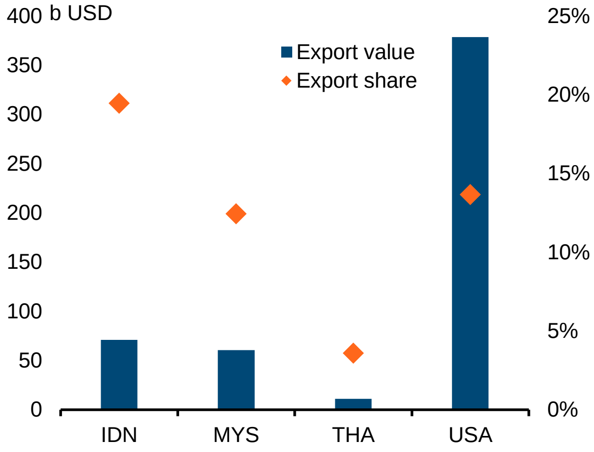
Transition also requires large, additional upfront investments. Additional investments for mitigation also partially crowd out productive investment elsewhere, raising opportunity costs[98]. Estimates from transition scenario studies suggested that a 1.5°C -consistent transition pathway would require a mean annual net-new investment of 0.36% (range between 0.2 – 1%) of global GDP [99]and subsequently lower in the long-term. Cumulative additional investments, however, can reach much higher figures over the same period. Required additional investments as a share of GDP may be much higher in developing countries. This is due to higher risk-return costs and generally lower GDP levels [100].

[93] Pisani-Ferry (2021)
[94] Luciani (2020)
[95] Ibid., Altenburg and Rodrik (2017)
[96] Lecocq et al. (2022)
[97] Shang (2021)
[98] Lecocq et al. (2022)
[99] Masson-Delmotte et al. (2018)
[100] Kreibiehl et al. (2022)

The main argument for a transition-driven economy cites industrial invigoration and job creation, which can positively affect output[101]. This is true insofar as the benefits of transition exceed the cost. In any case, uneven concentration of benefits relative to the spread of costs can lead to friction in the process[102]. **The distribution of net gains and losses along sectoral and national lines determines macroeconomic outcomes for different countries.** This means that countries whose economic activities rely on carbon-intensive sectors and house a larger share of labour in these sectors will bear deeper costs. Given the current global economy, these groups are mostly located in the Global South.

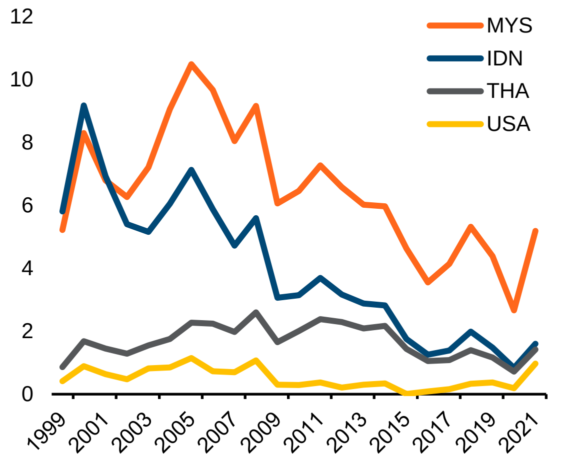
Because fossil energy is traded globally, whereas renewable energy is largely confined to local consumption and, at best, regional trade, the phase-out of fossil energy will substantially reduce the global energy trade balance, absent of equivalent sources of trade[103]. The shrunken demand for fossil energy is expected to be absorbed by regions with low production costs, notably the Gulf countries, likely shifting the political economy of energy trade[104]. Countries with high fossil dependence but higher production costs will be affected. Additionally, the effects will ripple through the job market. Wage impacts among lower-end jobs in vulnerable sectors can translate into local political issues[105]. Most countries in our comparison group sit outside of this set of competitive fossil producers despite fossil fuel being a significant share of trade.

Figure 3.1: Value of fossil fuel export and export share, 2021



Source: UN COMTRADE (n.d.)
Note: Fossil fuel exports include commodities under the category HS 27.

Figure 3.2: Total natural resource rent, 1999 – 2021 (% of GDP)



Source: Word Bank (n.d.)
Note: Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.

We may take the fossil fuel share of national trade value as a proxy for an economy's exposure against this risk of trade imbalance. As Figure 3.1 shows, the trade shares of fossil fuel (including trace mineral products) in Indonesia, Malaysia, and the USA are around 15%, whereas Thailand is relatively unaffected by energy trade risks. A country's share of fossil fuel revenue in national income indicates its economic dependence upon the sector. Malaysia and Indonesia rank among the highest in the group at 5.2% and 1.6% in 2021. Although the USA has a high trade exposure

[101] Luciani (2020); Altenburg and Rodrik (2017)
[102] Aklin and Mildenberger (2020)
[103] Mercure et al. (2021)
[104] Ibid.
[105] Note the sensitivity of energy price in modern democratic states have a track record of stirring civil unrest.

owing to its growing status as a net exporter of hydrocarbons (Figure 3.2), the country's exports are also much more diversified[106]. The USA exports a wide range of high-value-added commodities such as electronics, machinery, automotive parts, and medical equipment, among others[107].

High exposure also means higher pressures of economic diversification, much less an accelerated one. Developing economies like Malaysia and Indonesia have in the past achieved development on the back of resource extraction, which includes now now-exposed fossil fuel industry. Although both economies have since diversified into manufacturing higher value-add goods such as electronics, resource-based industries still constitute a large share of the countries' output[108]. As low-carbon transition kicks into high gear, the urgency of diversifying away from fossil fuels into other equivalent or higher-value sources of trade within a constrained timeframe and narrower trade conditions can be particularly arduous.

Fiscal space

Transition requires large upfront, high-risk investments. As a form of public investment, the scale of the capital flow requirement has only been matched by military spending of developed countries in the past[109]. Despite clarion calls for private investments to step in as the main driver of transition financing, due to the risks associated with low-carbon projects, such initiation of financial flow cannot happen without government support[110]. Theoretically, in the scenario where the cost of carbon is not fully imputed or appropriately priced, the private sector remains incentivised to channel capital to more profitable enterprises with higher certainty and lower risks. Market forces alone cannot move sufficient capital for an accelerated transition to take place. Because of the higher risk associated with low-carbon investments such as infrastructure and energy projects, especially in untested developing regions, private capital needs "de-risking" on the part of public finance[111]. This is exemplified in the push for public-private partnerships, blended finance, green bonds[112], and a host of debt and equity instruments that operate by deploying public resources to cushion potential losses, thereby transferring or spreading the risk to make low-carbon projects much more "bankable"[113,114]. Multilateral development banks are often enlisted for this purpose[115], but the mobilised quantum to date has been wanting[116]. National governments are now motivated to deploy domestic public finance to accommodate clean energy projects (Figure 3.6), moving transition risks into national balance sheets. There are fiscal risks associated with the expansion of public finance's role in de-risking models, however, we shall not provide treatment of the problem within this paper.

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[106] Löscher and Kaltenbrunner (2023)
[107] Simoes and Hidalgo (2011)
[108] Phi Minh Hong (2021)
[109] Tooze (2023) describe this global figure to match the American defence spending during the cold war.
[110] Lewis (2014)
[111] Choi, Zhou, and Laxton (2022); Griffiths (2012)
[112] Braga, Semmler, and Grass (2021)
[113] Ibid; Bayliss and Van Waeyenberge (2018)
[114] Modalities may differ from one instrument to another, which may not be entirely market-based. For example, some involve long-term contracts that hive off infrastructural services as assets capable of generating fixed income.
[115] Georgieva and Adrian (2022); Gabor (2019)
[116] Climate Policy Initiative (2021); Zagema et al. (2023)

In any case, public finance will be involved in the stimulus of investment needed for the transition to take place. There are fiscal risks associated with accelerated transition, particularly for fossil fuel-dependent countries.

Transition will likely lead to a decline in global fossil energy demand. This shift, combined with supply-side changes will keep prices of hydrocarbons unstable. Moreover, factors like constrained extraction further exacerbate this instability, which can lay a blow to public coffers relying on fossil fuel income[117]. Fossil fuel as a significant source of government income is commonly observed among developing countries with ample fossil resources and government control over fossil fuel assets through national oil companies (NOCs)[118], including Malaysia and Indonesia. Figure 3.3 shows the fossil fuel share of government revenue in selected countries, highlighting the vulnerability of public finances tied to fossil fuel income.

Figure 3.3: Fossil fuel as a share of government revenue, 2019 (per cent)

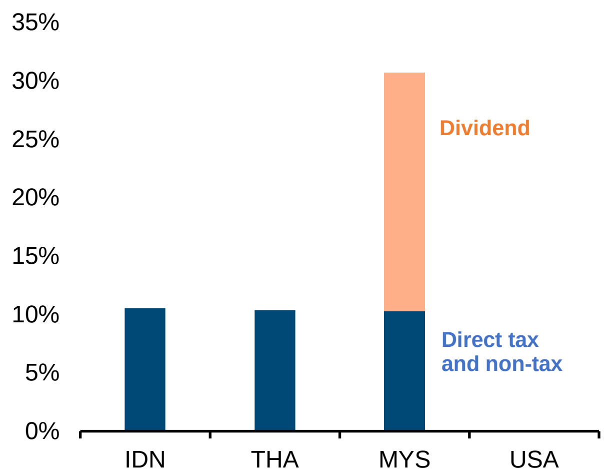
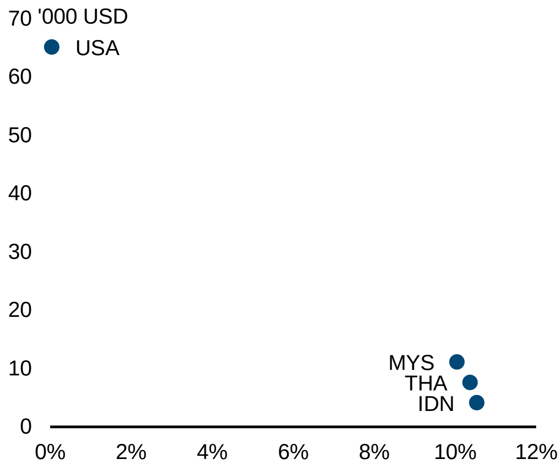


Figure 3.4: Fossil fuel share of government revenue against GDP per capita, 2019 ('000 USD)



Source: IMF (2021); BNM (2021); MOF (2021); FPO (n.d.); BNRR (2023)
Note: Fossil fuel source of government revenue inclusive of direct income tax for petroleum and natural gas, mining (IDN), and non-tax revenue. Non-tax revenue other than royalties are not included, e.g., inclusive of PETRONAS dividend pay-out, MYS O&G share will bump up to 30.5%.

Fossil fuel receipts, including tax and non-tax revenue, make up around 10% of government income in Indonesia, Malaysia, and Thailand. However, if we consider windfall dividends from NOC, Malaysia's figure bumps up to 30.5% in 2019. This figure fluctuates about a quarter of government revenue from 2019 to 2022[119].

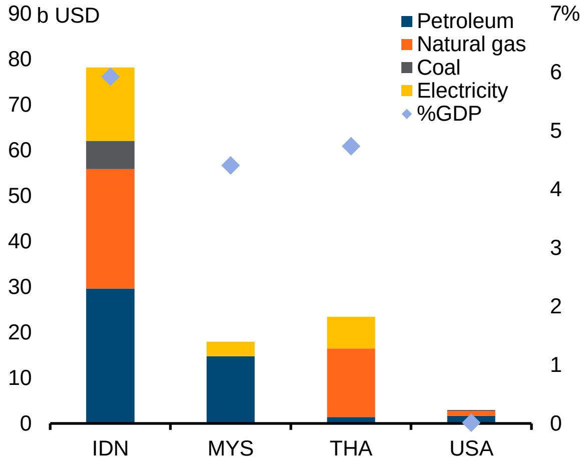
Figure 3.4 shows the relationship between fossil fuel share of government revenue to GDP per capita as a proxy of transition capacity. This relationship broadly illustrates the position of countries' capabilities in facilitating transition through domestic resource mobilisation[120]. Developing countries in our comparison are locked in higher risk fiscal position, with limited capacity of mobilising domestic resources for transition purposes. In the case where governments stand to lose around 10% of revenue base from loss in energy trade, without diversification

[117] Agarwala et al. (2021); Elgouacem et al. (2020)
[118] M. L. Ross (2012)
[119] MOF report this figure as "petroleum-related revenue".
[120] McNabb et al. (2021)

strategy or strengthening of the tax base, such impact can put pressure on public spending capabilities, which is sorely needed in the transition process.

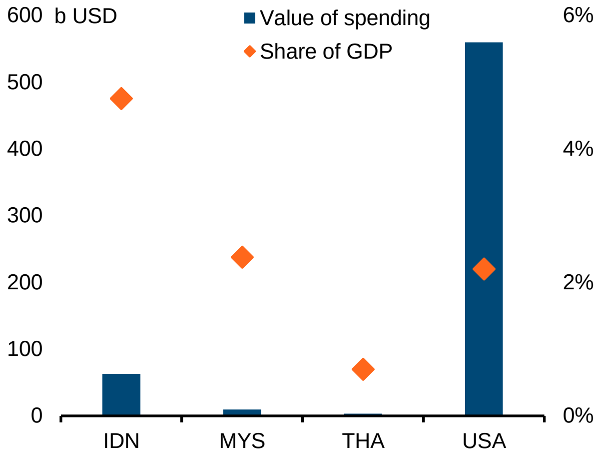
At the same time, developing countries also spend a significant amount on energy subsidies, in absolute value and as a share of GDP. Figure 3.5 shows that Indonesia and Thailand spend the most on energy subsidies, with the bulk of it in natural gas and petroleum. This may be a function of the lower income range of average households in these countries, which depresses their energy spending capacity, thus requiring subsidies. In contrast, developed countries like the USA spend more on clean energy compared to affordability measures (Figure 3.6).

Figure 3.5: Explicit energy subsidies spending in selected countries, 2022 (billion USD)



Source: IMF (2023)

Figure 3.6: Government energy spending (b USD) and as a share of GDP (% of GDP)



Source: IEA (2023)

Note: IEA Government Energy Spending Tracker measures two types of energy spending: clean energy investment support and consumer energy affordability measures.

Developing countries face the twin challenges of driving energy transition while ensuring affordability if clean energy is not cheaper than subsidised traditional energy. If clean energy is indeed made more affordable than traditional fossil fuel-based energy, possibly through successful transition policies, then a shave-off of fossil-based income only needs an equivalent replacement elsewhere. However, this is provided that sufficient public resources can support the costly transition to clean energy. If left behind in energy transition, developing countries will have to support growing energy use with less fiscal capacity. We discuss this further in Technology risks.

One argument for carbon pricing cites the ability of carbon tax to expand government revenue through proceeds from pollution tax on carbon-intensive energy producers. For countries with large NOCs, offsets in revenue loss with proceeds from carbon taxation may not be so direct, depending on the scope and point of tax. Lower fossil fuel production can reduce tax proceeds from NOCs, which often pay the most tax due to their large emission profile. Fossil-dependent developing countries with lower average income also relied upon high rates of energy subsidy (Figure 3.5), which are inadvertently funded through NOC-backed government spending. Without addressing structural household income gaps, the removal of energy subsidies can engender adverse distributional impacts.

Distributional risks

Low-carbon transition necessitates structural change that involves not just the decommissioning and creation of physical stocks, but their attached production factors like capital and labour. Importantly, because these processes are not uniform across the economy, they give rise to the reallocation of capital and labour[121]. Reallocation along sectoral and class lines will likely proceed with friction[122]. Certain productive sectors and segments of society have an advantage compared to others. For example, the energy sector has a higher exposure but also simultaneously a higher capacity to transition. Whereas other emissions-intensive sector such as mining and agriculture has no direct means of transition without incurring unavoidable losses, making rebound more difficult.

Reallocation effects have implications on labour and income distribution, particularly in lower-income households that face bigger challenges in transition. This is related to the concentration of lower-income households in employment exposed to transition risks[123] and their relatively higher cost of swapping sources of energy use[124].

Labour

Proponents of transition cite the capacity of coordinated investments to drive job creation[125]. Positive employment effects are expected to offset potential retrenchments due to phase-outs of carbon-inefficient industries, fossil fuel-based energy production, and environmentally harmful sectors. Job creation in the clean energy sector, building sector, and green transportation, among others, can theoretically engender net employment gains by labour substitution from traditional sectors into new sectors[126]. An important note is that the effects of reallocation are only meted out in the aggregate. Such "offsets" do not consider the qualitative differentials in job loss and gains across different sectors and skill levels. This means that low value-added or low-quality employment in certain sectors may well be over-represented.

Looking broadly at the total employment of an economy, **expansion in employment may not generate the same effects in every sector or for all workers.** Most Computable Generalised Equilibrium (CGE) models assume that, during the transition, capital flows in the short term will go into the substitution of capital equipment. This can lead to changes in potential output before reaching a steady state[127]. Under such conditions, economic growth is inhibited as resources are temporarily diverted away from capital accumulation (or profit-making) to targeted investments in the clean energy sector or carbon-efficient technology[128].

Input-Output (IO) models of developed economies show a shift in investment increases employment if it targets sectors with a higher share of labour in value-added, lower wages, or lower import rates[129]. These findings are consistent with the theorem that high labour

[121] Lecocq et al. (2022)
[122] Pisani-Ferry (2021)
[123] Chateau, Bibas, and Lanzi (2018)
[124] E. Ross et al. (2022)
[125] UNEP/ILO/IOE/ITUC, (2008); Wei, Patadia, and Kammen (2010); OECD (2012); IRENA and ILO (2021)
[126] Chateau, Bibas, and Lanzi (2018); IRENA and ILO (2021)
[127] Pisani-Ferry (2021)
[128] Bernardo and D'Alessandro (2016)
[129] Perrier and Quirion (2018)

productivity tends to reduce labour demand. Therefore, a boost in employment in the overall economy is necessarily a trade-off for lower labour productivity. This suggests that in the transition to a low-carbon economy, overall employment gains can be induced by investment in labour-intensive and low-productivity jobs. Some examples of these are observed in solar and building weatherization[130] industries. These sectors have a high labour share and despite lower wage levels, contribute to overall employment growth compared to the electricity and oil and gas (O&G), where labour productivity tends to be higher[131].

Because green sectors are also capital-intensive, investors are not ready to accept lower returns for the risks borne[132]. Capital share in new sectors will likely be higher. In a relatively young sector where unorganised labour has lower bargaining power, the labour share of income tends to be suppressed. More job substitutions into this sector shift revenue away from labour to capital, which translates into higher income inequality[133]. On the flip side is the growth in capital-intensive technologies, particularly in the manufacturing sector, which reduces labour demand and labour share of value-add, further influencing income distribution dynamics[134].

Nonetheless, the employment effects of low-carbon transition remain highly uncertain. Scenario modelling only offers an outline of what is to emerge under crude assumptions. The focus on employment gains in the green sector can obfuscate the losses elsewhere.

Accelerated decarbonisation has implied a risk of structural disruption to industries. No other sector is more directly affected than the mining and quarrying sector for extraction of fossil fuels, which is to be phased out under transition. Scholars have pointed to the long-lasting effects of pit closures under coal phase-outs as cautionary tales of disorderly transition. Mine closures in the United Kingdom (UK) during the 1980s have resulted in frontloaded job loss in all coalfields, which saw varied levels of replacement across time and regions[135]. The wage rate of displaced miners was estimated to decline by 40% and remained depressed by 20% fifteen years later[136]. One substantial effect was the withdrawal of displaced labour from economic activity[137]. In both the UK and Poland, a sizeable share of displaced coalfield workers (50% in Poland) has resorted to exit from the labour market owing to challenges in age, education, skill mismatches, and aversion to loss in wage premiums. This has resulted in a net loss in the labour force regardless of the number of jobs created in the green sector[138].

It is expected transition will increase risks of employment and wage loss, assuming re-employment is of comparatively lower quality, which can be the case of the renewable energy sector: where low security, contractual temp jobs are common[139]. Workers with more difficulties in re-skilling and seeking reemployment may be rendered more precarious. This is also true for downstream sectors affected by supply chain shifts, often not captured in energy

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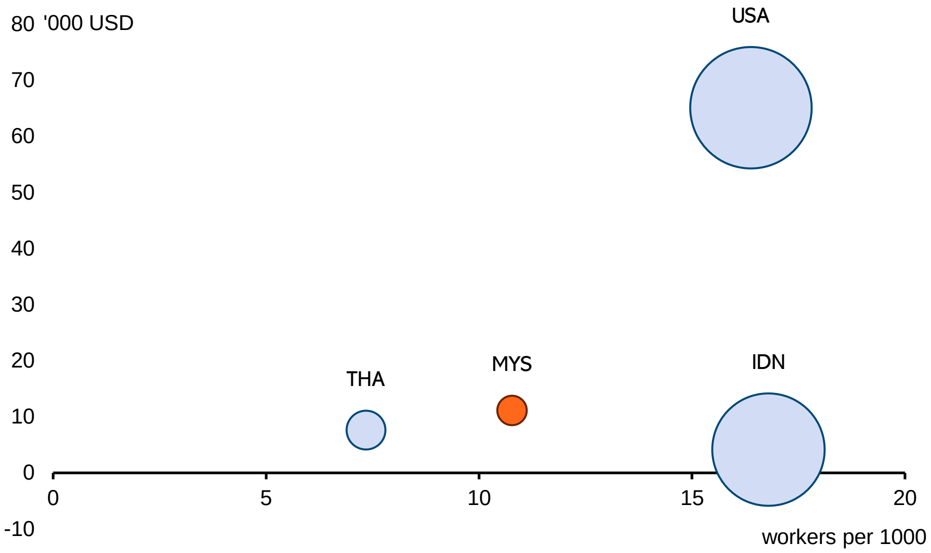
[130] Jobs involving weatherproofing and modifying buildings to withstand climate variations and optimize energy efficiency such as housing insulation.
[131] Luciani (2020)
[132] IEA (2023a)
[133] Luciani (2020)
[134] Acemoglu and Restrepo (2019)
[135] Beatty, Fothergill, and Powell (2007)
[136] Rud et al. (2022)
[137] Beatty, Fothergill, and Powell (2007); Baran, Szpor, and Witajewski-Baltvilks (2020)
[138] Baran, Szpor, and Witajewski-Baltvilks (2020)
[139] Harris (2022); Gurley (2022)

system modelling. In the process of frictional labour flow between sectors, many may end up in the informal sector or exit the labour market altogether, to the detriment of the overall green growth trajectory. **This suggests the need for a structural form of re-skilling on an unprecedented scale, which is impossible without major active labour market policies, often on the part of public sector intervention.**

Lastly, the geographical distribution of labour risks cannot be understated. Even when job creation is positive, reallocation among countries is likely to be unequal. Modelling studies have estimated job losses in fossil fuel producer countries to be generally under-compensated by job creation, while job creation outweighs job loss in importer countries[140].

Higher levels of green sector growth are observed in developed countries for technological and financial reasons. In contrast, the bulk of the world's resource-intensive extractive activities are located in developing countries. Consequently, **a global transition is expected to result in a lopsided drive of phase-outs in developing economies.** This may be challenging for countries whose growth that have historically relied on resource extraction (Figure 3.2). Such nations may face limited avenues in diversifying to higher value-added paths, for the same reasons over which developed economies enjoy comparative advantage in the transition process.

Figure 3.7: Employment share in mining and utilities against GDP per capita, 2019



Source: ILO (n.d.); World Bank (n.d.); Author's visualisation
Note: Data point size represents the size of labour employed; Labour share statistic follows ILO's classification of aggregated sector B, D, E (ISIC Rev. 4) representing mining and quarrying; electricity, gas and water supply.

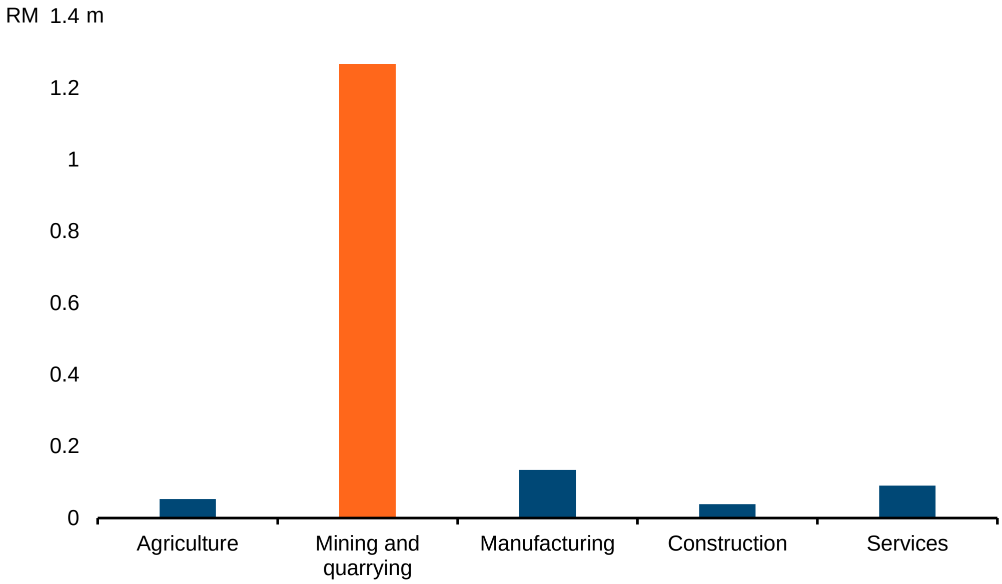
Figure 3.7 shows the employment share in the mining and utilities sector against GDP per capita as a proxy for capability in 2019 among four countries. Among compared countries, Indonesia has the highest share of labour employed in mining and utilities, followed by the USA. However, Indonesia simultaneously ranks low in terms of capacity in transition, as measured by GDP per capita. Furthermore, Indonesia faces the risk of employment shocks in the resource extraction sector and non-renewable energy sector, which can deepen sub-national inequalities. This risk is rooted in the geographical concentration of resource extraction, particularly coal mining, in Southern Sumatra and East Kalimantan (see Section 3.2). These regions' development centred mainly around the economic activity of coal mining[141], which has led to localised lock-in effects

[140] Mercure et al. (2021)
[141] ILO (2022); Rian Hilmawan, Rizky Yudaruddin, and Yuyun Sri Wahyuni (2016)

described as a "resource curse" by various scholars[142]. Although the sector is responsible for the bulk of output in these regions, studies have shown that they do not uniformly improve household income[143]. This complexity provides valid grounds for divestment from the sector. However, as the dominant sector brings much growth into these otherwise less developed regions, the transition threatens to disrupt not only the sector alone but also the broader regional political economy[144].

Despite both the USA and Indonesia boasting comparably high employment shares in the sector, the USA holds a significantly larger capacity to transition. In the USA's economy, a higher share of workers is employed in equally, if not higher value-added industries such as business and professional services (12.1% as compared to mining at 0.5% and utilities at 0.4% as of 2021)[145]. Moreover, the capacity of the USA to manage employment shocks in the sector through government programmes is substantially higher, irrespective of political limitations.

Figure 3.8: Annual labour productivity by sector in Malaysia, 2022 (RM million)



Source: DOS (2023)
Note: Graph shows value-added per employment.

Malaysia ranks in the middle in terms of labour-share in mining and utilities, with potential employment risks concentrated within the oil and gas sector, known for traditionally high labour productivity[146] (Figure 3.8). Nationally, the high productivity of the sector also sets it apart from other sectors. The oil and gas sector enjoys higher wages and job quality due to its high skill requirements and stability. However, the low-carbon transition directly affects this sector. Affected workers whose skills may not be immediately transferable face potential needs to reskill or to seek reemployment[147]. Without concerted support policies, they can be left vulnerable to

[142] Auty (1993); Ruppert Bulmer et al. (2021)
[143] Fatah (2008); Subanti, Hakim, and Hakim (2018); Rian Hilmawan, Rizky Yudaruddin, and Yuyun Sri Wahyuni (2016)
[144] Resosudarmo et al. (2009); Atteridge, Aung, and Nugroho (2018)
[145] U.S. Bureau of Labor Statistics (2023)
[146] Department of Statistics Malaysia (2023)
[147] ILO (2019); (2022)

labour market shifts. The country also needs to look for alternative industries that can provide equally productive and secure jobs, compensating for potential labour and skill losses.

Policies must consequently support the creation of equivalent decent, quality jobs in newer green sectors and, at the same time ensure smooth labour reallocation between sectors.

Household income

Transition is bound to reduce the costs of clean energy relative to carbon-intensive fossil fuels. At the same time, product prices are likely to rise as firms incur costly activities in pollution reduction[148]. In order to steer market forces in favour of low-carbon technology, governments deliberate on the use of market-based mitigation policies. These policies utilize carbon pricing instruments (CPI) such as carbon tax and cap-and-trade schemes to direct price signals that encourage the shift towards clean, low-carbon energy. CPIs impose a price on fossil fuels or carbon emissions, creating financial incentives for disinvestments from carbon-heavy sectors[149]. They also aim to reduce the chances of a "rebound effect", where the demand-supply shift to renewables depresses fossil fuel prices, potentially driving demand for fossil fuel back up[150].

However, it should be noted that market-based mitigation policies can have regressive effects, disproportionately affecting lower-income households[151]. The distributional impacts differ based on where carbon pricing is imposed, either upstream (e.g., on producers or imports) or downstream (e.g., on consumers). When carbon is priced upstream, the inflationary effects may depend on producers' ability to pass on costs to consumers. In contrast, downstream carbon pricing, such as fuel taxes, is more visible and involves less accounting and administrative costs but suffers the same regressivity similar to consumption tax[152]. Distributional effects also differ depending on the revenue recycling of collected tax proceeds.

CPI affects households in two ways:(1) through use-side impacts, which influence the relative prices of goods and services, and consequently households' expenditure, and (2) through source-side impacts, which affect nominal wages, capital, transfers, and consequently overall household income[153]. Given that energy expenditure takes up a larger share of poorer household's income, carbon tax will inevitably raise their daily energy costs without changing the quantum of their consumption. Metcalf (1999) found that the lowest income decile is disproportionately burdened by emissions tax compared to the top income group[154]. Regressivity is even more pronounced when measured in terms of disposable income rather than current expenditure[155]. Some studies have suggested that carbon pricing can have progressive effects when looking at the effect on source of income, which can offset the regressive effects of the pricing on poorer groups' expenditure[156]. It is important to note that a proportional offset does not necessarily equate to absolute change. For example, a proportional reduction in income for a rich household, which is

[148] Metcalf (1999)
[149] Kennedy, Sers, and Westphal (2023)
[150] A. Greening, Greene, and Difiglio (2000)
[151] Büchs, Bardsley, and Duwe (2011); Rausch, Metcalf, and Reilly (2011)
[152] Metcalf and Weisbach (2009)
[153] UNCTAD (2023)
[154] Metcalf (1999)
[155] Büchs, Bardsley, and Duwe (2011)
[156] Rausch, Metcalf, and Reilly (2011)

larger in absolute terms, cannot be directly compared to the reduction of an equal fraction of income from a poor household.

Alternatively, in parts of the world where energy is subsidised, governments may opt to remove fossil fuel subsidies, which ultimately arrive at the same result through the removal of price "distortions" and reintroducing market efficiency. Studies have shown subsidy removal yields distributional outcomes similar to carbon taxation, with outcomes depending on the developmental level and energy intensity of an economy[157]. To address potential regressivity, governments may implement targeted fossil fuel subsidies that exempt certain households. Nonetheless, it is important to recognise that the prices of many goods are closely tied to energy prices. Increased energy input costs will invariably be passed on to consumers. Given that poorer households spend proportionally more on carbon-intensive products, either due to previous price levels or ease of access, they are particularly vulnerable to the inflationary pressures resulting from these policy changes.

Energy use in lower-income households also tends to rely on fossil fuels, especially those that are located off-grid. The imposition of a carbon price on fuel can significantly burden their energy use. At the same time, they possess lower capital to change over to cleaner or more efficient alternatives, at least not in the near term[158,159]. Whereas wealthier households have more avenues to mitigate rising energy costs. They can allocate capital towards investments or changeover to low-carbon energy sources. In contrast, poorer households are generally limited in means and must absorb the cost associated with carbon pricing[160].

Figure 3.9 shows the income groups of Malaysia and their monthly expenditure on energy products. It should be highlighted that despite energy spending as a share of expenditure across income quintiles are roughly equal, energy spending constitutes a higher share of poor households' income than their richer counterparts. Downward pressure on income from labour market shifts and upward price changes can leave vulnerable households with a much constrained financial position.

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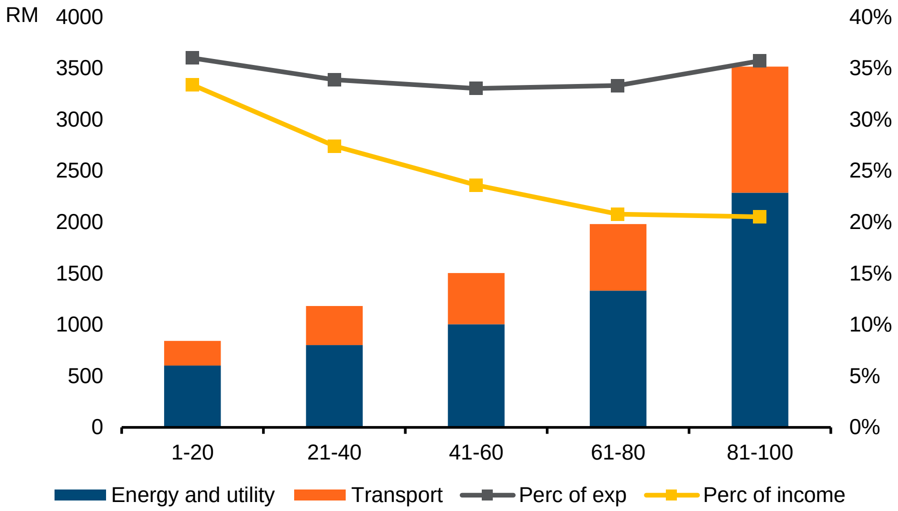
[157] Metcalf (1999); de Bruin and Yakut (2023)
[158] Lecocq et al. (2022)
[159] We refer to cleaner alternatives not only to power source, but a range of energy-use such as electric motor vehicles and electric heating or cooling systems which can be taken off-grid.
[160] Luciani (2020)

Figure 3.9: Monthly energy expenditure by household income quintiles in Malaysia, 2022



Source: DOS (2022), Author's visualisation

Proponents of CPI have mooted revenue recycling, i.e., the redistribution of revenue receipts from CPI to groups vulnerable to the effects of transition. Modelling studies sometimes implicitly or explicitly assume revenue recycling of carbon tax revenue, which normally yields positive distributional outcomes. One approach to revenue recycling involves deploying carbon tax revenue to offset other taxes, such as income tax. This can leverage the ability of carbon taxes to mitigate distortions caused by other taxes and result in positive macroeconomic outcomes[161]. The impact of revenue recycling, however, is not well understood. The effectiveness of revenue recycling is highly dependent on program design and delivery, with caveats for both lump-sum payment or reduced tax as instruments of redistribution. It is important to note that modelling studies often understate real-life complexities related to revenue recycling, such as administrative and market inefficiencies. **The key to an equitable CPI design is through transparent procedure and progressive mechanisms that do not trade off socio-economic well-being for market efficiency.**

Apart from CPI, governments are also availed with non-market-based instruments. These are policies that do not rely on price signals but still influence the cost of emissions. They can take the form of a disciplining 'stick', such as a uniform regulatory standard, or 'carrots' to targeted emission-abating behaviours, like subsidies that make lowering emissions much cheaper than otherwise.

While non-market-based policies such as energy efficiency regulations have been shown to reduce emissions in upper-to-middle-income countries over time[162], it is important to carefully assess their effects. Studies in the USA have shown that reduced energy consumption was as much a consequence of widening income disparity as it is a consequence of the energy efficiency policy[163]. As a larger share of income is accrued to the upper bracket, energy consumption, which could otherwise expand in the lower-income group, is curtailed. This highlights the inequities that are obfuscated in the transition to a low-carbon economy, where desirable mitigation outcomes

[161] Gandhi and Cuervo (1998)
[162] Zhang et al. (2021); Linn, Liang, and Qiu (2022)
[163] Linn, Liang, and Qiu (2022)

may be arrived at at the expense of other developmental goals, especially for socially marginalised classes.

Access to secure and affordable energy is a cornerstone of economic development for poorer groups. The transition to a low-carbon economy implies a shock to energy costs, at least in the near term. While these impacts may not be substantial over the long term when reaching a steady state, however, they can be detrimental to developing groups. Without adequate support during the transition period, they may face more difficulties in development.

Technology risks

Technological uncertainty

The transition of a country's energy system to a low-carbon one also presents technical or technological challenges. Achieving a systemic decarbonisation of all activities requires transformation at the source, involving the transforming of fossil-fuel-based energy systems to a distributed, renewable-based system. This often means high levels of electrification[164]. The combination of mass electrification and renewable integration will introduce imbalance to the power system in the short term, which requires managed system planning.

Increased electricity consumption by moving most off-grid fossil-based energy use into the grid (recall the production set in *Output*), depending on the corresponding pace of grid integration, will introduce imbalances into the power system. For example, substituting the majority of a country's transportation fleet for electric vehicles can significantly ramp up electricity demand during peak load hours, laying stress on the power supply and existing grid infrastructure[165].

Power systems built on dispatchable technologies like fossil fuels and nuclear are equipped with balancing capabilities to increase or decrease output subject to demand. Variable renewable energy (VRE) like solar and wind, however, are constrained by intermittency and non-dispatchability.

The non-dispatchability of VRE can introduce adequacy challenges to the power system. As VRE is unable to adjust output to cater to surges in demand, this requires backup capacity made up of dispatchable power or battery storage to match residual demand not covered by VRE[166]. Additionally, the intermittency of VRE means that they could not sustain a consistent power output and will need operating reserves to maintain base load[167].

The variability of VRE means that a high share of VRE in the power mix will need balancing resources and grid reinforcement[168]. Balancing and intermittency measures can incur high costs, which ultimately influence electricity prices for consumers[169]. The integration of VRE, such as solar photovoltaics (PV), also introduces auto-producers, or “prosumers”, who both consume and produce electricity. Prosumers encompass a wide range of capacities, from utility-scale producers to commercial and residential users[170]. As the penetration levels of VRE increase, this also raises

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[164] IRENA (2019); Clarke et al. (2022)
[165] Clarke et al. (2022)
[166] Baroni (2022)
[167] Holttinen et al. (2012)
[168] Banerjee, Jayaweera, and Islam (2016)
[169] Ibid.; Wedde et al. (2007)
[170] Baroni (2022)

the scale and diffusion of prosumers within transmission and distribution networks, laying stress on low-voltage distribution networks. This trend creates challenges for system operators to integrate new power sources while maintaining reliability and power quality[171]. Integration of distributed VRE at scale will, therefore, incur much higher system costs[172].

Prosumers also introduce additional distributional challenges to electricity markets. For example, electricity tariff systems with a cross-subsidisation design can face revenue sufficiency issues as bigger users choose to exit the tariff system by taking on the role of producer and moving their electricity consumption off-grid. High-band electricity users in the commercial and industrial categories, who have hitherto been paying higher tariff rates, which cross-subsidise lower-band users who consume below cost, have more capacity and incentive to become power producers themselves[173]. The exit of big tariff payees from the system, on aggregate, can leave smaller electricity consumers with the onus of footing the bill, which was once subsidised if traditional tariff schemes remain. Studies also found wealth transfers from consumers to prosumers under distributed generation[174]. Lower-band electricity use below production cost, likely to be low-income households, faces the potential of price hikes without subsidisation. As energy use already constitutes a larger share of poorer households' income, the tariff system shocks can translate into unequal distributional impacts on income.

Conventional economic assessment of power projects uses a levelized cost of electricity (LCOE), which tends to underestimate system costs[175]. LCOE, however, has generally been the yardstick for policy and investment decisions[176]. There are economic implications associated with a VRE-integrated power system, which influence the costs towards consumers, as well as the attractiveness of clean energy investments.

In competitive power markets, power systems dispatch electricity by merit order, i.e., the sequence in which power plants are dispatched to meet electricity demand based on their marginal costs. As they employ freely available input sources such as sunlight and wind, VRE can remove the marginal costs in producing per unit of energy, therefore having zero to near-zero marginal cost. They are dispatched first and can push more expensive generating technologies out of the merit order stack. However, this effect fluctuates incredibly hour by hour due to the intermittency of VRE. At high VRE penetration, wholesale markets can experience negative prices at specific hours and the reverse in the next. This is because VRE shifts the highest electricity prices away from peak demand periods to peak hours of residual electricity demand (i.e., where most demand cannot be covered by VRE, early morning or late afternoon).

The introduction of large shares of VRE into power systems influences the type and volume of capacity installed, as well as the ways in which power plants operate. In short, an increase in the installed capacity of VRE comes with a corresponding decrease in utilisation factors of dispatchable power plants and a reduction in wholesale power prices[177]. These effects have uneven implications for consumers of different classes, industries with and without capacities to transition, power producers and operators of distribution networks. A concerted system planning

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[171] Volosciuc, Sorin Dan and Dragosin, Monica Elena (2019)
[172] Picciariello, Reneses, et al. (2015)
[173] Borenstein (2017)
[174] Picciariello, Vergara, et al. (2015)
[175] Ueckerdt et al. (2013); Matsuo (2022)
[176] IEA (2022)
[177] Baroni (2022)

and power market reforms are key for economies envisioning an energy transition. Such reforms need to consider an equitable burden-sharing scheme that recoups potential system costs while supporting lower-band consumers who cannot pay above their means.

Technology transfer and diffusion

The success of transition is also dependent on innovation or technical change. Aside from a few variable renewable technologies, many low-carbon technologies related to production activities are either immature or have yet to make inroads into wider markets[178]. This is particularly true for energy storage technologies, which, despite great strides, have not matched the maturity of the corresponding RE technology[179]. The political appeal of transition is subjected to the perceived costs of decarbonisation, which are brought down by cost-effective technology. An accelerated transition means that innovative activities have to pick up rapidly and at a coordinated pace.

Goldthau, Eicke, and Weko (2020) highlighted the zero marginal cost problem with respect to technological importance. As discussed above, RE technology removes marginal input costs and can result in low wholesale electricity prices[180]. The implication of zero marginal costs of RE is two-fold: (1) lower profits from low prices discourage investors who seek revenue through power markets, and (2) magnifies the importance of technology in bringing down costs and widening profits.

Take the example of the energy sector alone. The cost profile of RE generation consists almost entirely of fixed or capital costs[181]. As fuel prices exit the production cost, technology in storage, distribution, and hardware upgrades become the main driver of cost reduction. Thus, value inclines towards technology development and design rather than resource extraction in low-carbon value chains[182]. Even where key low-carbon technologies rely on critical minerals, such as lithium cobalt used in battery development and copper in electricity distribution, innovation is occurring at speed to bring down costs by either switching to cheaper minerals or improving efficiency[183].

The technological primacy of a low-carbon economy will shift the geopolitical order of world trade, moving valence away from fossil fuel exporters to critical minerals and low-carbon technology producers. As discussed in *Output*, facing shrinking demands, the global fossil fuel market moves in favour of low-cost producers, which leaves high-cost, fossil-dependent developing countries to face the risks of stranded assets and truncated sources of trade. Fossil-dependent **developing countries with limited potential from critical minerals thus face the twin pressures of (1) losing resource rents whose redistribution safeguards social stability and (2) worsening terms of trade with respect to reduced exports against imports, hence increased pressure on currencies[184].**

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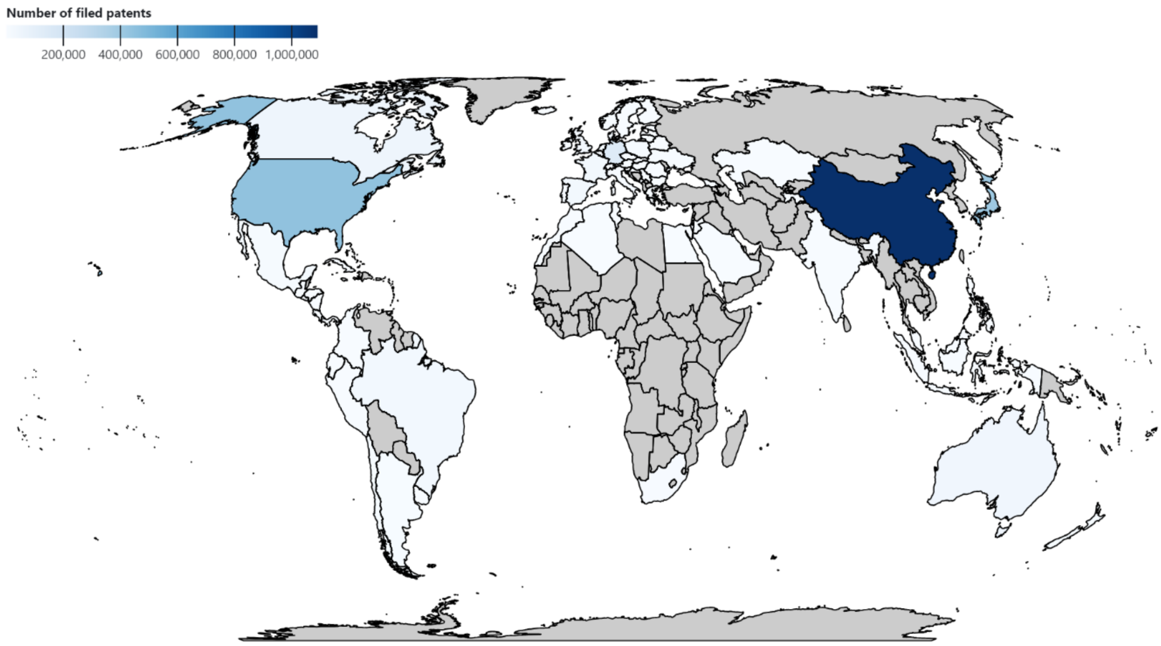
[178] Kittner, Lill, and Kammen (2017)
[179] Ibid.
[180] Goldthau, Eicke, and Weko (2020)
[181] Ueckerdt et al. (2013)
[182] Goldthau, Eicke, and Weko (2020); Gereffi, Humphrey, and Sturgeon (2005)
[183] Overland (2019)
[184] Goldthau, Eicke, and Weko (2020)

Within the broader context of global competition, the pressure on fossil fuel-dependent developing countries to diversify is doubly pressing, as they face the prospect of losing the trade advantage and must compensate for a depleted source of trade, all while having to leapfrog towards an advanced low-carbon economy under constrained conditions. This challenging balancing act poses cascading risks to their development goals. Depleting resource rents restricts fiscal capacity, making it harder to support populations susceptible to energy insecurities. Constrained economic output and deteriorating terms of trade further exacerbate these issues by heightening currency risks and potentially deterring crucial investments necessary for the transition. The potential consequences are devastating: stagnation in sustainable development progress, deeper development disparities in the most vulnerable regions, and a widening global inequality gap. There is thus a need for all countries, particularly developing countries, to accelerate low-carbon technology development. Absent of indigenous capacity, countries are relegated to importers of low-carbon technology, of which dependency creates inferior conditions for trade.

Figure 3.10: Cumulative number of registered clean energy patents by countries, 2000 – 2021



Source: IRENA (2022); Author's visualisation

Within the current global landscape, sites of low-carbon technology innovation, outside of China[185], are almost invariably located in advanced economies[186]. The intensive research and technology activities in the North have developed alongside the Intellectual Property Rights (IPR) regime, which observers have pointed out its poor design that served against the UNFCCC principles[187].

[185] The number of filed sustainable technologies patents for China in 2020 is at 128,933 (IRENA, 2022)
[186] IRENA (2022a)
[187] UNFCCC Article 4.5 outlined the responsibility of developed countries to "promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties" (UNFCCC, 1992).

Nonetheless, attempts to highlight IPR deficiencies at international negotiations have been met with defence from developed country parties[188]. It does not help when innovation, viewed as a high-risk, low-return bet funded by large capital, is protected with an IPR design that prioritises patents. Although Baker et al. (2017) suggested that evidence proved against the claim of IPR stifling technology diffusion[189], the catch is that global low-carbon transition requires more than simply diffusion of technology, which arises from the transfer of equipment or hardware, but actively enables developing countries to assimilate those technologies and improve their own innovative capacity[190].

In recent years, developed countries increasingly saw trade and industrial policies in the North being designed to secure a competitive edge. These policies sought to encourage domestic manufacturing for low-carbon technologies and raise barriers to foreign entry[191].

Models attributing economic growth to green technological change inherently assume frictionless technology transfer[192], envisioning in the long run, knowledge spill-overs and technology transfer will benefit developing economies and uplifting populations through co-benefits in the low-carbon transition[193]. Such extrapolations omit market failures and tendencies for agents to secure market power in a zero-sum game. In reality, technology transfer and diffusion are highly complex processes.

Developing countries such as China and Indonesia are able to leverage market size as terms of technology transfer. However, for countries with fewer bargaining chips on the table, it is common for governments to be held sway to the interests of foreign capital in return for inferior contracts. Poor technology transfer contracts allow multinationals (MNCs) to exploit favourable conditions in host economies, with lowered costs such as tax incentives, low wages, and basic infrastructures, while offering little in return[194]. This can be observed in Indonesian mining sectors where foreign capital reins large while a lopsided multiplier mainly benefits capital income[195].

Malaysia offers an interesting example of mixed success in capturing technology and knowledge transfer through foreign direct investments (FDI)[196]. Outside of resource-intensive sectors such as palm oil, technology transfer saw middling performance. This is especially pronounced in sectors such as the electrical and electronic products industry, where backward linkages into the local economy are less than impressive, while transfers largely derive from demonstration effects[197]. The wider extent of such transfer in the green sector remains to be understood. However, it stands to show that securing the technology to produce clean energy and green

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188 Rimmer (2011)
189 Baker, Jayadev, and Stiglitz (2017)
190 Ibid., Ockwell and Mallett (2012); Weko and Goldthau (2022)
191 Lewis (2014)
192 Ambec (2017)
193 For instance, most models assume away technological uncertainty through a 30-year technological horizon, wherein firms will be able to recoup investments and achieve growth at a projected steady-state (Riahi et al., 2022).
194 As vertically integrated MNCs can monopolise the entire production chain directly to export, preventing any backward linkages into local economies.
195 Rian Hilmawan, Rizky Yudaruddin, and Yuyun Sri Wahyuni (2016)
196 Felker and Sundaram (2007); Lebdioui, Kuen Lee, and Pietrobelli (2021)
197 Lebdioui, Kuen Lee, and Pietrobelli (2021)

products will be challenging, much less the know-how and skillsets required to move the economy up the green growth value chain.

We argue that the potential developmental risks of low-carbon transition cannot be assessed outside of the backdrop of risks imposed by climate change. However, developing countries have equal rights as developed countries to assert their own developmental aspirations, which cannot be attained without growing indigenous capacities and securing competitive terms of trade, at least within the context of the global economic order. Given the growth-oriented world economic order is unlikely to change in the foreseeable future, developing countries should not be expected to bear the burden of finding development pathways decoupled from energy or resource use[198], which subject them to all the risks of social instability, while developed countries, primarily responsible for the climate crisis, are given a pass. Sustainable and climate-resilient development has to be considered in the context of equitable conditions and outcomes, where developing countries have the space to develop socio-economically amidst transition.

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[198] See Steckel et al. (2013)

3.2. National LT-LEDS comparisons

The concept of Low Emission Development Strategies (LEDS) emerged in international fora in the 2008 Bali Action Plan, later in the Copenhagen Accord, followed by the Cancun Agreement[199]and the Durban decisions[200] , which called on developing countries to formulate their LEDS[201]. The Paris Agreement invites all parties to "strive to formulate and communicate long-term low greenhouse gas emission development strategies (LT-LEDS)"[202], taking into account the CBDR-RC principle of UNFCCC. This was further nudged in the Glasgow Pact of 2021, where parties were urged to communicate their respective LT-LEDS "towards just transitions to net zero emissions by or around mid-century, taking into account different national circumstances"[203].

At the time of writing, out of the 58 LT-LEDS submitted to UNFCCC, 30 of them are submitted by Annex I countries, which has a total of 44 member parties[204]. In numerical terms, non-annexed parties have contributed to nearly half of all LT-LEDS communicated.

LT-LEDS is a policy tool that aims to inform national long-term planning towards achieving climate objectives. It is important in placing short-term action in the context of long-term structural changes required to transition to a low-carbon economy[205]. As "structured strategy exercises", LT-LEDS commonly employ scenario modelling to explore socio-technical pathways to meet low-carbon targets[206]. This allows governments to inspect the economic, social, technological, and institutional changes required to meet climate goals, as well as trade-offs associated with the structural transformations[207]. Thus, high-level planning with detailed impact projections and simulated levers allows some degree of foresight and informs various actors.

Because LT-LEDS has primarily been focused on mitigation, it has progressively become "a proxy for countries' vision on how to reach net-zero emissions"[208]. Almost all LT-LEDS involve energy system surveys that inform domestic energy transition, mainly in power production[209]. A deep structural transition of energy systems has implications for developing countries. There is wide consensus on the relationship between energy consumption and economic growth[210]. As higher rates of energy use are often associated with the industrial stages of development, developing countries whose economies are dependent on cheaper sources of energy may not have the best transition options available to them, notwithstanding the reliance of global value chains on the low-cost production in these regions[211]. LT-LEDS ought to offer governments a guided view of a balance between mitigation action and developmental priorities.

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[199] 1/CP.16 Para. 45 and 65
[200] 2/CP.17 Para. 38
[201] Waisman et al. (2021)
[202] Art. 4.19
[203] 1/CMA.3 Para. 32
[204] UNFCCC LT-LEDS portal, accessed 27/2/23
[205] Waisman, Spencer, and Colombier (2016)
[206] Ibid.
[207] Jaber et al. (2020); IRENA (2023a)
[208] Waisman et al. (2021)
[209] IRENA (2023a)
[210] See Nanthakumar and Subramaniam (2010); Azam et al. (2015); D. I. Stern, Burke, and Bruns (2017)
[211] Trienekens (2012); Menegaki (2014); Goldthau, Eicke, and Weko (2020); Dorninger et al. (2021)

It is important to maintain the role of LT-LEDS in facilitating a just transition, i.e., socio-technical transformations toward decarbonisation, with the prerogative of ensuring the protection of the vulnerable and equitable access to socio-economic development.

As Malaysia's LT-LEDS is being developed, a weighing exercise of the appropriate transition pathways and corresponding measures is essential. To that end, we compare two LT-LEDs from selected ASEAN peer countries, Indonesia and Thailand, and one developed country from the G7 group, the United States. The selection of candidate countries is made on the basis of (1) developmental needs, (2) capacity for low-carbon transition, and (3) responsibility towards climate change. These are reflected in each county's (1) developmental status, (2) climate vulnerability, (3) production structure and energy system, as well as (4) historical emissions.

Indonesia and Thailand are selected for their proximity in developmental status and economic structure, i.e., similar developmental priorities and economic composition of main productive sectors[212]. They are also close regional neighbours of Malaysia who have similarities in climate vulnerabilities. The two countries are a reference to Malaysia's own LT-LEDS formulation. The USA is chosen as a representative for Annex I countries with high climate change responsibility and high capability reflected in development status while being lower in climate vulnerability.

Table 3.1: Overview of selected countries

	Malaysia	Indonesia	Thailand	United States
Country code	**MYS**	**IDN**	**THA**	**USA**
Socio-economic				
GDP per capita (2019 USD)	11,132	4,151.2	7,630	65,120.4
GI 2019	40.9	39.0	37.0	41.4
HDI 2021 [ranking]	0.803 [62]	0.705 [114]	0.800 [66]	0.921 [21]
Share below IPL (% below USD2.15 per day)	0.02	3.55	0.05	1
Climate				
Historical emissions (share of global emissions)	6.05Gt (0.36%)	14.31Gt (0.44%)	7.5Gt (0.84%)	416.9Gt (24.53%)
fossil fuel share-energy mix (%)	96.12	73.24	81.56	80.78
Vulnerability Index (ND-GAIN)	0.377	0.451	0.438	0.329

Source: UNDP HDR (2020); World Bank, accessed 09 Mar 2023; PIP World Bank, accessed 20 Mar 2023; ND-GAIN (2020); UNU-WIDER (2023)
Note: Historical emissions of CO_2 since 1750, as of 2020.

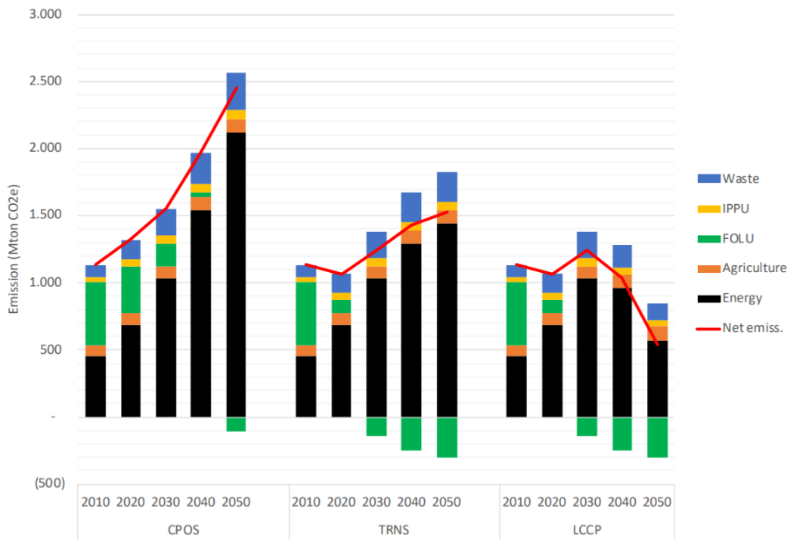
[212] Similar sectoral composition of GDP is observed in the three countries, see World Bank (n.d.).

Indonesia LTS-LCCR

The Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR) outlined a long-term plan consistent with the enhanced NDC. The strategy boasts impressive coverage and details that inform policy direction for major sectors and sub-sectors in achieving climate goals. This is done through the modelling of three mitigation pathways of staggered emissions scenarios: the current policy scenario (CPOS), Transition scenario (TRNS), and Low Carbon Scenario compatible with the Paris Agreement target (LCCP). Each scenario is based on a composite of projected change in sectors and sub-sectors, with a set of explicit assumptions about the properties of the modelled feature.

The document sets out quantifiable targets for both mitigation and adaptation. In terms of mitigation, an emissions target of 540 $MtCO_2e$ by 2050 and net zero by 2060 is put forward. The emissions targets of all pathways are consistent with the enhanced NDC in 2022, i.e., an unconditional reduction target of 29% and a conditional reduction target of up to 41% of the business-as-usual scenario by 2030 (41% of 2.869 $GtCO_2e$ = 1.69 $GtCO_2e$; 29% = 2.04 $GtCO_2e$).

Figure 3.11: Projected emissions under LTS-LCCR pathways



Source: Indonesia LTS-LCCR 2050 (2021)

The LCCP mitigation scenario envisions emissions to peak by 2030 at 1.27 $GtCO_2e$ and further decline to 540 $MtCO_2e$ by 2050. This is accompanied by the TRNS scenario where transient, less ambitious targets were projected. In terms of adaptation, with the help of integrated assessment modelling (AIM/CGE), the plan quantified climate change impact in GDP terms and designated a quantifiable goal aimed at reducing GDP loss at the projection upper bound (3.45% loss at 3.0°C temperature change). This is combined with both regional and sectoral pathways outlining key actions.

The LCCP pathway, which aims to make deep emissions cuts by 2050, depicted major reductions in the power sector without shifting too much of the power supply mix until 2030. The anticipated power generation mix until 2050 is 43% of RE share, 38% of coal, and natural gas at 10%. To put this in the context of current trends, as of 2019, coal takes up 59% of the generation mix, followed by gas (21%) and RE (16%). Although the national utility provider *Perusahan Listrik Negara* (PLN) has put a halt to new coal plants after 2023, expansion of coal-fired capacity is expected to increase between 14 – 16GW by 2030 (equivalent to 33 – 62% increase in coal consumption)[213]. Coal is to remain a dominant source of power domestically, which sees no trend of waning in the mid-term. Instead, the large reduction of emissions is counted upon the development of carbon capture, storage, and utilisation (CCS/CCUS) retrofits in the power and energy sector, equipping up to 75% of fossil fuel-based plants with carbon capture by 2050.

The country signed a pilot program with ADB in 2019, secured investments in the field from the USA in 2022[214], and made regulatory commitments in 2023[215]. However, deep uncertainties remain associated with the effectiveness of the technology, much less the secondary impact on energy prices, societal well-being, and environmental sustainability. World Bank (2015) pilot study of power plant CCS in Indonesia identified secondary impacts such as large land use, significant loss of electricity output (~30% energy penalty), and doubling of electricity cost (USD 100 per tonne of CO_2 emission avoided)[216].

Apart from direct capturing of carbon emissions, Indonesia also enlisted the Agriculture, Forestry, and Land-Use (AFOLU) sector to achieve deep cuts, mainly through reforestation (89% or 680 Mt of the committed 29%)[217]. This is reinforced through legal measures, e.g., an extended moratorium on palm oil expansion[218] and regulations on peatland management to induce rehabilitation (PR No. 57/ 2016). Although other productivity and efficiency measures in agriculture and livestock sectors are indicated as means to reduce emissions, the restoration of biomass towards "net sink" is primarily a role for the forestry sector. However, there are limits to the method of sequestration by biomass restoration, given the heavy reliance of mitigation goals on reforestation.

Basuki et al. (2022) show that under a realistic scenario (1.7m ha), Indonesia stands to reduce emissions by -17 $MtCO_2e$ yr^{-1} via reforestation, taking into account historical absorption value[219]. This is equivalent to -187 $MtCO_2e$ over 2019 – 2030. Based alone on the Indonesian government-reported land cover data (11.6m ha), potential carbon sequestration from reforestation under a realistic scenario reaches up to -250.5 $MtCO_2e$ or -23 $MtCO_2e$ yr^{-1}. This is merely half of the 497 $MtCO_2e$ expected reduction through the forestry sector in the 2021 updated NDC; with historical absorption accounted for, the figure drops to 35%[220].

Under the LCCP pathway, 5.8m ha of unproductive land is targeted to be rehabilitated, which is expected to help Indonesia reach net sink status. There are, however, practical problems associated with this approach. First, land use emissions mitigation policies rein in the land supply that has fuelled Indonesia's growth in the past. Restrictions in land supply for agriculture will leave ramifications in the real economy, in particular the palm oil industry, of which its expansive agricultural model has relied on relatively cheap land supply[221]. As global demand for palm oil grows while land availability constricts, smallholders with low access to high-yielding varieties will inevitably lose out. Second, the political economy of the Indonesian forestry sector is marred

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213 Reyes (2021)
214 Bose and Davies (2022)
215 Battersby (2023)
216 Takahashi (2015)
217 CCS-COE (n.d.)
218 Gaveau et al. (2014)
219 Basuki et al. (2022)
220 Ibid.
221 World Bank (2023)

by electoral clientelism at state-level natural resource management[222]. Poor enforcement has led to non-compliance and deepened local conflicts among landholders and communities[223], notwithstanding leakage issues that can emerge in opaque emissions accounting, which make netting emissions through sinks arduous in practice.

Southeast Asia has 1.21m km^2, or 121m ha of terrestrial, freshwater and mangrove area biophysically suitable for reforestation, which could mitigate 3.43 ± 1.29 $GtCO_2e\ yr^{-1}$ through 2030[224]; however, reforestation is only feasible in a small fraction of this area (0.3 – 18%) given financial, land-use and operational constraints[225].

The macroeconomic impact assessment carried out in the plan found that under all scenarios of CPOS, TRNS and LCCP, positive economic growth can be achieved. Given higher additional investment to support mitigation action, macroeconomic loss will be less under the stringent GHG reduction pathway (LCCP).

Growth in employment is also projected to be positive (~0.6%), provided positive economic growth leads to higher labour absorption in the agriculture, energy, and construction sectors. This optimistic growth trajectory is premised upon high capital injection. Under all scenarios, total investments will have to grow by an annual average of 4.13 – 4.38%, as well as an additional investment in the energy sector.

LTS-LCCR projected investment needs for CPOS, TRNS, and LCCP are 821.5b (CAGR: 4.38), 749.5b (4.14), and 745.8b USD (4.13, or additional annual 8.2% increase in investment) respectively. Notwithstanding the LTS-LCCR 2050 targets, the reported finance needs to achieve the NDC targets are 281-285b USD from 2018 to 2030[226]. This translates to approximately 2.8% of GDP annually (20b USD); while ADB estimation of climate infrastructure needs is estimated to be 6% of GDP annually from 2016 to 2030 (82b USD)[227]. To put things in perspective, the annual investment required would be 27% of the gross capital formation of Indonesia in 2021 (373.14b USD)[228], while public capital spending in 2020 alone only accounted for 3.4% of GDP[229]. In terms of direct public spending, government budget allocation for both mitigation and adaptation stood at 55.1b USD from 2015 to 2019, or 13.78b USD per year[230]. While the private sector contributed 21.3b USD of climate financing in the same period[231]. The combined annual contribution of both public and private finances (19.1b USD) may just about suffice the finance needs but still does not match the extent of estimated climate infrastructure needs[232], which are key for achieving mitigation and resilience in public infrastructure.

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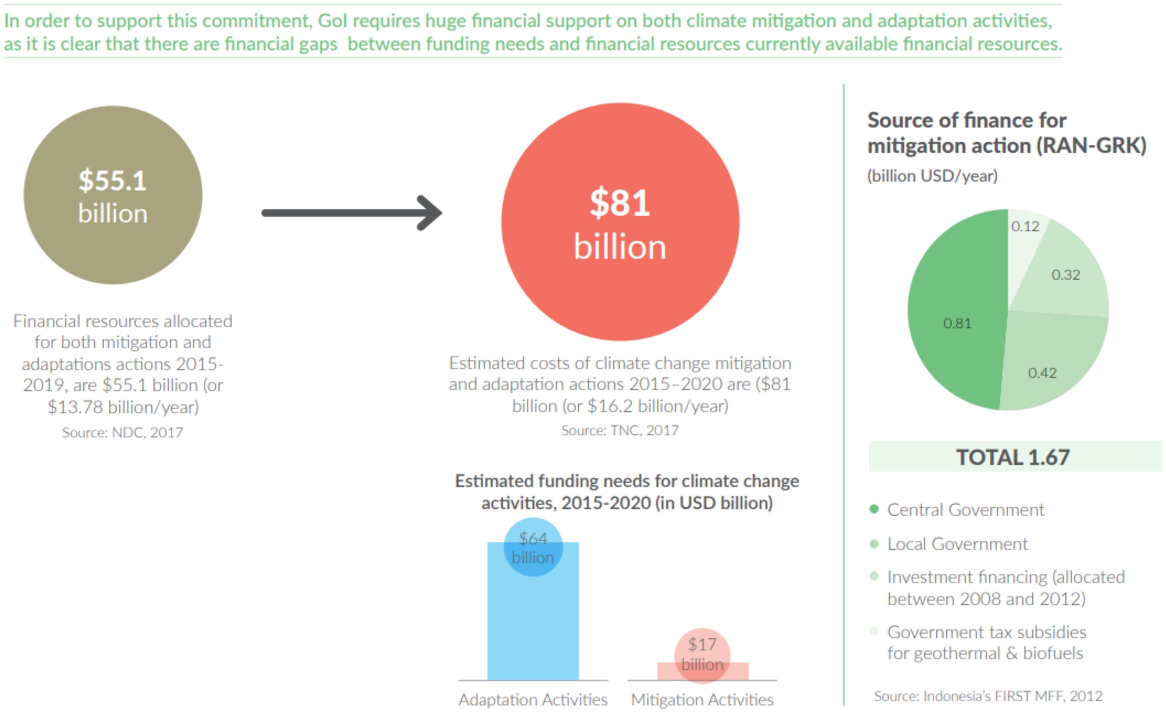
[222] Berenschot et al. (2023)
[223] Jong (2023)
[224] IPCC figures in petagram (Pg), which is equivalent to gigatonnes (Gt).
[225] Cooley et al. (2022)
[226] Indonesia Directorate General of Climate Change (2021)
[227] International Monetary Fund. Asia and Pacific Dept (2022)
[228] World Bank (2022b)
[229] OECD (2021)
[230] Indonesia Ministry of Finance and UNDP (2018)
[231] Government of Indonesia (2022)
[232] ADB (2017a)

Figure 3.12: Indonesia government budget tagged for climate change, 2016 – 2019



Source: Ministry of Finance Indonesia and UNDP (2018)

The transition to a low-carbon economy also implies a constriction of trade-embodied emissions. One large source of trade-embodied emissions is coal. Indonesia was the largest exporter of thermal coal in 2020[233], truncation of coal exports can send ripples across both the country and global supply chains. In 2018, the coal mining labour force amounted to 240,000 while producing a value of 221.b USD, 11.1% of total exports[234]. To achieve the emission goal, the LTS-LCCR projected a 203Mt of production loss by 2050 from export cuts, of which unexploited reserves considered "stranded assets" represented an opportunity loss of 218b USD[235]. Foreclosure of mining operations can pose disruptions to regional economies within Indonesia, as coal is economically critical in "geographically concentrated areas with few economic alternatives" like Kalimantan and south Sumatra[236]. Further complexities also arise where coal is known to generate cascading effects across economic inter-dependencies through its ability to pull up wages in some sectors while crowding out jobs and stymieing wage growth in other sectors[237].

Capital requirements for a scaled transition can be daunting, especially for a developing Indonesia with tight fiscal space and a natural resource-based economy highly exposed to transition risks. Governments have limited levers to pull yet are increasingly pressured to "leapfrog" towards a low-carbon state against their established position within the global value chain.

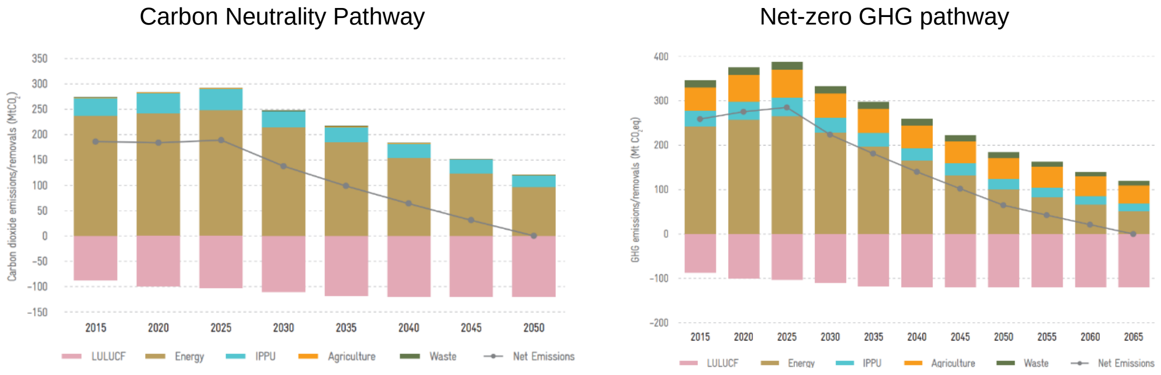
[233] Simoes and Hidalgo (2011)
[234] Ruppert Bulmer et al. (2021); Simoes and Hidalgo (2011)
[235] Government of Indonesia (2021); Tao (2021)
[236] World Bank (2023)
[237] Ruppert Bulmer et al. (2021)

Thailand LT-LEDS

The Thailand Long-term Low Emission Development Strategy was communicated to UNFCCC in 2021 and revised in November 2022 to incorporate national circumstances and enhanced ambition in accordance with technical analysis.

The plan also employed scenario modelling to explore multiple pathways of decarbonisation with staggered levels of ambition. There are two main scenarios in the plan, i.e., the Carbon Neutrality Pathway and Net Zero GHG Emission Pathway. The Carbon Neutrality pathway projected net nationwide CO_2 emissions to be 137.3 $MtCO_2$ in 2030, then 63.1 $MtCO_2$ in 2040. The Net Zero GHG Emission Pathway instead target all GHG emissions. The pathway projects peak GHG emissions of 388 $MtCO_2e$ in 2025 while making further reductions and achieving net GHG emissions at 64.1 $MtCO_2e$ in 2050, then net-zero around 2065[238]. The pathways represent complementary carbon dioxide-targeted and all GHG-inclusive scenarios, with CO_2 reduction prioritised (net-CO_2 at 2050) and all GHG later (net-zero GHG at 2065).

Figure 3.13: Projected emissions under Thailand LT-LEDS pathways



Source: Thailand Office of Natural Resources and Environmental Policy and Planning (2022)

The former is premised on deep cuts in the energy sector, by increasing the RE share in new power generation to at least 50% by 2050[239] and up to 69% share of electric vehicles by 2035. The pathway also expects expansion of LULUCF sinks to 120 $MtCO_2e$ in 2037. While the latter relies on ramping up LULUCF sinks and CCS removal technologies to offset remaining non-CO_2 emissions.

The transition scenario envisions that by 2050, the country has a capacity for 350-400 GW of renewable energy production, including at least 250-300 GW of solar photovoltaic (combining both solar farm and rooftop), and a mixture of wind, biogas, and biomass power plants[240]. This renewable production will need to be backed up by 50 GWh of large-scale grid batteries[241]. A target of this scale naturally entails an accelerated rate of energy system transformation.

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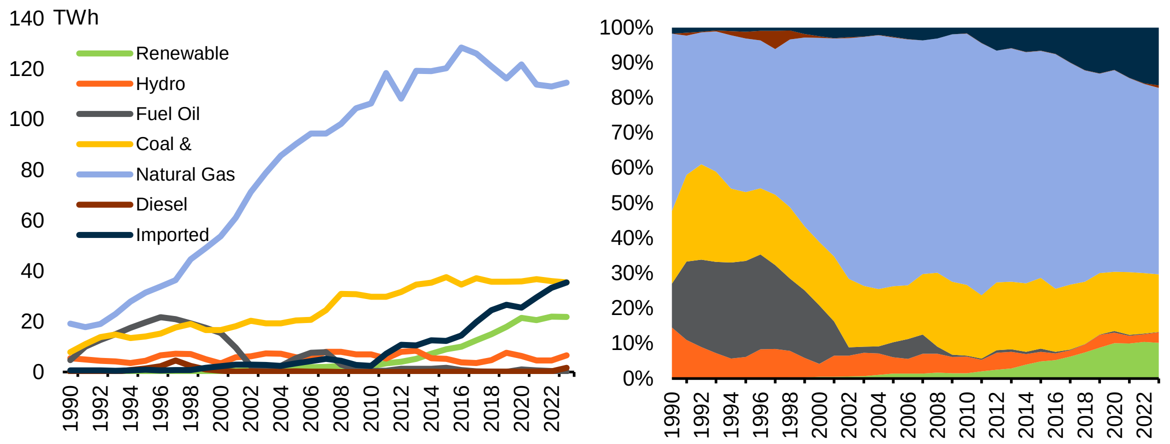
[238] As of 2019, total annual GHG emissions in Thailand stood at 437.18 $MtCO_2e$ (ClimateWatch. n.d.).
[239] 68% RE of total electricity generation by 2040.
[240] Current renewable capacity is around 15 GW, and current plans foresee an increase to 63 GW by 2030.
[241] FES Asia (2022)

Figure 3.14: Thailand power generation by fuel type, 1990 – 2022 (TWh)



Source: Thailand Energy Policy and Planning Office (n.d.)

As of 2022, the RE share of the power generation mix stood at 13.2% (28.4 TWh, including hydropower), of which total RE generation only experienced a compounded annual growth of 7.6% between the decade 2012 and 2022, where VRE growth picked up towards the end of the decade[242]. A modelling study by Chaichaloempreecha et al. (2022) projected total electricity generation to reach between 751 – 814.6 TWh by 2050[243]. This reaches the target of at least 50% renewable generation share; a CAGR of 9.44 – 9.73% is needed from 2020 to 2050[244]. There are, nevertheless, constraints vis-a-vis the energy trilemma considerations that Thai energy policies must address. Under the Net Zero GHG Emission pathway, projected energy system cost alone is set to increase by 62% in 2050 as compared to BAU levels, aside from cost increment in transport systems and other public infrastructure[245]. This requires additional investments of considerable magnitude without accounting for the economic and welfare loss from the transition process, which needs to be absorbed by increased public spending.

With this in mind, Thailand needs to balance growing demand and cost of consistent energy delivery at the same time ensuring RE transition runs its course without risky disruptions. According to the ERIA energy outlook (2021), Thailand's energy consumption is projected to grow at 2.8% per year between 2017 and 2050 (211 Mtoe in 2050), of which industry accounted for 40.4%[246]. Although the power appetite of the sector is expected to be dampened through efficiency improvements, the growth in energy demand will have significant distributional impacts under cost constraints. Power generation in the country has, in recent years, grown dependent on natural gas, which exposed the country to global gas price instability. Notwithstanding the cross-subsidisation mechanisms under the Power Development Fund, the average electricity retail price in Thailand has grown above the affordable range[247]. As domestic reserves of natural gas shrink, the Thai energy system will risk higher exposure to trade volatility

[242] Thailand Energy Policy and Planning Office (EPPO) (2023)
[243] Chaichaloempreecha et al. (2022)
[244] Author's calculation based on the business-as-usual scenario, expected RE share at 60% and VRE share range 35.8 – 56.5%, carbon prices and CCS technology are not considered. Total generation based on EPPO reported figure 25,069 GWh (incl. hydropower) (EPPO, 2023).
[245] Government of Thailand (2021)
[246] Kamalad, Han, and Kimura (2021)
[247] FES Asia, Sirasoontorn, and Koomsup (2017)

as more energy sources are imported. This may build the case for more aggressive RE uptake to substitute for uncertain fuel sources. However, there are high upfront costs for a transition to a RE-integrated power system. IRENA (2017) estimated the required investment to value at 2.6b USD per year for the period 2016 – 2036 if the target under the Alternative Energy Development Plan (AEDP 2015) were to be met (30% RE share in TEFC by 2036), which is 2.5% of the 2021 government budget (1.3tr THB; 105.4b USD, as of 2020)[248]. Authorities have to navigate the tightrope of easing in RE transition without compromising affordable access to energy within multiple constraints.

An IEA (2018) assessment modelled that, consistent with the target of Thailand Power Development Plan 2018 – 2037, i.e., a 20% share of RE by 2036, the cost of VRE generation is lower than gas-centric reference case but higher than coal. The levelized generation cost (LCOE, including investments and avoided fuel cost) would need to fall below approximately 2250 THB/MWh (70 USD/MWh) to achieve net savings for consumers. Such estimates are also premised on lower costs of RE investments, which can remain uncertain despite technological advancement[249]. Inconsistencies also remain with cost estimations, as mid- to long-term energy policy targets remain unaligned; all the while LT-LEDS has set for the country a more ambitious target.

The assessed macroeconomic impacts of modelled mitigation pathways are (1) a projected 1.31% loss in overall GDP in 2050 and (2) 2.6% in 2065 due to more stringent measures after 2050. GDP loss is incurred mainly by lower productivity in petroleum refineries, coal and lignite mining industries, manufacturing industries, and agriculture and transport sectors. This is coupled with an expectation of a 3.4% welfare loss between 2020 and 2050, with which the plan identified raising government spending as a countermeasure. Nonetheless, productivity loss is to be offset by anticipated gains in other sectors such as forestry, electricity, trade and services, et cetera, provided an increase in capital investment. However, job transition is not detailed in scenario-building, which only includes employment creation as a positive component of low-carbon transition.

LT-LEDS suggested a set of policy incentives aimed at inducing private low-carbon investments, such as tax schemes for low-carbon technology and market instruments for blue-green finance, as well as a voluntary emissions trading market. These measures do not negate the fact that government spending is a prerequisite for achieving the ambition set out in the LT-LEDS. In the context of a fiscal squeeze, the Thai government is still grappling with higher levels of fiscal deficit post-COVID (-5.6% for 2022) and limited capital spending[250]. Likewise, the need to alleviate energy poverty has incurred the government 1.1% of GDP on diesel subsidies in 2022 alone[251].

In terms of adaptation, the policy document identified climate risks in two RCP scenarios and set out corresponding provisional actions along sectoral lines. These measures range from managerial measures such as standard and code setting, integration into planning, adjustment in management practices, and knowledge training to economic instruments and infrastructures such as Payment for Ecosystem Services (PES), early warning systems, and watershed management structures. It is estimated the enabling measure for full implementation of the National Adaptation Plan (NAP) would cost up to 3,600 million THB or 98 million USD during the

[248] IRENA and Thailand Ministry of Energy (2017)
[249] Ibid.
[250] World Bank (2022a)
[251] Ibid.

NAP implementation period of 2018-2037. This is equivalent to 0.11% of the average government budget size for the period 2017 – 2021[252].

LT-LEDS also identified the country's support needs, including technical assistance, technological transfer and development, capacity building, seed funding and capital investment support, and pilot implementation in all sectors. A just transition for Thailand, given the ambitious targets, requires the government to balance clean energy objectives with security, as well as amping up adaptation efforts in addressing sectoral vulnerabilities to changing climate. This suggests more international support should be accorded to the country, and the government have to coordinate effective measures in capturing support.

United States

The United States' Long-Term Strategy (LTS) was issued by the White House in 2021 by the Biden administration following the country's re-entrance into the Paris Agreement. The federal plan follows the 2016 Mid-Century Strategy on Deep Decarbonisation, updating the Obama-era target of 26-28% below 2005 levels by 2030 and deep decarbonization of 80% below 2005 levels target with a net-zero by 2050 ambition.

The LTS chart pathways to achieve NDC of (1) reducing net greenhouse gas emissions by 50-52% below 2005 levels in 2030[253], and (2) achieving net-zero emissions by 2050. The plan modelled a range of 12 scenario pathways but boiled down to one representative pathway, taking the median of all scenario sets.

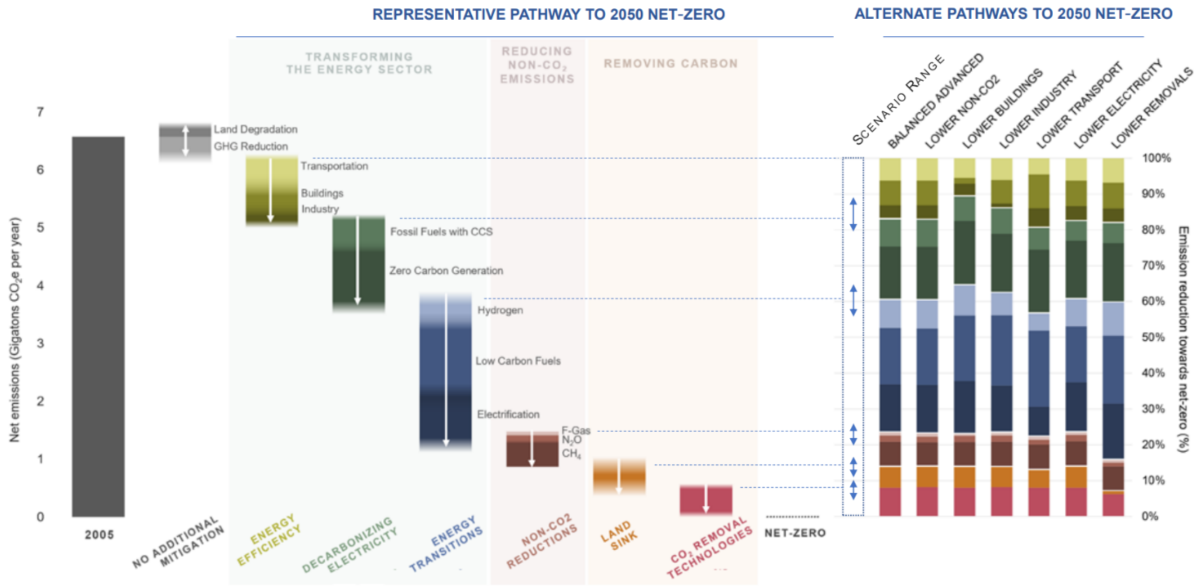
The LTS strategy is centred on five main transformations:

1. decarbonize electricity;
2. electrify end uses and switch to other clean fuels;
3. cut energy waste (energy efficiency);
4. reduce methane and other non-CO_2 emissions; and
5. scale up CO_2 removal through carbon sinks and engineering strategies.

Potential pathways are modelled to arrive at a unified net-zero goal. Although the weights of each component vary, among all scenarios, a bulk of the reduction will occur in the transformation of the energy sector (Figure 3.15). A combination of electrification, green fuel transitions, energy efficiency measures, and decarbonizing electric generation through renewables and CCS is expected to contribute 66 – 88% of emission reduction until 2050.

[252] Author's calculation, IMF (n.d.)
[253] Equivalent to reducing net U.S. emissions from roughly 6.6 Gt CO2e in 2005 (and 5.7 Gt CO2e in 2020).

Figure 3.15: Emissions Reductions Pathways to achieve 2050 Net-Zero in LTS



Source: United States Department of State (2021)

Based on the strategy, energy system transformation will contribute the most to emissions reduction, roughly 4.5 Gt of the 6.5 Gt annual reduction against 2005 levels. This involves the transition to renewable generation (1 Gt annual reduction by 2050) and energy efficiency measures in the building and transportation sector, representing roughly 0.5 Gt. The strategy sets a sub-target of 100% clean electricity by 2035 through deep electrification and a switch to low-carbon fuels, especially in the transportation sector (transportation energy use from fossil fuels of 24 EJ in 2020 is projected to decrease to 0 – 5 EJ by 2050; energy use of the sector from alternative fuels will rise from 2 to 6 – 9 and 3 – 6 EJ from electricity in the same period), LTS is expected to lower energy-related emissions to lower than 1 GtCO2e by 2050.

Energy-related emissions in the USA have fallen over the past two decades by an average of -46 MtCO2 annually (annual average change of -0.79% from 2001 to 2021). In absolute terms, the USA remains the largest in production and consumption of energy. Despite comparatively lower carbon intensity, by the sheer scale of absolute annual emissions, the USA still holds significant sway over global emissions as a single country just after China.

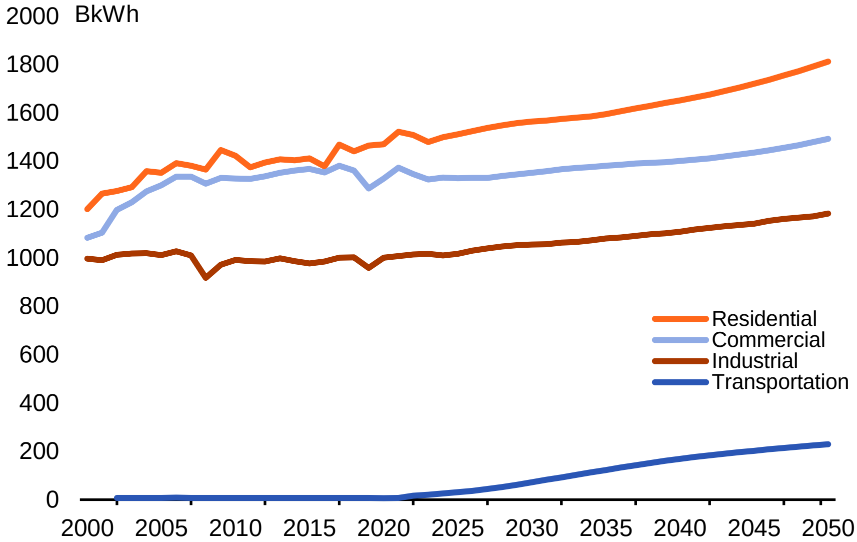
Compared to developing countries like Indonesia or Malaysia, which saw coal grow as a major component of generation over the past decade, the USA's electricity mix has been steadily de-carbonising through a steady reduction of coal from 2.02b MW down to 0.83b MW in 2021 since peak net generation in 2006[254]. This phase-out is also seen in the number of additional coal power plants, which is outstripped by the number of retiring plants in 2021[255].

This phase-down of coal, however, is paralleled by an increase in natural gas within the electricity mix, from 0.88b MW in 2006 to 1.69b MW in 2021[256]. The upward trend of natural gas is projected to dampen and stabilise by 2030 as renewables make bigger inroads into the electricity mix (Figure 3.17). While the energy consumption trend remains relatively stable through 2050, the composition of energy use will accrue to the power systems following higher electrification.

[254] EIA (2022)
[255] 24 to 0 in 2021EIA (2021)
[256] EIA (2022)

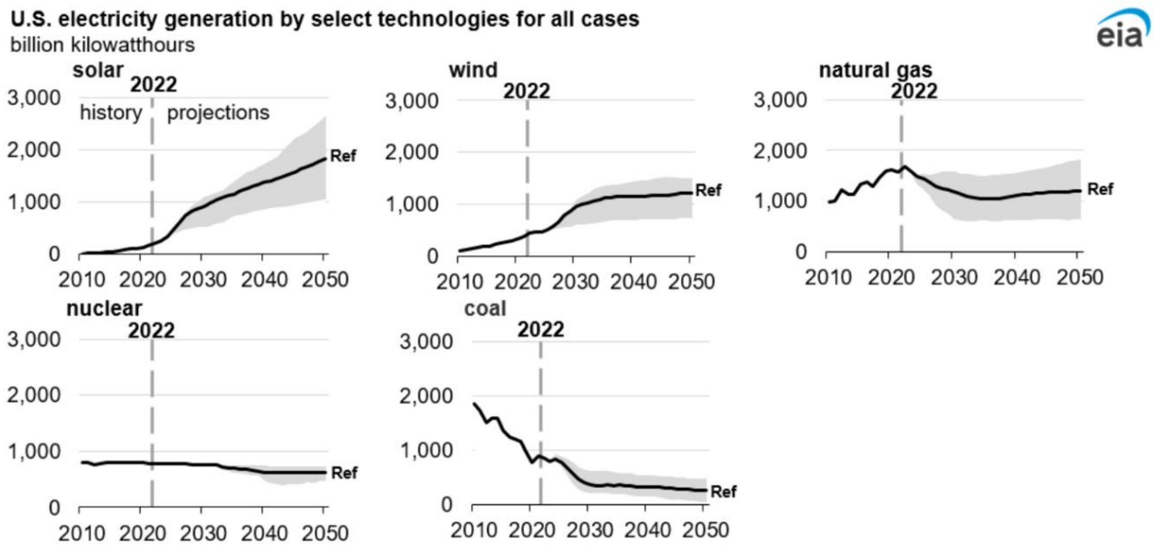
Electricity sales in all sectors are projected to rise through 2050, with significant growth in the transportation sector (Figure 3.16). This calls for stronger electric system integration policies, as well as electricity market reinforcement, to address issues discussed in *Technology risks*.

Figure 3.16: Electricity consumption by sector in US (BkWh)



Source: EIA (2023)

Figure 3.17: US electricity generation by select technologies (BkWh)



Source: EIA (2023)

The EIA's Annual Energy Outlook (2023) forecasts are based on the expectation of lower renewable energy technology costs and rising subsidies under the recently passed Inflation Reduction Act (IRA). The shift to increased electrification, equipment efficiency, and renewable technologies for electricity generation is expected to reduce energy-related emissions by 2030 up to 25% to 38% below 2005 levels (1.6 – 2.5 $GtCO_2e$)[257]. This figure may fit within the LTS projections up until 2030[258]. However, the reduction in energy-related emissions does not

[257] EIA (2023)

[258] LTS projected electricity, transportation, and building sectors combined reduce roughly 2.6 $GtCO_2e$ of emissions below 2005 levels, or 39% of 6.6 $GtCO_2e$.

continue in the EIA projection until 2050 but stabilises after 2030 around 4 $GtCO_2e$, assuming nominal policy conditions (Figure 3.17). At best, energy-related emissions stabilise around 3 $GtCO_2e$ under low-growth and zero-carbon technology cost cases. Whereas LTS assumes economy-wide net emissions to hit the NDC (50 – 52% below 2005 levels, or a reduction of 3.3 – 3.4 $GtCO_2e$) and subsequently fall to 0 $GtCO_2e$ through 2050.

By the USA's own pledged targets, energy sector transformation may, at best, lead to conservative mitigation results, at least under current policy conditions, which includes the IRA[259]. This means to meet the USA's own NDC targets, the country needs more aggressive policies to accelerate decarbonisation. Because energy-related emissions constitute the bulk of total national emissions (82% of all GHG emissions in 2021)[260], the limits in energy-centred mitigation suggest the need for offsetting means through sink enhancements and carbon removals. Net emissions is a premise built-in for the Net-zero target, which for the wave of support, is not without issues. As discussed in Section 2, global warming is the result of radiative forcing amplified by the stock of GHG accumulated in the atmosphere. The offset assumption holds that the amount of carbon emitted into the atmosphere should be equalised with the carbon absorbed by land and ocean sinks[261]. This may theoretically hold the flow of carbon at zero but leave the stock largely untouched.

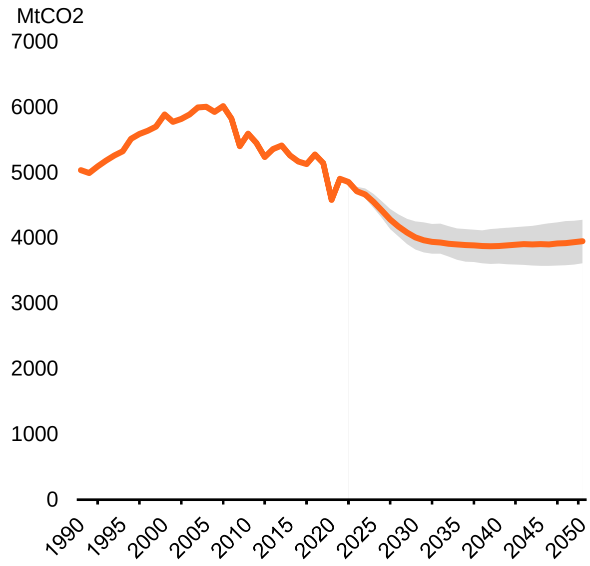
The hypothesis does not account for the radical uncertainties associated with processes controlling both land and ocean sinks, which are increasingly affected by future emissions[262]. The natural carbon cycle can slow down or be disrupted in response to climate forcings, which have non-negligible effects on the capacity of offsetting to effectively curb emissions. Whereas direct CO_2 removal through carbon capture and storage (CCS) technologies remains a steep slope to climb as commercial development largely remains commercially nascent, facing deep institutional issues such as economic viability[263]. Putting aside its merit, **net-zero emissions are, at most, a politically appealing target and inexcusable for a historically responsible country like the USA.** We demonstrated in Section 2.1 that a fair obligation for the USA, considering historical responsibility and capability, would require the USA to reach negative emissions before 2030 (Figure 2.11 and Figure 2.12). In the context of significant impedance, as both EIA projections show, net-zero appears to be the more realistic target for the USA.

As a high-emitting developed country, the United States takes a markedly different approach to long-term decarbonisation from low-emitting countries. The country alone accounts for 13.5% of global CO_2 emissions and a quarter of global GDP. Purely by virtue of proportion, the country has a much bigger leverage on global emissions mitigation. This is echoed in the strategy's acknowledgement of the USA's place as a pacesetter in global decarbonisation. In an equity-based global transition, the USA ought to take on the responsibility of reducing not only national emissions but also contributing to expanding carbon space for developing countries whose emissions peaking have to be delayed (see Section 2.1). This meant that cognisant of the limitations of mitigating domestic emissions, the USA bears the onus of supporting other developing countries in achieving sustainable development. In the absence of a developmental paradigm that is decoupled from energy use, this can transpire in the direct subsidization of energy transition in regions with relatively low marginal costs. Where private finance could shy

[259] See EIA (2023); Tsao (2023)
[260] EPA (2023)
[261] Fankhauser et al. (2022)
[262] Canadell et al. (2021)
[263] Bui et al. (2018); Ma (2022)

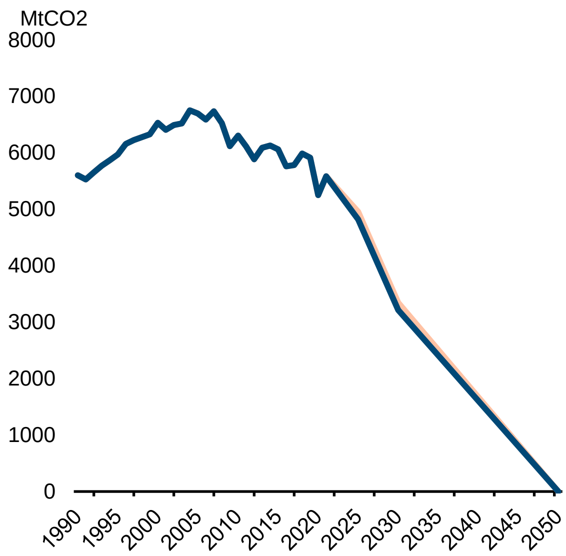
away from the high risk premium of developing regions, the use of public funds to mobilize substantial transition should be pursued.

Figure 3.18: Total US energy-related CO_2 emissions projection ($MtCO_2$)



Source: EIA (2023)

Figure 3.19: LTS 2050 Net-zero emissions projection ($MtCO_2$)



Source: US LTS (2021); EPA (2023)
Note: NDC emissions figure according to EPA updated inventory 2005 net emissions data; as per 1(f) of US 2021 updated NDC. The line represents the lower bound of the NDC range, the upper bound is shaded light orange.

While LTS is mainly a document for planning decarbonisation domestically, which made little reference to the international actions of the country, the US government has announced international support initiatives in the past, such as the 3 billion USD pledged contribution to the Green Climate Fund[264] and the pledged annual 11 billion dollars aid for developing countries by 2024[265].

Nevertheless, there are challenges with aligning domestic strategy as LTS has to take into account the variations of climate policy development among states[266]. By the convention of the policy process in the federation, there are limits in a comparative exercise of government action owing to the key structural difference between the USA and other countries in this comparison. US climate policy space is characterised by a high degree of state autonomy on energy, industrial, and environmental policies[267], as well as a sluggishness of federal climate action[268]. Karapin (2016) noted that the relative weakness of the federal government in moving climate action is a function of structural barriers in the political system, i.e., the separation of powers and pluralist interest group system, aggravated through party polarization[269].

[264] Feast and Gardner (2014)
[265] The White House (2023)
[266] Basseches et al. (2022)
[267] Karapin (2020)
[268] Fisher (2013)
[269] Karapin (2016)

3.3. Discussion

Table 3.2: summary of observations

	Indonesia	Thailand	United States
Party	Non-Annex I	Non-Annex I	Annex I
Historical CO_2 (global share)	7.5Gt (0.84%)	14.31Gt (0.44%)	416.9Gt (24.53%)
NDC	Unconditional: 30% below BAU by 2030 conditional: 40% below BAU by 2030	Unconditional: 31.89% below BAU by 2030 conditional: 43.2% below BAU by 2030	50-52% below 2005 levels in 2030
Mitigation			
Targets	Yes, NDC-aligned; net-zero CO_2 by 2050, GHG by 2065	Yes, NDC-aligned upper bound; net-zero CO_2 by 2050, GHG by 2060 or sooner	Yes, NDC-aligned; net-zero GHG by 2050
Modelled scenarios	3	3	12
Identified measures	CCS/CCUS IPPU technology upgrade Carbon sink expansion	RE share expansion energy efficiency retrofits IC engine phase-down vehicle tax nudging IPPU technology upgrade	Sector-specific goals with provisional measures
Impact assessment	Minor positive effect on GDP	GDP loss of 1.31% in 2050, average welfare loss at 3.7%, increased government spending	Avoided cost of 400 b 2017USD by 2090
Enabling conditions	Identified; international support	Identified; international support	
Adaptation			
Clear targets	Overall reduction of projected GDP loss	Mainstream adaptation into sectoral plans	none (NAP)
Scenarios	RCP4.5	RCP4.5, RCP8.5	none
Impact assessment	0.66-3.45% GDP loss in 4 basic needs	none	none
Enabling conditions	Identified	Identified; international support	none

Source: Friedlingstein et al. (2022); Author compilation
Note: Indonesian projected BAU in 2030 is estimated at 2.869 $GtCO_2e$ (Indonesian Enhanced NDC, 2022); Thailand projected BAU in 2030 is estimated at 555 $MtCO_2e$ (Thailand 2nd updated NDC, 2021)

LT-LEDS gives an indication of the government's intent and direction towards climate goals and structuring steps towards a low-emissions society. LT-LEDS explores more pathways than what countries communicate in NDCs. This is exhibited in the net-zero ambition adopted by all LT-LEDS in this review. Notwithstanding the reliability of net-zero as a meaningful target for global climate stabilisation, all countries in the comparison adopt a net-zero by 2050 goal as the upper bound[270]. The similarities in the ambitions reveal inequities across countries. Because LT-LEDS essentially deploy a back-casting approach, i.e., setting a target before exploring means of meeting the target[271], target-setting is necessarily an arbitrary exercise. The fact that the USA sets a similar target as Indonesia and Thailand to reach net-zero CO_2 by 2050, understated the USA's deep historical responsibility and, thus, the need for the country to outdistance developing countries

[270] The net-zero target set by the USA, IDN, and THA differs in terms of landing date and scope. These are 2050, 2060, and 2065 respectively for all GHG, whereas for CO_2 is 2050 for all three.
[271] Waisman, Spencer, and Colombier (2016)

in terms of ambition. Section 2 shows that the USA should reach negative emissions before 2030 by fair burden-sharing terms.

In our comparison, all LT-LEDS identified levers for mitigation and economic opportunities associated with those mitigation options. Because achieving climate objectives involves trade-offs with other developmental goals, the strategic element of the LT-LEDS comes through in the order of prioritisation. Governments face constraints on both economic and social fronts, e.g., trading off key economic sectors and jobs for environmental goals. The energy sector, as the largest emitting sector, is positioned as the frontline of mitigation, where the largest abatement is located. This is not always the case, as developing countries are observed to leverage other sectors for mitigation. Indonesia, for example, although anticipated heavy reduction in the energy sector, expected CCUS and LULUCF sinks as the key drivers of mitigation. This reflects the Indonesian government's priority in ensuring energy security by protecting the consumption of cheap local coal in the mid-term. Whereas both Thailand and the USA projected deep energy sector transformation for emissions reduction. While the approach taken by Thailand may be attributed to concerns over the high import dependency of current energy production, the country has generally lower capability compared to the USA. This is reflected in the Thailand LT-LEDS' extensive identification of areas where international support is needed in the country's LT-LEDS.

What does this mean for Malaysia?

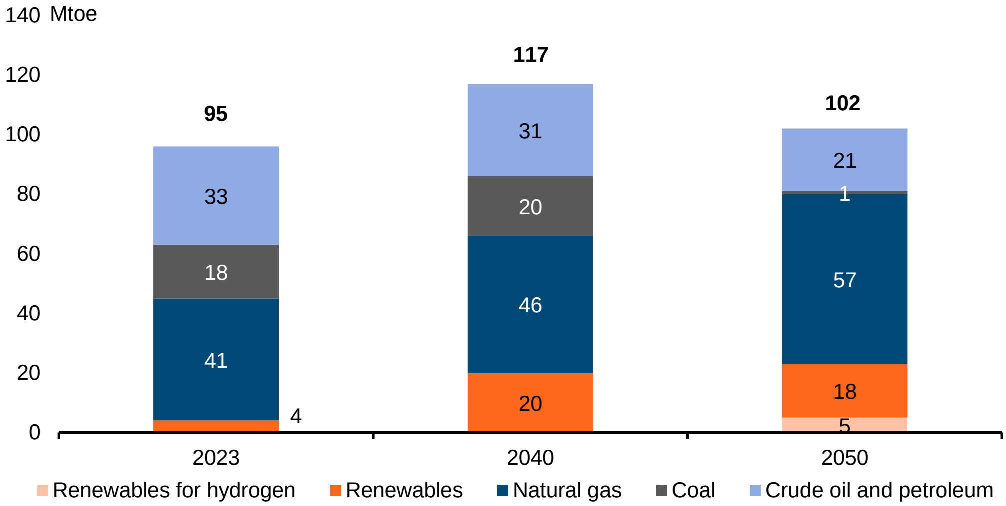
We situate Malaysia among the compared countries as a midway country of higher capabilities to transition and mid-to-low historical responsibility, both in per capita terms and carbon intensity terms. Malaysia is uniquely positioned as a higher middle-income country amid the compared group, with a specific growth pattern that had since diversified from the resourced-based extractive economy of the late colonial period. However, the country still depends on fossil fuel resources for national income and government revenue (see *Fiscal Space*). The country's energy needs are also expected to grow over the mid-term, along with economic development. Moreover, there remain sub-national imbalances with respect to economic development and energy access, where certain regions have higher poverty rates and higher energy insecurities than others.

The recently published National Energy Transition Roadmap (NETR), which complements the forthcoming LT-LEDS, offers an indication of the government's intended strategy over the mid-term. NETR envisions a target of net-zero emissions in the energy sector by 2050. The NETR is expected to deliver 32% of GHG emission reductions relative to the 2019 baseline by 2050. The plan projected future primary energy supply to remain largely derived from natural gas (57 Mtoe, 56%), followed by renewables (23 Mtoe, 22.5%) (Figure 3.20).

In view that the main energy supply will still rely on fossil fuels, energy transition in Malaysia has two implications. First, the goal of net-zero emission by 2050 is contingent upon large carbon removals. The plan has expected an offset of nearly 200 $MtCO_2e$, mainly through LULUCF sinks. The size of this LULUCF sink, i.e., territorial carbon storage composed mainly of forests, is assumed to remain at the same level as 2019 over almost 30 years. This assumption omits the ongoing degradation of forested land as well as the uncertainties associated with mitigation potential through carbon sequestration. Second, the potential global price shocks of fossil fuels can affect energy use in Malaysia if CPI is implemented. Carbon tax and energy subsidy removal can raise the cost of energy use in the case where global transition destabilises fossil fuel prices. Without equitable policies, an unmanaged transition can worsen distributional outcomes for vulnerable groups.

It remains unclear how the goals of NETR will align with global goals of climate stabilization. As discussed in Section 2, the Malaysian NDC based on emissions intensity is dependent on GDP growth. This puts pressure on the country to maintain output growth. By crude assumptions, Malaysia's NDC target is fair, provided the emission reduction of developed countries such as the USA follows the size of their corresponding obligation. Given that the developed countries are aiming below their fair target, efforts to meet global climate stabilisation objectives may result in inequitable pathways that weigh down on developing countries. Both these prerogatives present a challenge for a fossil-dependent Malaysia, which has to find pathways to maintain economic growth with lowered emissions and, at the same time, face the potential of contributing above its fair share of mitigation efforts to collectively meet global goals. This entitles Malaysia to international transfers of resources, which supports the country's mitigation effort without hurting equally important developmental goals such as economic growth.

Figure 3.20: Projected total primary energy supply in Malaysia until 2050 (Million tons of oil equivalent)



Source: Adapted from National Energy Transition Roadmap (2023)

NETR anticipates an expansion of renewable energy in installed capacity, strengthening of grid infrastructure in power systems, expansion of public transportation infrastructure, increase of local EV production capacities and charging infrastructure, building of comprehensive CCUS systems, as well as hydrogen production. The roadmap sets forth targets in energy efficiency (20% by 2035), bioenergy, transport (60% public transport modal share by 2050), and CCUS. In terms of power sector transition, the key target is to expand RE installed capacity share to 70%, of which 58% will consist mainly of solar PV. This is an installed capacity of 56 GW, equivalent to 23 Bakun dams. However, this maximum power output is different from actual generation capacity, which typically keeps some level of output at bay. It should be noted that as more primary energy use previously sourced from fossil fuels moves into the grid, for example, the expanded EV transport sector, and more distributed generation is integrated, the power sector will experience complex shifts despite the change in energy supply share may not appear drastic.

Transformations in the identified regions are expected to create opportunities across the value chain in equipment manufacture and distribution, project development, construction and installation, operations and maintenance. This is expected to generate generally favourable effects, citing additional GDP growth (RM220 billion), job creation (310,000 new jobs by 2050), and positive source-side income impact to households, fuelled by investment across the energy transition value chain.

In contrast to the benefits highlighted, less evident are the socio-economic costs associated with energy transitions. The anticipated energy system targets entail a financing need of RM1.2 – 1.3 trillion until 2050 and RM210 – 240 billion in the short term. This consists largely of investments in, by order of quantum, transportation, RE generation (solar PV), hydrogen, grid network, and CCUS. Of the estimated RM210 – 240 billion financing required in the short term (2023 – 2029), half of the identified sectors are "marginally bankable", indicating the need for public funds to de-risk private investments, such as public catalytic funding and blended finance. These sectors concentrate mainly on transportation and CCUS. Apart from investments in renewable generation, which are considered commercially viable (41%), the remaining investments with no financial return totalled up to 9%, or about RM20 – 30 billion over six years, which requires direct public funding. These investments may well be fundamental to enable transition, such as upskilling and reskilling programmes for the impacted workforce, public transportation infrastructure build-out, and grid infrastructure reinforcement. Public domestic resources, thus, are an important means of driving a successful transition. However, the potential shrunken pool of fiscal revenue[272] and limited debt capacity[273]means that public coffers are subject to higher constraints.

NETR also highlighted challenges in system costs hike over the mid-term to 2050, as well as potential trade imbalance in fossil fuels as the country's natural gas reserves deplete and imports grow in the future along with transformations in the electricity system. The plan hedges against this by proposing early investment into the hydrogen and CCUS industry, of which commercial viability remains "unproven" due to nascent technology and uncertain markets[274].

Potential losses in labour and household income may be substantial and are, at best, indirect (for example, see Section 3.1). An equitable, just transition must take into account the imbalances in labour transfer across sectors, of which adverse impact can be amplified by other labour market woes, such as skill mismatches and brain drain. Labour income growth has also been suppressed over the past decade[275]. High investment in the near term may boost the capital share of GDP, depending on the type of capital assets involved, which may further suppress the labour share of income if left unmanaged. Regardless of whether the effects of transition are source-side improvements or use-side decline, they will inevitably hit vulnerable households that have limited resources. In segments where job transition is less smooth, adverse impacts on affected households may be starker. There is a need to eliminate drastic income differences and strengthen labour outcomes with a resilient labour market and economic policies that cut across overlapping issues.

Electricity market and tariff restructuring will also be important to cushion energy cost impacts that unevenly affect lower segments of power users, as electricity consumption is bound to expand. Finally, fiscal reforms are needed to account for the potential government income loss from the depressed fossil fuel revenue. Given that the global energy transition will destabilise fossil fuel prices, Malaysia needs a diversified fiscal revenue source through an expanded tax base, which can be achieved through a flatter income distribution by raising wages and improving income equality.

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[272] See *Fiscal space*.

[273] Malaysia has passed a Fiscal Responsibility Act in 2023 that sets a ceiling on debt-to-GDP ratio.

[274] Ministry of Economy Malaysia (2023), p. 58

[275] Nithiyananthan Muthusamy, Jarud Romadan Khalidi, and Mohd Amirul Rafiq Abu Rahim (2023)

Through scenario modelling, LT-LEDS can provide more insights into cross-sectoral interactions within the economy. This helps complement the NETR plans, which focus solely on the energy sector. Transition plans grounded in equity principles should identify emerging distributional risks to avoid inequitable outcomes. It is important that a clear and fair climate goal aligns all national and sub-national actions. Climate action that recognises Malaysia's responsibility, capability, national circumstances and rights as a developing country allows the country to lay claim to developmental needs and international resources, thus increasing the chances of the attainment of treaty obligation.

4. Equitable institutions

One enabling condition of climate policies is a well-designed institution[276]. In this paper, we are interested in the formal institutions developed for climate governance. In the climate change governance context, institution refers to the set of “humanly devised constraints” [277], structured incentives and disincentives that shape human actions contributing to the problem or the solution of climate change.

Climate change framework law, or National Climate Change Act (NCCA), is one formal means of instituting national climate governance. NCCA refers to an overarching “framework legislation […] that lays down general principles and obligations for climate change policymaking in a nation-state”[278].

According to the GLOBE Climate Legislation Study (2014), “framework legislation” consists of

> *laws or regulations with equivalent status, which serve as a comprehensive, unifying basis for climate change policy, and address multiple aspects or areas of climate change mitigation in a holistic, overarching manner.*[279]

The adoption of framework law is shown to be useful in defining “an agreed national long-term objective and establish the processes and institutions needed to meet it”[280]. To this extent, framework law is capable of installing a “commitment device” by ensuring policies endure beyond turnovers of political regimes, thus establishing the credibility of policy pledges[281]. NCCA is seen as a safeguard of national climate commitments[282], legitimizing and stabilizing the climate policy environment[283] , leading to direct climate outcomes[284].

The Kyoto Protocol (KP), which laid down the first negotiated agreement to implement the UNFCCC, commits Annex I parties to a target of emission reduction by an average of 5% below 1990 levels between 2008 and 2012 (first commitment period)[285]. Towards the end of the second commitment period (2013 – 2020), many Annex I countries that have treaty-bound targets saw faltering progress[286]. The Paris Agreement, developed in 2015, did away with binding emissions targets and allowed countries to independently form targets by committing to submit, maintain, and periodically review Nationally Determined Contributions (NDCs).

The NDC mechanism, also known as the pledge-and-review process, has been described by observers as a ‘bottom-up’ approach that, in theory, reduces the uncertainty associated with non-cooperative treaties[287]. This, however, has weakened the action required to address global

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[276] IPCC (2022c)
[277] North (1990)
[278] Nash and Steurer (2019)
[279] Nachmany et al. (2014)
[280] Averchenkova, Fankhauser, and Finnegan (2021), 202
[281] UN.ESCAP (2012); Averchenkova and Guzman (2018)
[282] Averchenkova, Fankhauser, and Nachmany (2017); Averchenkova, Fankhauser, and Finnegan (2021); S. Eskander, Fankhauser, and Setzer (2021)
[283] Rüdinger et al. (2018)
[284] S. M. S. U. Eskander and Fankhauser (2020)
[285] Kyoto Protocol Art. 3.1, Rogner et al. (2007)
[286] IISD (2012)
[287] Caparrós (2016); Harstad (2023)

warming and allowed developed countries to evade their historical responsibility by setting commitments according to arbitrarily defined national circumstances[288]. The voluntary nature of the NDC also has implications for national legal enforcement. As the NDC mechanism of the PA allows states to define respective commitments, albeit without clear penalties in the case of breach, strong national compliance to NDC, then, is predicated upon domestic laws. In other words, the onus falls on the state to

> *internally lock substantial emission reduction targets and associated long-term decarbonisation pathways into binding national framework climate legislation at the national level, this can serve to provide greater degree of certainty, rigour and long-term stability within states, acting in turn as a partial remedy to problems arising in an international climate legal regime that has been subject to Paris-track weakening[289].*

Prior to the PA, there has been a proliferation of both direct framework climate laws and indirect climate-related laws worldwide[290]. This is despite the absence of international agreements regarding such legal instruments[291]. Many countries have taken it upon themselves to adopt national legislation with specific provisions for climate actions and targets, set up statutory bodies for climate governance, and regulatory framework for emissions control[292]. Dubash (2021) attributed this to an international diffusion of ideas and institutional models with the aim of installing legitimacy and credibility[293]. In the post-Kyoto international climate legal regime, where an international 'top-down' enforcement system of emission reduction is absent, national framework laws have become a compelling option for establishing compliance domestically.

Insofar as NCCAs are instrumental in holding governments up to their own climate goals, the question of fairness remains. In keeping with equity principles, the design of NCCA ought to be consistent with the appropriate national circumstances, capabilities, and responsibilities. A GLOBE mapping study (2022) found that of all Climate Vulnerable Forum (CVF) member countries with climate laws in place, more than half seek to integrate mitigation in their laws, while links to adaptation and resilience are notably weaker[294]. CVF is made up of developing countries that are disproportionately impacted by climate change, most of which rank below average in the Human Development Index (HDI). The combined share of the group's global emissions amounted to only 5.5% in 2019[295]. Despite the low culpability of the group, the design of their laws is not reflective of their priorities.

National climate action not only needs to align with international commitments, but also weighs up the potential costs of over-commitment that can exert an undue burden on developing countries that have priorities in socio-economic development. Among the climate change laws and policies of LDCs surveyed by Nachmany et al. (2017), energy constitutes the biggest focus

[288] Khor and Raman (2020)
[289] Muinzer (2020)
[290] Dubash et al. (2013); Nachmany et al. (2014)
[291] Nachmany et al. (2017)
[292] Averchenkova, Fankhauser, and Nachmany (2017)
[293] Dubash (2021)
[294] 57% of all assessed countries contain no reference to adaptation and 70% no reference to resilience in climate laws and policies.
[295] CVF (2022)

area (28% of all laws and policies and 75% of all countries)[296]. Considering the importance of energy in driving development, inadequate laws can lead to unjust results for developing countries.

4.1. National Climate Change Act (NCCA) comparisons

We perform a comparison of six national climate change laws among six countries, i.e.;

1. the United Kingdom Climate Change Act 2008;
2. Australia Climate Change Act 2022;
3. South Korea Framework Act on Carbon Neutrality and Green Growth for Coping with Climate Crisis 2021;
4. Mexico General Law on Climate Change 2012;
5. Philippines Republic Act No. 9729 of 2009; and
6. Pakistan Climate Change Act 2017.

The selection is made on the basis of the candidate country's party status, historical contribution to climate change, and corresponding political system. Table 4.1 shows the overview of selected candidate countries.

Grantham Institute classified climate laws as direct or indirect[297]. For this comparison, we refer specifically to framework law that has direct reference to the organisation of national responses towards climate change. Indirect laws are excluded from this analysis. However, countries with a set of interrelated climate laws in parallel to a framework law are discussed.

[296] Nachmany, Abeysinghe, and Barakat (2017)
[297] Koehl (2022)

Table 4.1: Overview of selected countries

Country	United Kingdom	Australia	South Korea	Mexico	Pakistan	Philippines
Country code	UK	AUS	KOR	MEX	PAK	PHI
Law	Climate Change Act 2008	Climate Change Act 2022	Framework Act on Carbon Neutrality and Green Growth for Coping with Climate Crisis 2021	General Law on Climate Change 2012	Pakistan Climate Change Act 2017	Climate Change Act or Republic Act No. 9729 of 2009
State Type	Unitary	Federation	Unitary	Federation	Federation	Unitary
Party Status	Annex I	Annex I	Non-Annex I	Non-Annex I	Non-Annex I	Non-Annex I
GDP per capita 2019 (cur USD)	42747.08	54941.43	31902.42	10145.17	1437.17	3413.85
NDC	100% below 1990 levels by 2050	43% below 2005 levels by 2030	40% below 2018 levels by 2030	40% (35% uncon.) below BAU by 2030	50% (15% uncon.) below BAU by 2030	75% (2.71% uncon.) below BAU by 2030.

Our qualitative assessment proceeds along three criteria:

1. Scope or objective of the law;
2. Utility of the law; and
    a. What does the law do for climate action?
    b. What problems does the law seek to resolve?
3. Relevance of the law.
    a. How does the law fit in national circumstances?

This is followed by a discussion of the observations in each country, compared with potential implementation in Malaysia.

Table 4.2: Comparisons of NCCA

	UK	Australia	South Korea	Mexico	Pakistan	Philippines
Historical CO_2 emissions as of 2020	78.16Gt (4.60%)	18.58 Gt (1.09%)	18.31 Gt (1.08%)	20.18 Gt (1.16%)	5.04 Gt (0.30%)	3.39 Gt (0.20%)
Constitutional provisions	none	none	yes [Art 35]	yes [Art 73.XVI.4]		yes [Art II Sec 16]
Code	Climate Change Act 2008	Climate Change Act 2022	Framework Act on Carbon Neutrality and Green Growth for Coping with Climate Crisis 2021	General Law on Climate Change 2012	Pakistan Climate Change Act 2017	Republic Act No. 9729 of 2009
Key provisions						
Mitigation targets	yes, 80% by 2050 34% by 2020	yes, 43% below 2005 levels by 2030	yes, cut >=35% from 2018 levels by 2030	yes, conditional 30% below BAU by 2020, 50% reduction by 2050 based on 2000 level, 35% RE share by 2024	no	no
Adaptation targets	line agencies obligation	no	state obligation	yes, to reduce social and ecosystem vulnerability	no	inter-agency coordination
Institutional framework	Climate Change Committee	Statutory duties of minister; Extension of Climate Change Authority advisory role	2050 Carbon Neutral Green Growth Committee	National Institute of Ecology and Climate Change (INECC) Inter-ministerial Commission on Climate Change (IMCC)	Pakistan Climate Change Council Pakistan Climate Change Authority	National Climate Change Commission
Market Instruments	yes	no, covered in the Carbon Credits Act 2011	yes	yes	no	no
Finance mechanism	no	No [covered in CELP]	Climate Response Fund	Climate Change Fund*	Pakistan Climate Change Fund	yes, intra-agency budget
Other powers	carbon budget, requirement for disclosure of emissions trading scheme	-	climate impact assessment, climate-responsive budgeting, detailed policy measures	-	-	-

Note: *MEX CCF was defunct in 2020.

The UK Climate Change Act 2008

Circumstance. Considering the historical responsibility of human-induced climate change, the UK ranks high as one of the top emitters, right behind the EU-27 and China (78.16 $GtCO_2$, 4.6% in 2020). The country alone was culpable for more than half of the world's emissions prior to the 20th century before being overtaken by the EU-27 and the USA in the 20th century (16.74 $GtCO_2$ in 1900). The British Empire was built off the back of fossil fuels and spread across the globe through expanded extraction and trade. The best estimates may offer only an inkling of the extent of colonialism's contribution to climate change[298].

Towards the end of the millennium, the structure of the UK economy shifted away from manufacturing towards the service sector[299]. This trend towards a service economy was associated with a decoupling of emissions with economic growth as advanced economies progressed[300]. However, the growth in the financial sector was coupled with employment loss in traditional industries, which led to class polarisation and rising inequality[301].

Scope. The UK Climate Change Act was passed just before the PA in 2015. Being the first of its kind, the Act is widely considered to be a key element of the UK climate governance as it provides an "economy-wide, top-down governance framework" for the organisation of climate response[302]. The Act contains several major provisions, including (1) setting a legally binding long-term mitigation target, (2) legislating intermediary short-term targets through annual carbon budgets, which the government is responsible for meeting[303], (3) setting up an independent advisory body, i.e., the Committee on Climate Change (CCC) for general oversight and reporting, (4) establish a continual process of adaptation planning, (5) mandates periodic government progress reporting, (6) establishes National Adaptation Programme, and (7) emission trading scheme(ETS).

Utility. The establishment of a legally binding mitigation target of at least a "100% reduction of emissions relative to 1990 levels by 2050" is enforced through the allocation of an economy-wide carbon budget, i.e., a cap on GHG emissions in the UK over a five-year period, up until 2050. Under this mechanism, the government sets a budget for the defined period 12 years in advance. The Secretary of State is required by law to report before the Parliament on proposals and policies for meeting carbon budgets [Sec. 14]. The CCC advises on the level of the carbon budget and reports an annual statement of emissions for reporting against progress in meeting the carbon budget [Sec. 16]. Owing to the accounting requirements, mandatory emissions disclosure is enforced upon firms in covered sectors. The CCC also prepare the UK Climate Change Risk Assessment every five years, as well as the progress report on adaptation actions.

Despite legislating a unified target and rolling programme of assessment through carbon budgeting, it does not necessarily prevent subsequent instability in corresponding policies, which were seen in instances of policy backsliding[304]. Lockwood (2021) attributed this to the dominant paradigm involved in drawing up the law, which is described as "market-led" and cost-

[298] The Global Carbon Budget national emissions estimates account for consumption-based or trade-based emissions up to 1990, and stock changes due to changing national borders up to 1990 (Friedlingstein et al., 2022; Andres et al., 1991; Andres et al., 2016; Carbon Brief, 2021)
[299] Amina Syed (2019)
[300] Cohen et al. (2018)
[301] Wardley-Kershaw and Schenk-Hoppé (2022)
[302] Lockwood (2021)
[303] Climate Change Committee (n.d.)
[304] Climate Change Committee (2015)

sensitive[305]. This resulted in the law conferring high flexibility for government departments to manage costs and accord budgets in terms of climate policies [Sec 4.1]. In this regard, the advisory nature of CCC as a "non-majoritarian institution" with little influence over the policy-setting of ascendant authorities, is consequential of a prevailing political cost-sensitivity in the governance. Such an arrangement is described to "amount to significant weakness in the framework"[306], for substantive powers remain, and sometimes in fragment, within departments of varying interests. This has led to a "multi-paced" government[307].

Relevance. Nonetheless, the monitoring and reviewing mechanisms installed through the law allowed, to an extent, policy certainty and provided safeguards for public scrutiny and accountability. The CCC progress report in 2022 found Net Zero Strategy proposals submitted in 2021 too ambiguous in their delivery of legal targets (in the sixth Carbon Budget). This has led to a high court rule that the government to revise their strategies[308], and a subsequent re-table of the Carbon Budget Delivery Plan 2023. In terms of meeting its own goals, the UK saw the potential of drifting off track from its NDC target, which required an accelerated rate of emissions reduction[309]. In terms of meeting global climate goals, the UK, being one of the largest historical emitters, is nowhere near meeting its fair share[310].

Australia Climate Change Act 2022

Circumstance. Australia is the 17th top emitting country in the world (annual CO_2 emission of 406.76 $MtCO_2$ in 2019)[311]. The abundance of natural resources in the country has shaped the carbon-intensive economy to be dependent on fossil fuel production, particularly coal production[312]. Australia is the top exporter of coal briquettes in the world, valued at 53.4 billion USD in 2021. The commodity is also the country's second major export, standing behind iron ores (118 b USD) and before petroleum gas (39.2 b USD) in the same year[313]. The mining sector, of which primary commodity alone, makes up 14.6% of the national GDP[314]. This combination of a fossil fuel-based economy and trade-exposed fossil fuel industry makes climate policy particularly tricky. Nevertheless, high per capita income relative to OECD standards accorded the country with ample capacities in financial terms (68,701 USD per capita)[315].

On the flip side, the country's wide range of variable climates also presents a governance challenge [316] . Climate legislation of the country has to balance mitigating emissions responsibilities, adapting to variable climates, and economic valence of carbon-intensive production, which is rendered more complex by the federated political system with strong and

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305 Lockwood (2021)
306 Muinzer (2019)
307 Climate Change Committee (2021)
308 Friends of the Earth Ltd & Ors, R (On the Application Of) v Secretary of State for Business, Energy and Industrial Strategy [2022] EWHC 1841 (Admin) (2022)
309 Climate Change Committee (2023)
310 Climate Action Tracker (n.d.) defined UK fair share in line with 1.5°C is -151.6$MtCO_2$/year by 2030 excl. LULUCF, UK NDC target which is potentially off-track (251$MtCO_2$/year by 2030) is of 402.6$MtCO_2$/year difference. Other fair share approaches may depict a varied number, for example, CERc used in this paper assign a target of -536 $MtCO_2e$/year by 2030, following Section 2.1's settings.
311 Crippa et al. (2022)
312 Spencer, Carole-Anne, and Anna (2012)
313 Simoes and Hidalgo (2011), accessed 4th May 2023
314 Reserve Bank of Autralia (n.d.)
315 OECD (2023a)
316 Head et al. (2014)

varied state and territory governments with different economic and energy outlooks, as well as individual climate legislation and targets[317].

Scope. The Australian Climate Change Act 2022 sets out (1) Australia's GHG emission reduction targets, (2) provides for annual climate change statements, and (3) confers advisory functions to the Climate Change Authority.

Australian climate legislative architecture has some important feature distinctions. Rather than a comprehensive framework law, the Australian system of climate governance was set up in 2011, known as the Clean Energy Legislative Package (CELP)[318], in addition to adaptation-tilted disaster management laws and sector laws. The Climate Change Act operates within this legislative framework composed of a set of laws specific for each relevant domain for climate governance, such as emission trading, renewable technologies, energy efficiency, carbon capture and storage, bio-sequestration and adaptation[319].

Utility. The Act introduces a binding emission reduction target[320] [Sec. 10.1]. The target is enforced through a consequential amendment bill, amending up to 14 laws, including eight of the pre-existing laws under CELP, Climate Change Authority Act 2011, Infrastructure Australia Act 2008, and Science and Industry Research Act 1949, among others. This overarching target set out to align related laws and regulations with respect to a national-level mitigation goal consistent with NDC.

The third provision of the law provided a basis for the extension of the functions carried out under the independent body Climate Change Authority. As per the original 2011 Act, the Authority has limited functions on research, reporting, and policy review and an advisory role upon request [CCAA 2011, Sec. 11]. This is further expanded in the 2022 Act to ordain review and advisory role on GHG emissions target [Sec. 14 and 15] and preparation of an annual climate change statement. The involvement of public consultation through progress and scheme reporting ensures public accountability of government policies and programs[321]. The Authority also operates in tandem with two other statutory bodies, the Clean Energy Regulator and Productivity Commission, responsible for managing carbon offsets, reporting, industry assistance, and carbon unit allocation respectively[322]. This setup means the Authority functions are mainly advisory, while policy control resides with the government.

It is insufficient to examine the Act apart from the nested CELP. The CELP establishes the climate governance of Australia, including energy efficiency strategy and standards (Greenhouse and Energy Minimum Standards Act), carbon tax (Clean Energy Act), voluntary offset scheme, Emissions Reduction Fund (Carbon Farming Initiative Act), clean energy finance (Clean Energy Finance Corporation Act), and ETS (National Registry of Emissions Units Act, Clean Energy

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[317] Christoff and Eckersley (2021)
[318] Department of the Treasury Australia (2021)
[319] Zahar, Peel, and Godden (2013)
[320] Emissions reduction of 43% below 2005 levels by 2030 to be implemented as point target, and net zero by 2050.
[321] Spencer, Carole-Anne, and Anna (2012)
[322] Clean Energy Regulator served as the core administrator of Carbon Pricing Mechanism, (2) Carbon Farming Initiative, (2) Renewable Energy Target, and (3) GHG inventory under National greenhouse and Energy Reporting System, while Productivity Commission reviews and provide advisory services to the Ministry on (1) International pollution reduction actions, (2) industry assistance for transition of trade-exposed industry under Jobs and Competitiveness Program, and (3) fuel excise and taxation.

Regulator Act, Renewable Energy (Electricity) Act). The legislative package introduced the carbon pricing scheme (carbon tax at AUD23 per tonne) under the Clean Energy Act, which would transition to a cap-and-trade scheme in 2015. The tax scheme exempts "high-polluting" emissions-intensive, trade-exposed activities through assistance in the form of free carbon permits[323], as well as offering transitional aid in parallel, such as income tax cuts and increased pensions for low-income groups[324]. This tax, known as the carbon pricing mechanism, was axed in the 2014 repeal under the Abbott government[325]. The main mitigation policy in place is a subsidy program through the Emissions Reduction Fund for carbon abatement and sequestration projects[326].

Relevance. Apart from a collective commitment to net-zero emissions by 2050, alignment between sub-national and federal targets is not immediately evident[327]. Sub-national states and territories have long passed innovative climate legislation before national laws. For example, the South Australian government enacted the SA Climate Change and Greenhouse Emissions Reduction Bill in 2007, which enshrined a 2050 target with interim targets. In 2017 the Victorian government passed a framework Climate Change Act also established a 2050 net-zero target with a set of policy objectives and guiding principles. State governments are also self-motivated to adopt climate policies and planning, including adaptation planning, which can be legally mandated through state enactments.

South Korea Framework Act on Carbon Neutrality and Green Growth 2021

Scope. The South Korean Framework Act on Carbon Neutrality and Green Growth for Coping with Climate Crisis 2021 amends but largely retains the 2010 Framework Act on Low Carbon and Green Growth. The flagship law provided for (1) the government to develop national strategies, action plans, and five-year plans for green growth and climate responses, the Act also (2) sets up a Presidential Committee with an oversight role, (3) establishes the Climate Crisis Response Fund, (4) emissions trading system along with a GHG cognitive budget system, and (5) climate information management system[328]. The Act served as an update to the 2010 Act, which lacked clear measures for climate response and was absent of binding targets[329]. The framework act outlined principles for green growth and climate governance [Art 3], designated statutory obligations of governments, businesses, and citizens [Art. 4, 5], as well as monitoring and assessments of climate impact [Art. 48]. The Framework Act also provided for the establishment of medium- and long-term emission reduction targets [Art. 42], of which a quantifiable target was prescribed under a matching Enforcement Decree [Art. 25][330].

Circumstance. In line with the post-2008 South Korean developmentalist industrial policy, the climate action pursued prior to 2021 tilted towards the development of green industries[331]. This is embodied in the green growth initiatives legislated through the 2010 Act, which promoted "green technology and green industries as core engines for economic growth", mainly

[323] Treasury Ministers (2011)
[324] Ibid., Nachmany et al. (2015)
[325] Taylor (2014)
[326] MacKenzie (2018); Clean Energy Regulator (2023)
[327] Christoff and Eckersley (2021); Australia Climate Change Authority (2019)
[328] GHG IIS for inventory reporting and TMS (Art 45); Meteorological IS for climate impact assessment (Art 48).
[329] Han (2021)
[330] Office for Government Policy Coordination (2018)
[331] Kim and Thurbon (2015); Kalinowski (2021)

emphasising the role of government in vitalising market functions, spurring investments, and expanding new jobs [Art. 3]. The provisions for climate actions, particularly adaptation, have been side-lined by a larger portion of the law dedicated to industrial development. This is observed in the level of flexibility accorded to the government to set mid- and long-term emission reduction targets [Art 40] and adaptation measures, which are largely limited to disaster prevention [Art. 48, 52].

Utility. As a whole, the law was designed to organize government policies towards the concerted promotion of green industries and technologies. This is underscored by principles outlined in the Act to guide government policies in support of developing green industries and reduction of fossil fuel dependencies, these include tax incentives [Art. 31.3], financial support, and investments in R&D [Art. 34]. The law also requires the government to produce a series of high-level strategies and periodic plans, under which green growth was prominently highlighted; of ten policy directions developed under the National Strategy, six are related to green industrial and technology development[332].

This is also reflected in the established statutory body, the Green Growth Committee, whose primary function is to deliberate on strategy and coordination of low-carbon, green growth policies. The Presidential Committee on Green Growth, comprised of members from relevant ministries and a selected group of experts, operates mainly in oversight and direction-setting as a high-level meeting. The framework for policy-setting and implementation, however, takes the form of inter-agency coordination, with the planning role resting with designated ministries while implementation falls with the ministry or sub-ministerial agency. For example, the maintenance of emissions inventory and TMS fall under a Greenhouse Gas Inventory and Research Centre subsumed under the Ministry of Environment [PE No. 28583, Art. 36.1][333], and adaptation programs under MoE [Art. 38].

Relevance. The focus on green growth as a pathway to decouple energy use from fossil fuel is associated with South Korea's high dependency on fossil fuel import for energy and the developmentalist interest of a linked bureaucrat-industrial network[334]. This view of harnessing the economic potential of environmental technology has been a dominant narrative since Lee Myung-bak's administration first introduced the green growth rhetoric in 2008[335]. The rapid growth of the Korean industry over the last three decades has depended upon high emission intensity, and international pressures upon the country to ramp up climate ambition have influenced the country's intent to decarbonize its economy[336]. However, the connected business regime has restrained heavy-handed climate-related manoeuvres against industrial interest, which coalesced in a more flexible target management scheme[337] and free allocation of emission permits to energy-intensive, trade-exposed sectors in the ETS[338].

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[332] Lee, Lee, and Shin (2020)
[333] Office for Government Policy Coordination (2018)
[334] Kalinowski (2021)
[335] Kim and Thurbon (2015)
[336] Kalinowski (2021)
[337] The GHG and Energy Target Management Scheme, enforced through Art 42-45 is a "system to set the goals of GHG emissions and energy consumption by mutual agreement between the government and firms" (Lee, 2012).
[338] Winchester and Reilly (2019)

Mexico General Law on Climate Change 2012

Circumstance. Mexico was among the earliest adopters of a National Climate Change Act and the first large oil-producing developing country to do so[339]. The country was noted for its leadership in voluntary commitments (50% below 2002 levels by 2050) among developing countries. Despite pioneering commitments towards mitigation, as well as early adoption of economic instruments such as the carbon pricing scheme and ETS, the varied implementation was arguably driven by international and domestic forces[340].

Scope. The Mexico General Law on Climate Change (GLCC) contains provisions for (1) defining mitigation and adaptation targets [Transitory Art. 2], (2) the set-up of a National System on Climate Change for climate policy development and delivery, outline (3) policy planning tools such as National Strategy on Climate Change and Special Programme on Climate Change, establishes (4) a GHG emissions registry, and a (5) Climate Change Fund. Through the 2018 amendment, the law also sets up a (6) emissions trading scheme, (7) mandates a National Adaptation Plan, and improved the targets.

Utility. The Mexico GLCC is notable for its role in the "construction of an administrative scheme"[341] for the development and articulation of climate policy. The law establishes a National System of Climate Change (SINACC), an overarching institutional mechanism that defines the procedure of climate policy process. For the law's strong emphasis on policy integration, the system is as comprehensive as to span all levels of government, comprising the federal, state, and municipal governments, as well as statutory bodies set up by the law: the Inter-ministerial Commission on Climate Change (CICC), its consultative body the Council on Climate Change, and the National Institute of Ecology and Climate Change (INECC). The system operates as a high-level meeting and serves to promote cross-governmental coordination and policy integration at multiple levels. CICC itself brings together heads of Secretariats of multiple ministries, all the while in consultation with the non-governmental stakeholder members of the Council on Climate Change. Insofar as the conceived institutional architecture is impressive, it has been criticised as being ineffective in producing expected results in practice due to uneven participation and communications issues[342].

The law also defined the responsibilities of national, sub-national, and local governments in preparing action plans and implementing programmes towards mitigation and adaptation. Article 28 defines the scope of adaptation actions to be undertaken by the government. Goal setting is guided by general objectives outlined in Article 27 and planning instruments formulated at the federal level. On mitigation action, the law sets forth qualitative sectoral goals [Art. 33] and general principles of implementation [Art. 31, 32]. Quantitative goals were included under the Second Transitory Article in a 2018 amendment. The decree also established a voluntary emissions trading pilot program ten months after the reform[343].

Along with the original 2012 enactment was an amendment to the Special Tax Law on Production and Services to establish the implementation of carbon tax and credit. These two economic instruments form the foundation of Mexican mitigation policy. Despite the pioneering adoption of carbon tax, the structure of the tax exempts natural gas use and only taxes the additional

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[339] Averchenkova and Guzman (2018); Fransen et al. (2015)
[340] Belausteguigoitia, Romero, and Simpser (2022)
[341] Kraiem (2012)
[342] Solorio (2021)
[343] Elizondo (2022)

emissions compared to if natural gas is used[344]. In spite of strong legislative support for the ETS and fiscal reform[345], the tax was estimated to rake in a 7-year average of 405.3 m USD of revenue[346], lower than the expected annual 1 b USD[347].

Relevance. Owing to the design of the economic instruments, the carbon tax was notably disconnected from ETS with free allocation of emission allowances[348]. This divorce was partly a result of industrial lobbying in the tax reform design, as well as Mexico's reliance on oil revenue for economic growth. In recent years, Mexico has made reforms to reduce tax burdens on the sovereign oil and gas company Pemex. The amount of government support towards fossil fuel also overshadows the carbon tax revenue (475.19b MXN in 2021)[349], with the bulk going to tax reduction for Pemex and excise tax refund on diesel use[350]. This creates an uneven bias of government support for both fossil fuel extraction and taxation on energy use, which is defined largely by pressures of internal and external interests, as well as fiscal considerations[351].

The Pakistan Climate Change Act 2017

Circumstance. Pakistan was ranked fifth among the most vulnerable by the Global Climate Risk Index[352]. Recurring climate shocks such as floods, drought, and glacial lake outbursts have deeply impacted the country's agriculture-based economy. The agriculture sector has comprised the second-largest share of GDP since 1950[353]. The 2022 floods have caused immense damage to the country, with an estimated loss of 15.2b USD and require reconstruction of at least 16.3b USD, other than a displacement of 8 million people and potentially pushing 9.1 million below the poverty line[354]. The acuteness of Pakistan's experience with climate impacts requires more than careful planning for future impacts, but addressing current woes may well exceed the state's strained capacity under simultaneous socio-economic loss and high costs of shock absorption.

Scope. The Pakistan Climate Change Act of 2017 works predominantly to establish an institutional framework of climate governance, which sets up three institutions: the (1) Climate Change Council [Sec. 3], (2) Climate Change Authority [Sec. 5], and the (3) Climate Change Fund [Sec. 12]. The law ordains functions of policy-setting, implementation, resource distribution, and coordination to the established institutions.

Utility. The Act aims primarily to establish mechanisms of coordination, particularly among Federal and Provincial governments [Sec. 3a, 3b, 3c], through the inclusion of the Federal Ministry, provincial Chief Ministers, and local government departments in the Climate Change Council (PCCC) membership. The PCCC operates as a high-level meeting convening twice a year, having mainly oversight powers in monitoring and approval of policies.

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344 Grantham Research Institute (n.d.)
345 The 7/2018 decree passed with zero opposition votes and one abstention in Congress.
346 Equivalent to 8.2b MXN2021, nominal prices at April 1 2021, World Bank, 2022
347 Carl and Fedor (2016); Altamirano and Martínez (2017)
348 Elizondo (2022)
349 OECD (2023b)
350 Ibid.; OECD (2019)
351 Belausteguigoitia, Romero, and Simpser (2022)
352 Syed Muhammad Abubakar (2019)
353 State Bank of Pakistan (2021)
354 Government of Pakistan et al. (n.d.)

The second major provision of the Act establishes and confers powers to the Climate Change Authority (PCCA), a technocratic corporate body charged with the functions of policy-setting. The Authority is responsible for the (1) formulation of federal and provincial adaptation and mitigation policies, plans, programmes, projects for funding, guidelines, and measures, (2) reporting and maintenance of the national GHG registry, (3) conducting research and advising services [Sec. 8]. Because PCCA is solely responsible for the development of local action plans, the authority thus represents a centralising shift in governance, which calls into question its legitimacy in relation to the 18th amendment of the Pakistan constitution, which promulgated provincial autonomy in matters of climate change[355]. The third provision for the establishment of a Climate Change Fund is under the purview of the PCCA. The fund operates to appropriate financial resources for mitigation and adaptation projects as directed by the Authority [Sec 12.2]. The fund was meant to streamline climate finance in an independent body with a climate change focus and to replace the pre-existing portfolio of the Climate Finance Unit within MoCC[356].

In spite of the further establishment of the PCCA, matters related to climate change have resided largely with the Ministry of Climate Change (MoCC). The Ministry, formerly the Ministry of National Disaster Management, was re-notified in 2015 in response to the recurrent floods of 2010 – 2013[357]. The speed at which the process of operationalizing the three institutions has taken longer than the expected 18-24 months[358], which may have deferred the development of the National Adaptation Plan, among other action plans. Amidst the time-consuming operationalization, MoCC has been responsible for the development of major policies such as the National Climate Change Policy, its Implementation Framework, and Technology Needs Assessments mandated to the PCCA under the Act.

Relevance. Recurrent spells of extreme climate events in the country have made adaptation the priorities of Pakistan's climate agenda[359]. This urgency, however, was not matched by the institutional processes required to cope with the impacts[360]. The Act was introduced in an attempt to strengthen institutional endurance, in theory avoiding inconsistent government support to the agenda due to political overturn. However, this exercise in reform has met with challenges of potential redundancies and drawn-out processes. The effect of the Act has yet to be further studied.

The Philippines Climate Change Act 2009

Circumstance. The Philippines was among the earliest countries to adopt a framework law for climate change. The country is highly vulnerable to climate change impacts, ranking 114 on the ND-GAIN Index[361]. The country is particularly cyclone-prone for its location in the typhoon belt and is also exposed to periodic drought linked to the El Niño Southern Oscillation phenomenon[362]. This has led the country's climate policies to focus on short-run disaster management (DRRM).

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[355] Rina Saeed Khan (2017); Sarim Jamal (2022)
[356] Government of Pakistan and UNDP (2017), p. 9
[357] Pakistan Ministry of Climate Change (2016)
[358] Government of Pakistan and UNDP (2017), p. 22
[359] ADB (2017b)
[360] For instance, the MoCC, renamed from MNDM was demoted to a sub-ministerial division in 2013 and faced 60% budget cuts until re-notified in 2015 (Khan, 2017). However, the ministry's role has largely been facilitation and coordination, owing to finance shortages and under-capacity. This is reflected in the CC-related expenditure which fluctuates between 5% to 8% between 2010 and 2014 (ADB, 2017)
[361] The lower the rank the higher the vulnerability.
[362] ADB (2021)

The country's emerging industrial economy is at risk of suffering high losses from extreme events amplified by climate change (13.6% of output by 2040)[363].

Scope. The Philippines Republic Act No. 9729 of 2009, also known as the Climate Change Act, is unique for its emphasis on climate adaptation[364]. World Bank (2013) observed that the passing of the law marked a deliberate shift towards prioritising adaptation and DRRM in the climate change agenda from a predominantly mitigation focus in the earlier 2000s (e.g., in the Philippines Development Plans)[365]. The act provided for (1) the establishment of the National Climate Change Commission (PHCCC) [Sec. 4], (2) mainstreaming of climate change and disaster risk reduction (DRR) into development plans and programs, (3) assigning statutory duties for government departments [Sec. 15], and (4) legislates internal revenue allotment for climate change purposes [Sec. 18].

Utility. The Act is seen as pivotal in the centralisation reform of the Philippines' climate governance through the set-up of an institutional and fiscal arrangement that stresses the role of the national agency of coordination, i.e., the Climate Change Commission (PHCCC). As the central coordinating agency with policy-setting power, PHCCC is given wide authority in drawing up planning and monitoring frameworks, formulating strategies in adaptation and mitigation, and coordinating with local government units and private entities but without implementing powers.

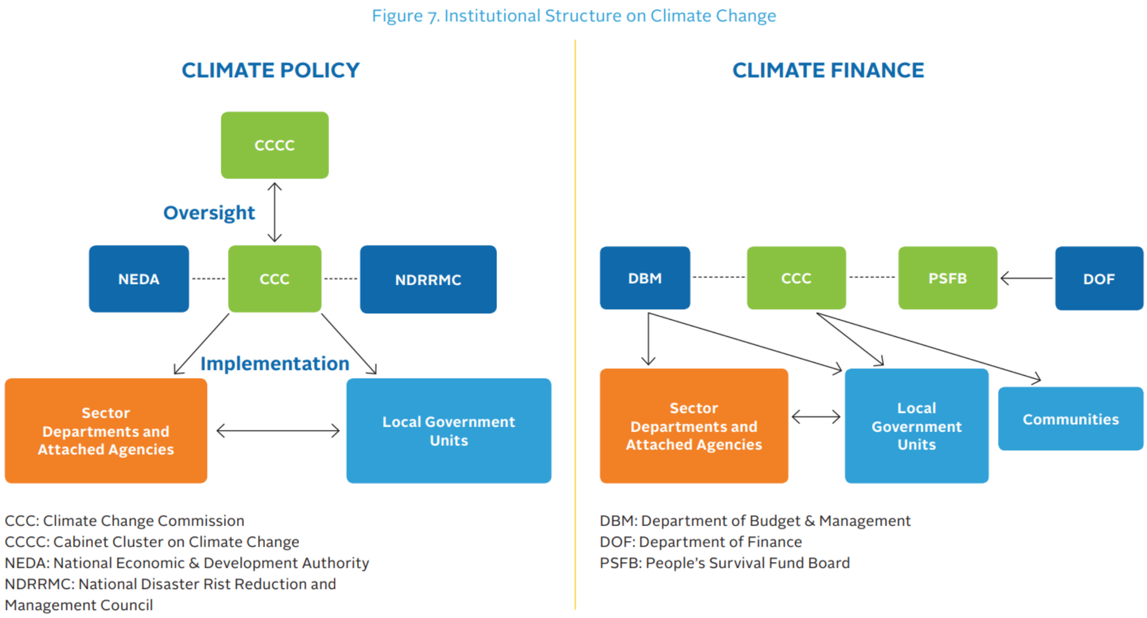
The commission is tasked with administering climate policy and climate finance, as shown in Figure 4.1. The PSF Act 2012 amends the CCA to institute a People's Survival Fund (PSF), which is disseminated directly to Local Government Units to support adaptation programs[366]. PSF supplements the annual climate-tagged budget allocation for government departments and LGUs mobilized through Internal Revenue Allotment [Sec. 18][367]. This arrangement provided a long-term financing solution, which is relevant to adaptation functions as compared to the short-run cost of disaster response, and serves to redistribute the imbalances of costs in different localities that are not considered by equal IRA allocations[368].

This moves in contrast to the fiscal decentralisation since the passing of the Local Government Code 1991, where the main mechanism of funding for LGU functions was intergovernmental fiscal transfer through IRA and other local revenue-raising sources[369]. Nonetheless, CCA delegates LGUs as the frontline of planning, implementation and response. By requiring LGUs to develop Local Climate Change Action Plans, which are to be integrated into local development and land-use plans (CDPs and CLUPs), the Act places the foci of response planning at the local level[370]. Despite the national government being mandated to provide technical and financial assistance in the

[363] Lema (2022)
[364] de Leon and Pittock (2017)
[365] World Bank (2013)
[366] Ibid.; OECD (2020)
[367] Internal Revenue Allotment is an intergovernmental fiscal transfer mechanism in Philippines, the mechanism allocates an annual share of the national internal revenue towards local government units. As the LGC 1991 devolved many government functions from national to local level, IRA is in part a mead for the fiscal burden of added executive responsibilities.
[368] Canare (2016)
[369] Diokno-Sicat and Maddawin (2018)
[370] World Bank (2013)

development of Action Plans, issues of alignment, limited capacity, and jurisdictional ambivalence remain some of the identified impediments[371].

Figure 4.1. institutional structure of the Philippines' climate governance



Source: Adapted from World Bank (2013)

Relevance. Owing to the country's extensive history of natural disasters, the Climate Change Act 2009 came in time to re-orientate the national agenda towards climate adaptation. The law works in parallel with two other laws, i.e., the Disaster Risk Reduction and Management Act 2010 (RA 10121) and the People's Survival Fund Act (RA 10174), to provide the framework for co-integration of adaptation and DRRM governance. In comparison to other framework laws that resolve national targets, the Philippines law focuses mainly on organising institutional and fiscal arrangements for adaptation purposes. This feature aligns with the priorities of the country which was highly vulnerable to climate impact.

[371] World Bank (2013)

4.2. Discussion

The role of NCCAs under the equity principle

A framework legislation is seen as a first step to mainstream or integrate climate change considerations into public policies, development strategies, and contingency planning. This involves the alignment of the framework law with global objectives of climate stabilization with cross-sectoral and cross-agency policymaking. This is observed in some countries with corresponding amendments made in tandem with the framework law.

The question, then, is whether the passage of a national framework law and its following provisions is made on equitable grounds. This is important as legislation has both the ability to provide certainty for local actors and lock in burdens for the country[372]. Incredible ambitions, if petrified into law, can engender inequitable results, externally and internally, at the expense of overall development goals.

Institutional framework

In terms of scope, we found that all NCCAs establish an institutional framework for climate governance with varying forms and practices.

The NCCAs of KOR, MEX, PAK, and PHI provide for the design of intergovernmental coordination architecture. This takes the form of a high-level council that holds periodic meetings, serving as a permanent platform of communication and coordination among governmental departments to align climate goals[373]. The membership of such meetings can vary from selected key ministries [KOR, PAK, MEX] to blanket inclusion of all departments [PHI].

Most NCCAs involve the setting up of a central statutory body. This includes NCCAs of the UK, AUS, MEX, PAK, and PHI. The nature of the body varies across countries, with different levels of implementing roles and policy-setting power. Statutory bodies of the assessed countries can be generally classified into two categories: (1) independent bodies and (2) non-independent bodies subsumed under government departments. These bodies' functions range from strategic decision-making in the formulation of basic strategies, policies, or programs down to more executive roles such as acting secretariat, maintenance of information systems, data collection and reporting.

In Malaysia, an institutional framework of the first type already exists. Malaysia Climate Change Action Council (MyCAC) is the highest decision-making body for climate change matters, which also operates as a platform for intergovernmental coordination. The council is chaired by the Prime Minister. Its members are made up of state leaders and key cabinet ministers[374]. The council holds biennial meetings. As climate-related policies such as national strategies and adaptation plans are subject to endorsement by the council, it is arguable that climate policies are coordinated across the cabinet, as well as among federal and state governments. Much remains to be learnt about the effectiveness and procedures of the council.

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[372] Hovi, Sprinz, and Underdal (2009)

[373] Solorio (2021)

[374] Ministry of Natural Resources, Environment, and Climate Change Malaysia (2022)

Targets/Institutional commitments

Binding targets are not commonly featured among surveyed NCCAs, notably quantifiable point targets for emission reduction. The degree of formality in targets also differs in developed and developing country groups, which are represented in Annex I and non-annexed groups[375]. This disparity shows variation in government approaches in the presence of quantifiable mitigation targets in the NDCs of all assessed countries.

Among all surveyed laws, mainly Annex I countries, i.e., UK and AUS, have formally legislated legally binding emission reduction targets. Among non-annexed countries, MEX has included a transitory article in the 2018 amendment of the General Law on Climate Change, with conditional clauses for foreign support [Transitory Art. 2], while the KOR emission reduction target is set through an enforcement decree [ED Art. 25][376]. This legal convention is not observed among developing or climate-vulnerable non-annexed countries, of which mitigation may be less of a priority (such as PAK and PHI) or when flexibility constitutes a prime concern of the administration (such as in MEX).

The legislation of emission reduction targets is mooted as an instrument of holding the government accountable to NDCs[377]. Under this perspective, domestic legislation is considered a devolution of international treaties in the absence of a global enforcement mechanism[378].

It stands to reason that Annex I countries face more pressure in passing laws consistent with not just international commitments, but global objectives of climate stabilisation. For example, the AUS Climate Change Act 2022 contains a direct reference to the Paris Agreement, which obligates the national target to be consistent with PA objectives [Sec. 10.2]. This reinforcement of NDC through law may be an internal commitment device for strengthening credibility, which helps signal to international actors a government's devotion to the protection of global public good. However, it may also incur trade-offs in responsiveness in achieving other goals[379].

More stringent goal management systems can also establish public accountability. For example, the UK Climate Change Act 2008 mandates evaluation and progress reports of the government's climate actions to the parliament [Sec. 36]. This has proved effective in the past as the government is made answerable to potential backsliding[380]. However, the polities that these systems operate in are mostly democracies. The political systems of developing countries ought to be taken into context, where the effectiveness of public accountability may vary.

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[375] Formality refers to the status of climate targets being legislated or discretionary, see Averchenkova and Bassi (2016).

[376] Enforcement decrees are statutory instruments enacted by administrative power, i.e., the President, of which legal status is equivalent to executive orders (see KLRI, n.d.).

[377] Morton (2023)

[378] Muinzer (2020)

[379] Brunner, Flachsland, and Marschinski (2012); Hovi, Sprinz, and Underdal (2009)

[380] Gayle (2022); Friends of the Earth Ltd & Ors, R (On the Application Of) v Secretary of State for Business, Energy and Industrial Strategy [2022] EWHC 1841 (Admin) (2022)

Policy tools

A legal instrument can enhance the credibility of a long-term commitment by mandating the adoption of required policy tools towards achieving set targets. Almost all countries in our comparison adopt some type of climate or climate-related policies, e.g., energy, technology development, and disaster management policies. The degree of formality of these policies varies, i.e., whether policy tools are discretionary or mandated by law in design and procedural aspects[381]. We group the policies by types: (1) planning tools, (2) market and (3) non-market instruments. We only discuss the policies that are provided by law.

Planning tools

Commonly observed planning tools are national-level strategies [UK, KOR, MEX, PAK, PHI] and lower-level action plans [KOR, MEX, PHI].

National strategies are most observed in both unitary and federal states. Such a document outlines a country's long-term goals and objectives for addressing climate change, which may include policies, programs, and initiatives aimed at adaptation and mitigation measures, as well as institutional arrangements for their implementation, monitoring, and reporting. While national strategy defines broadly the national objective, specific actions to be taken are laid out in action plans. These plans can be developed at various levels of governance, including national, regional, and local levels. An ideal action plan has short-term steps and substantive outcome objectives implemented at sub-national scales; thus, adaptation is an important component here as adaptation measures are often locally targeted. Examples of laws that define the local government's role in developing adaptation-specific action plans include KOR [Art. 4], MEX, and PHI [Sec. 14].

Nevertheless, laws may only require the government to develop plans but not mandate any follow-through. This often requires interregnum performance reviews or a goal management system. A higher credibility can be established with monitoring and evaluation systems of policy. Countries including the UK, KOR, MEX, and PHI mandate evaluation mechanisms through law. Variations in modalities are also observed. For example, the UK and PHI CCA designate an independent body for this purpose (i.e., UK Climate Change Committee, PHI Climate Change Commission), while KOR framework law assigns this role to the head of central administration agencies [Art. 12, ED Art. 8]. The UK CCA also require periodic progress reporting with respect to carbon budgets [Sec. 36] and adaptation actions [Sec. 59].

Market instruments

The deployment of market-based emission control schemes can involve legislative steps, particularly for compliance market mechanisms such as a cap-and-trade system or carbon taxation. Compliance markets require the government to set a rule with respect to carbon emissions, either in the form of direct pricing (tax) or quantity control (tradeable emissions allocation)[382]. This requires regulation to impose constraints on carbon either through taxation on carbon-intense goods and services or a limit on emissions allowed into the atmosphere. Table 4.3 shows the provision of tax law and emissions trading schemes in compared countries.

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[381] Averchenkova and Bassi (2016)
[382] See Nordhaus (2006)

Countries also adopt voluntary market instruments, i.e., baseline-and-credit systems with no emissions cap, such as the Clean Development Mechanism (CDM) and Voluntary Offset Market (VCM)[383]. Although voluntary schemes can be implemented without passing legislation, we observe a few countries include some type of legal provisions with reference to the management of voluntary markets. For example, MEX GLCC designated INECC as the arbiter of CDM projects [Art. 45; Trans Art. 5].

Despite legal instruments are often the direct means of creating artificial scarcity that enables market-based policy to work, there are no hard-and-fast rules for the legal form. There is also a lack of studies on the effect of the law on compliance, ergo, emission reduction performance of markets. Countries like Australia have seen governments walk back on carbon pricing instruments, despite being established through law. This suggests that, at least in democratic polities, climate policies remain subject to political processes, which at times challenge the enforcement of legislation.

Table 4.3: Market instruments established under NCCAs

	Emissions taxation	Emissions trading systems (ETS)	
	Carbon tax	Cap-and-trade	Baseline-and-credit (VCM, CDM)
UK	yes*	yes	
AUS	repealed*	yes*	yes*
KOR		yes	yes
MEX	yes*		yes
PAK			
PHI			

Note: asterisks denote market instruments established by laws other than framework law. (1) The UK carbon tax was established under The Greenhouse Gas Emissions Trading Scheme Order 2020; (2) AUS carbon tax was established under the Clean Energy Act while the emissions trading scheme was under three separate acts; (3) MEX carbon tax was established under Special Tax Law on Production and Services 2012 amendment.

Non-market instruments

Apart from market-based instruments, governments are also equipped with non-market tools. Command-and-control (CAC) regulations prevalent in environmental policy are also widely employed in energy and technology policies, with varied references towards climate change adaptation or emission reduction as a goal [UK, AUS, KOR, MEX, PHI]. This is coupled with differences among countries in enacting CAC regulations via framework law, sector laws (asterisks in Table 4.4), or *ex-post* alignment between legislations.

Among all CAC regulations, energy efficiency standards are widely adopted among surveyed countries, albeit not all made direct reference to climate goals. For example, AUS CCA made consequential amendments to Energy Minimum Standards and Building EE Disclosure law to integrate national targets [GEMS Act 2012, BEED Act 2010]. Countries such as PHI and the UK have set up standards through energy sector laws and building codes [PHI RA No. 11285; UK Energy Act 2011]. Whereas MEX framework law made direct reference while retaining a separate law for detailed schedules [GLCC, Ch X; Art 102.v].

[383] See OECD (n.d.)

Conversely, active policies sourced from the non-market toolkit are also legislated in some jurisdictions. Active industrial support measures are prescribed under legislation by some countries to induce or circumscribe government actions. Countries such as KOR developed standards and active industrial support for green technology within its framework law, and others have passed sector-specific or separate public laws to similar ends. For example, PHI passed the Green Jobs Act 2016 [RA No. 10771] to incentivize job transition by prescribing the government's role in active labour market policies, and MEX passed the Energy Transition Law 2015 as a combination of CAC regulation and obligated active support policy.

Table 4.4: Non-market instruments established under NCCAs

	CAC approaches [a]	Active industrial support [b]	Voluntary agreements	Financial measures [c]
UK	yes			yes
AUS	yes*			
KOR	yes	yes		yes
MEX	yes*	yes*		yes
PAK				yes
PHI	yes*	yes*		yes

Notes: [a] Command-and-control (CAC) approaches include but are not limited to performance and technology standards, building code and environment standards, prohibitions, and renewable energy obligations (Duval, 2008); [b] active industrial support policies include but are not limited to public and private R&D funding, public procurement and investments, labour market policies; [c] financial measures include but not limited to introduction or phase-out of subsidies, Feed-in tariffs, taxes and tax exemption.

Other provisions

NCCAs are also responsible for setting up institutional arrangements to finance climate actions domestically, indicating sources of raised funds and means of distribution towards mitigation and adaptation projects. There are two main types of domestic climate financing strategies, among them dedicated climate funds [MEX, PAK, PHI] and climate-tagged budget allocation [KOR, PHI]. Government budget support may be the more straightforward route, wherein the law mandates the government to set aside a budget for climate-related expenditures. In the case of PHI, governments are required by law to allocate a defined amount for climate-related spending through Internal Revenue Allotment. Whereas in KOR, the establishment of the GHG cognitive budget system under the act [Art. 24] required state and local governments to deliberate the climate impacts of budgetary spending and reallocate accordingly. National climate funds appear to be preferred among developing countries in our comparison. This is possibly associated with the capacity of a climate fund to channel both budgetary outlays and international or private finance, as well as the function of systematically tracking climate finance[384]. However, the scope of climate funds differs among countries. Some source donor contributions and international finance [PAK], while others manage both budgetary and non-budgetary sources [MEX].

[384] Bhandary (2022)

What does this mean for Malaysia?

A review of Malaysia's national circumstances shows that Malaysia is a climate-vulnerable developing country. Despite not being as exposed to acute disasters as some of our neighbouring regional peers, the long-term chronic effects of floods and rising sea levels render the country vulnerable to climate impacts and in dire need of adaptation actions. At the same time, the country's responsibility for global climate warming is little compared to developed countries (Section 2). The relatively small annual emissions also indicate the limited leverage of the country on global emissions reduction, lest through the aggregated mitigation of all developing countries.

An equitable climate change law for Malaysia should consider both the needs of Malaysia in adaptation and its potential risks in low-carbon transition. Across the world, climate laws are historically designed with national intent and interests in mind. Developed countries and advanced economies [UK, AUS] saw the passing of climate laws as a means to institute carbon pricing, set up a market for trading emissions, and regulate emissions to meet pledged targets. In comparison, newly industrialised high-income countries [KOR] have employed climate laws to drive green industrial policy[385]. Climate laws in low-income developing countries are oriented towards enabling cross-agency coordination and adaptation [PAK, PHI].

Malaysia, as an upper-middle-income country with a specific set of climate risks and industrial strength, can leverage legislative means insofar as the law serves a clear direction of national interest. In this case, we take the Mexican GLCC as a reference. GLCC is, if not one of the most comprehensive among the compared legislation, of which coverage spans (1) cross-agency coordination, (2) institutional commitments, (3) national strategy and local planning, (4) market and non-market-based policy tools, and (5) financing measures. In terms of socio-economic context, the Mexican per capita GDP (10,145.17 USD in 2019) is on par with Malaysia (11,132.02 USD in 2019). The economic structure also leans towards manufacturing and fossil fuel products.

The developmental priorities of the two countries are comparable as both have the prerogative of uplifting underdeveloped groups and ironing out intranational inequalities, all of which require economic stability to allow growth in household income and productivity. This must be attained parallel to a balanced transition to a low-carbon economy (see Section 3) and reduced environmental impacts, all the while adapting to ongoing climate impact. Domestically, this entails a whole-of-government approach to climate strategy, normalizing inter-agency coordination, and viewing policy problems holistically. Internationally, this involves cooperation among governments as encapsulated by Articles 3 – 5 of UNFCCC. An equitable national climate law should consider the implications of its provisions on intra-national inequities, i.e., the potential distributional outcomes between subjects of the law, and the implications of its provisions with relation to international obligations, i.e., the expected role of a country within the international climate treaty.

This raises the question of how laws enable sustainable or climate-resilient development in line with the capability and responsibility of the country. Malaysia, for instance, is neither an Annex-I party with large historical responsibility nor a developed country with high technological and financial capability. As discussed in Section 3.3, indicative plans such as NETR show that the government is motivated to steer the economy to a low-carbon one, with the help of renewable energy and low-carbon transport, aside from which the aspirational net-zero target will rely on a huge bulk of emissions removal expected from LULUCF sinks, which is neither supported by

[385] Kang, Oh, and Kim (2012)

conservation plans nor a robust target. In order to develop sustainably, the country will need to balance both managed energy transition and conservation for carbon sink expansion, all the while building resilience against potential fiscal shrinkage from loss of revenue source. This meant that the country needed a robust but flexible goal management system which allowed the government to adjust to immediate social objectives while simultaneously keeping track of climate targets articulated in NDCs. This can be instituted through a progress monitoring and report system that allows target revision under stipulated circumstances.

Second, climate laws can be designed to mobilize and channel finance and streamline processes to secure international support. National law can consider the rights of the country as a developing country party by setting up corresponding institutions to secure transfers of technology and financial resources, facilitate the reception of transfers, and strengthen negotiating terms for transfers. This can be done through the setting up of dedicated funds acting as accredited bodies to secure and manage project funds[386].

As low-carbon transition entails associated distributional risks, we argue that an equitable framework climate law ought not to entrench adverse risks. Inequity directly caused by climate policies, for example, can emerge from the carbon pricing systems regressive towards low-income households or prohibitive to micro-enterprises. These can be corrected through stronger social protection and industrial support, funded through strengthened fiscal sources.

Framework legislation or legislative framework?

Climate change framework legislation serves as the foundation for all associated laws in fields such as energy, environment, disaster management, land and town planning, and so on. Regardless of the scope of this article, the priority of framework legislation must be considered in the context of its political system. In certain countries, the extent of a framework legislation's legal power is limited, whereas in others, framework law takes precedence over other laws.

In order to avoid conflict of laws, some framework legislations contain overriding clauses (For example, Pakistan PCCA Sec. 16), which makes it possible for the law to pre-empt other laws deemed inconsistent with the Act. Other times, the resolution takes the form of a legislation package, as seen in Australia, where several laws are realigned concurrently through a parliamentary bill. The latter resembles a legislative framework where sectoral laws reinforce a set of rules under a common principle, for example, Australia's consequential amendment of the CELP, which incorporates unified emission reduction targets into related laws.

There are no hard-and-fast rules on what type of legislation a country should pursue based on its circumstances, and a large part of that decision is politically driven[387]. The value of climate legislation lies in its ability to establish authority and a legal basis for government policies, making it harder to backslide or renege on policies. This creates regularity and certainty in the policy environment, which is desirable for public interests and investor risk assessment.

In relation to that is the need for policy coherence. Climate legislation creates the opportunity for the establishment of this coherence by mandating co-alignment of government plans and programmes, which are separated by jurisdictions and governed under disparate principles and objectives. One example of this is the Mexican GLCC, which provisioned all levels of government

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386 Commonwealth Secretariat (2022)

387 For a longer treatment of the political economy of domestic climate legislation see Frankhauser et al. (2015).

to "exercise their powers on climate change mitigation and adaptation in accordance with the distribution of powers" [Art. 5]. The law outlined the jurisdiction of each government level and provided principles for the incorporation of climate considerations into local and sectoral policies [Art. 26]. This can be particularly difficult for Malaysia as the convention of law-making is demarcated along sectoral lines[388]. Jurisdictional divide, especially over natural resources and fiscal revenue has historically been a point of contention for natural resource management, land-use planning, and disaster response management[389]. This is likely to be transposed into climate governance as climate policy, by broad definition, includes all three policy spaces.

[388] Ainul Jaria Bt. Maidin (2005); Tan (2011)
[389] Ibid.; Azmi Sharom (2002); Hutchinson (2014)

5. Conclusion

This paper outlines the challenges in climate policy and governance with respect to equity. Because the climate problem is inequitably constructed and will inherently lead to inequitable outcomes, climate policy and governance should perform the role of counterbalancing inequitable impacts. Rather, broad climate policies that are not framed to address the different needs and capacities have the capacity to entrench unequal distributional impacts, even engender new forms of inequities.

To parse the challenges, we first nest our discussion in the fair share of a country's obligations to climate mitigation. Equipped with the understanding of countries' capabilities and responsibilities, we review the risks faced by governments moving forward with a whole-of-society transition to a low-carbon society with the aim of cutting emissions for climate stabilization. We also compare the details of countries' strategies working towards that goal. We find inequitable distribution of risks inter- and intra-nationally, which adversely impacts marginalised groups concentrated in developing countries. Developing countries face more challenges in balancing overall development goals with climate goals but also more constraints in doing so.

Given the growth-oriented world economic order is unlikely to change in the foreseeable future, developing countries must grow socio-economically to meet the basic developmental needs of a vast majority of their population. They should not be required to pursue low-carbon transition or achieve decoupled economic growth by themselves, provided most enabling technologies are held in advanced economies. Developed countries are obliged to provide finance, technology, and capacity to developing countries under equitable grounds as provisioned under the PA.

Sustainable, climate-resilient development must be considered in the context of equitable conditions and outcomes, where developing countries have the space to develop socio-economically amidst transition. Against the backdrop of an evolving international climate legal regime, national institutions become ever more important in ensuring the compliance of responsible countries to their climate pledges and the delivery of support.

We explore formal institutions of climate legislation that can facilitate an equitable policy environment. We explore the options through cross-country comparisons of national climate law. Our findings indicate that developed and developing countries deploy climate legislation for different objectives, aligned with their national circumstances, with a throughline of institutional governance framework as a common feature.

5.1. Policy Implications

This paper finds that:

1. Developed countries, i.e., the USA, have set climate goals that are below their fair share of emission reduction efforts required to keep global temperature within safe levels, whereas developing countries, i.e., Indonesia and Thailand, are within their fair share. Malaysia's NDC target is above its fair share when LULUCF removals are included but slightly lower than its fair share when excluding removals. This means that Malaysia must conserve and maintain existing LULUCF sinks and removals as well as emphasise climate adaptation, as Malaysia is relatively less responsible for global warming.

2. Low-carbon transition risks, encompassing socio-economic and socio-technical dimensions (macroeconomic and technology), are distributed unevenly among developed and developing countries.
3. Developing countries dependent on fossil fuels, such as Indonesia and Malaysia, face the risks of a shrunken fiscal revenue and distributional impact from employment loss in key productive industries. Malaysia is highly exposed to transition risks due to high fiscal dependence on fossil fuel revenues. This sets it apart from other compared peer countries, which do not face similar fiscal risks.
4. Higher employment share and importance of fossil fuel sectors in Indonesia and Malaysia also present labour risks to the economies.
5. A comparison of LT-LEDS shows different transition approaches countries pursue to mitigate emissions according to their respective national circumstances. Decarbonisation through renewable energy, carbon capture and storage, and expansion of carbon sinks are among the common options identified. However, practical problems of carbon sink expansion and the current rate of fossil phase-out may pose challenges.
6. Because all LT-LEDS defined NDC-aligned targets as the baseline aspiration, Indonesia and Thailand's LT-LEDS set ambition above their fair shares, whereas the USA's net-zero by 2050 target remains below its fair share. This means that developed countries must deliver much more on resource transfers to developing countries to enable their mitigation action and sustainable development as prescribed under the PA if domestic mitigation is unfeasible.
7. NCCAs establish institutional commitments and create enabling conditions for domestic climate governance. Common features of NCCAs include the establishment of institutional frameworks for inter-agency coordination, dedicated authority for policy-setting and monitoring and evaluation, mandating the government's role in policy-setting, and financing mechanisms for climate-related purposes.
8. NCCAs in developing countries function mainly to establish institutional frameworks, whereas legislation in developed countries is observed to institute legally binding climate targets and set up market-based tools such as carbon pricing instruments and cap-and-trade schemes.

Malaysia, as a middle-capacity, developing country with mid-to-low climate change responsibility, faces specific challenges. **The country has both the exigency of achieving climate-resilient development and the risks of slipping off track due to fiscal reliance on transition-vulnerable industries.**

Malaysia has the right as a developing country to proclaim social development aspirations, which cannot be realized without increasing indigenous capacity, ensuring competitive terms of trade, and raising income. **In pursuing a low-carbon transition, it is important to ensure that the costs and benefits of transition are distributed equitably. This entails the need to design appropriate institutions that improve whole-of-government coordination, secure international resource transfers, and careful assessments of policy instruments that risk inequitable outcomes.**

5.2. Limitations

The data used in this paper are from publicly available secondary sources. This includes the GHG emissions data (Climate Watch, GCP, and national BURs), national fiscal reports (IMF and various national government depositories), macroeconomic indicators (World Bank), energy statistics (IEA and various national agencies including EIA and EPPO) used in Section 3. Legislative documents reviewed in Section 4 are sourced from the Grantham Institute Climate Change Laws of the World and FAOLEX. The selection of candidates for comparison is also limited by the public availability of policy documents, therefore, inexhaustive.

In Section 2, our comparisons of national fair shares and nationally determined contributions are limited to national CO_2 emissions excluding LULUCF removals due to methodological reasons. This is owed to the availability of data on LULUCF removals in historical emissions data used by CERF, which is sourced from the PRIMAP-hist database. This creates a challenge in comparing NDCs that account for net emissions. We produce an estimate of NDC targets without accounting for LULUCF for comparability with CERF fair shares but retain NDC targets with net emissions.

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In Section 2.1, we noted that comparison between CERF-defined fair shares of burden, or emission reduction obligation and the country-defined NDC target emission reduction level can result in discrepancy. This is a discrepancy caused by the difference between baselines, which can lead to problems of comparability.

NDCs are based on country-reported emissions baseline[390], either as a quotient of a projected business-as-usual future emission level (such as Indonesia and Thailand) or an estimation of past emission level (such as US and Malaysia). National Greenhouse Gas Inventory reported by countries in their submitted NDCs are different from the CERF emissions baseline. CERF uses national emissions data from independently compiled inventory database, the PRIMAP-Hist dataset, to calculate fair shares.

We attempt to minimize this problem by applying the NDC target quotient on the CERF emissions baseline, then compare it to the fair share. For example, the conditional NDC target of Indonesia is reduction of 43.2% below BAU baseline, the rebased NDC will be 43.2% below CERF baseline. Indeed, this exercise is not without caveats. NDC targets are defined with national circumstances in mind, which are irreducible. Rebased NDC is an attempt to provide context to the discrepancy. Moreover, the difference between developing countries' GHG inventory reports and atmospheric inversion database tend to be higher due to accounting capacity. This is less so in developed countries with better accounting capacity. This also highlights inequities in capacities of solving climate change.

For Indonesia and Thailand, the NDC targets are above their fair share reduction. If we rebase to CERF baseline, both country's conditional and unconditional target stays within their fair share, if not overcontributing. The results remain the same for both countries if we include LULUCF emissions and removal within our comparison. The rebased NDC targets with LULUCF, both conditional and unconditional, are shown to stay within fair shares for both countries (Table 7.1 and 7.2).

For Malaysia, the targeted emission reduction (derived from assumed emissions intensity from country reported emissions projection) falls short of approximately 1 $MtCO_2e$ when excluding LULUCF. However, if we rebased this to CERF baseline, we find the emissions reductions appear as a negative value, which means the country aimed not to reduce but potentially increase emissions above baseline. If we include the country-reported LULUCF removals, Malaysia stayed within fair shares by around 10 $MtCO_2e$. But if we rebased to the CERF LULUCF inclusive emissions baseline, Malaysia falls short by roughly 400 $MtCO_2e$. This is likely due to a difference between the country reported (BUR4) and PRIMAP-hist LULUCF data, which may stem from methodological differences.

[390] See country NDCs "Information for Clarity, Transparency, and Understanding" section.

Table 7.1. NDC emission reduction targets rebased to CERF baseline excl. LULUCF (MtCO₂e)

Country	NDC emission reduction		NDC rebased emission reduction		Fair share
	Unconditional	Conditional	Unconditional	Conditional	
IDN	915	**1,240**	351.4	476.1	130.4
THA	166.5	**222**	135.1	180.2	103
USA	**3,317.5 – 3,450.2**		3,586.8 – 3,730.3		7,912.1
MYS	**126.37**		-1.5		127.1

Note:

1. The BAU baseline for IDN and THA in this table refers to the updated NDCs submitted by respective countries, which are different from the CERF baseline which is derived from CERF method. Indonesia projected BAU in 2030 is est. 2.869 GtCO_2e (Indonesian Enhanced NDC, 2022); Thailand projected BAU in 2030 is est. 555 MtCO_2e (Thailand 2nd updated NDC, 2021). US baseline (net emissions in 2005) is reported at 6635 MtCO_2e, referred to updated NDC (US updated NDC, 2021).
2. MYS NDC is quantified in emission intensity following reference indicator reported in BUR4.
3. Shaded cells denote NDCs without conditionality. MYS updated NDC in 2021 has removed conditionality, which expanded the 35% unconditional and 10% conditional targets to a target of an unconditional reduction of 45% of economy-wide emissions intensity (MtCO2e/GDP) relative to 2005 levels.

Table 7.2. . NDC emission reduction targets rebased to CERF baseline incl. LULUCF (MtCO₂e)

Country	NDC emission reduction		NDC rebased emission reduction		Fair share
	Unconditional	Conditional	Unconditional	Conditional	
IDN	915	**1,240**	824	1,116.3	201.7
THA	166.5	**222**	137.4	183.1	120.5
USA	**3,317.5 – 3,450.2**		3,181.7 – 3,308.9		7,784.8
MYS	**217.32**		-247.6		131

Note: Based on 5(e) of the MYS NDC, we include LULUCF removals data from BUR4 into the quantification of NDC.

Figure 7.1 NDC target against fair share excl. LULUCF

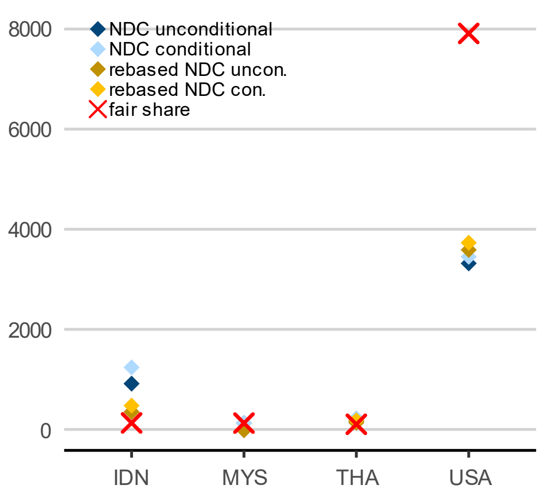
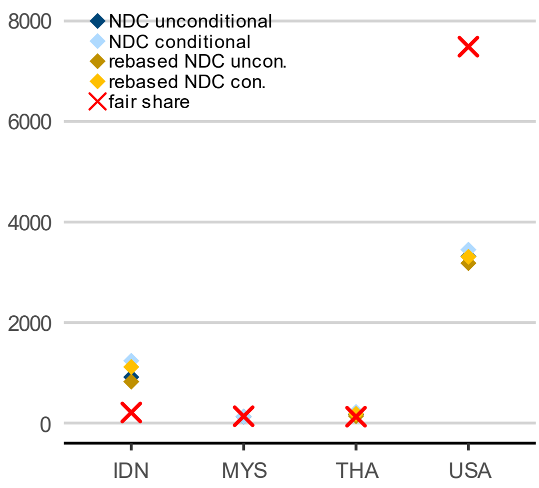


Figure 7.2 NDC target against fair share incl. LULUCF



Source: Author's visualization

APPENDIX B Abbreviations

ADB	Asian Development Bank
AUS	Australia
BAU	Business-As-Usual
BkWh	Billion Kilowatt per hour
BUR	National Biennial Update Report to UNFCCC
CAC	Command-and-Control Regulation
CAGR	Compound annual growth rate
CCA	Climate Change Act
CCC	UK Committee on Climate Change
CCS/CCUS	Carbon Capture and Storage/ Carbon Capture, Utilisation, and Storage
CELP	Clean Energy Legislative Package
CERc	Climate Equity Reference Calculator
CERF	Climate Equity Reference Framework
CICC	Mexico Inter-ministerial Commission on Climate Change
CPOS	Current policy scenario
CVF	Climate Vulnerable Forum
DRR/DRRM	Disaster Risk Reduction and Management
EIA	U.S. Energy Information Administration
EJ	Exajoule
EPPO	Thailand Energy Policy and Planning Office
ETS	Emission Trading Scheme
EU-27	European Union
EV	Electric vehicle
FDI	Foreign Direct Investment
GCP	Global Carbon Project
GDP	Gross Domestic Product
GHG	Greenhouse gas
GI	Gini Index
GtCO2e	Giga tonnes of carbon dioxide equivalent
GW/GWh	Gigawatt / Gigawatt per hour
HDI	Human Development Index
ICE	Internal Combustion Engine
IDN	Indonesia
IDR	Indonesian Rupiah
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPL	International Poverty Line
IPPU	Industrial Processes and Product Use
IPR	Intellectual Property Rights
IRA	Inflation Reduction Act
IRENA	International Renewable Energy Agency
KOR	South Korea
KP	Kyoto Protocol
LCCP	Indonesia Low Carbon Scenario compatible with the Paris Agreement target
LCOE	Levelized cost of electricity

LGU	Local Government Unit
LT-LEDS	long-term Low-emission Development Strategy
LTS	Long-term Strategy
LTS-LCCR	Long-term Strategy for Low Carbon and Climate Resilience
LULUCF	Land Use, Land-use Change and Forestry
MEX	Mexico
MoE	Ministry of Environment
MOF	Malaysia Ministry of Finance
MtCO2e	Million tonnes of carbon dioxide equivalent
MW/MWh	Megawatt / Megawatt per hour
MXN	Mexican Peso
MYS	Malaysia
NAP	National Adaptation Plan
NC	National Communications to UNFCCC
NCCA	National Climate Change Act
NDC	Nationally Determined Contribution
ND-GAIN	Notre Dame Global Adaptation Initiative
NETR	Malaysia National Energy Transition Roadmap
NOC	National oil company
OECD	Organization for Economic Cooperation and Development
PA	Paris Agreement
PAK	Pakistan
PCCA	Pakistan Climate Change Authority
PCCC	Pakistan Climate Change Council
PHCCC	Philippines Climate Change Commission
PHI	The Philippines
R&D	Research and Development
RCI	Responsibility-Capacity Indicator
RE	Renewable energy
RM	Ringgit Malaysia
THB	Thai Baht
TRNS	Transition scenario
UK	The United Kingdom
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USA	The United States of America
USD PPP	United States Dollar at purchasing power parity
VRE	Variable renewable energy
WEO	World Economic Outlook