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The Current State of Global Climate Policy: How to Improve Regional Cooperation

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Abstract

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Keywords

global climate policies, dynamic general equilibrium modelling, G-Cubed

JEL Classification

F41, F42, H23, Q54

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Global greenhouse gas emissions will continue to rise to 2050 under current policies, according to projections from the G-Cubed multi-country model. We evaluate an approach to international climate cooperation to substantially reduce greenhouse gas emissions designed to sustain participation: national policies implemented through domestic institutions; a common reference carbon price adjusted for national emissions intensities; free allocation of carbon bonds, which transfers wealth to households and firms while the policy continues; and a safety valve that caps carbon prices at an agreed, negotiated level. This is based on the Hybrid/CALM framework of McKibbin and Wilcoxen (2002b) and McKibbin (2020).

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1. Introduction

The world is at a critical juncture on the climate change journey. Recent years have witnessed the hottest summers, the warmest sea waters, and significant loss to human wellbeing. The climate negotiation Conference of the Parties (COPs) have now reached their 30th edition. Despite efforts devoted to the issue, Greenhouse Gas (GHG) emissions have continued to rise. Under the Paris Agreement, countries agreed to hold the increase in global average temperature to well below 2° C above pre-industrial levels and to pursue efforts to limit it to 1.5° C. It is now widely understood that this goal will not be achieved; warming will more likely 2.8 degrees under the current policy setting[1]. The current geopolitical fragmentation has hampered progress in political commitments. Without a significant course correction, the wellbeing of both people and planet is at considerable risk. Against this background, this paper presents what kind of policy instruments should be adopted, what kind of international coordination should be formed and how the negotiation process should be modified to get the global goal of decarbonization back on track. It uses the G-Cubed model to project greenhouse gas emissions under various policy frameworks, exploring the costs and benefits of alternative policies.

One of the early obstacles in international negotiations, starting with the 1997 Kyoto Protocol, was a focus on specific targets and deadlines for countries' GHG emissions, without sufficient consideration of the costs of meeting those goals by a given date. It also challenged the sovereignty of countries.

The Kyoto Protocol's failure to alter the global emissions path led to a breakthrough at COP21 in Paris in December 2015 with the Paris Agreement. Countries agreed to focus on Nationally Determined Contributions (NDCs) to voluntarily shift toward a low-emissions profile towards 2 degrees with aspirational goal of 1.5 degrees by the second half of the century. The Paris Agreement also introduced a new framework of requiring countries to submit targets, strengthen them every five years and report on their progress. The Agreement does not legally bind nations to specific reduction outcomes; it functions as a driving force for global decarbonization by institutionalizing a process. The Agreement also included a collective annual mobilization target (proposed initially in the Copenhagen Accord and extended in Paris

[1] UNEP Emissions Gap Report 2025

to 2025) that US$ 100 billion be provided annually as climate finance to developing nations. The money could come through several channels:

- bilateral aid and concessional loans from governments;
- multilateral development banks and UN climate funds, including the Green Climate Fund;
- grants, loans, guarantees, equity and risk-insurance arrangements; and
- private investment mobilized by public finance, such as through guarantees or co-financing.

Since then, the collective mobilization target has been superseded for the post-2025 period by a much higher (US$300 billion) collective goal, agreed at COP29.

The Intergovernmental Panel on Climate Change (IPCC's) 2018 Special Report on Global Warming of 1.5°C concluded that to limit the temperature rise to 1.5°C, global net-zero emissions would need to be achieved around 2050. After the IPCC report, countries started adopting 2050 targets more broadly, and at the COP26 in Glasgow in 2021, commitments to achieve 1.5 degrees had become de-facto common targets for decarbonization efforts. At the same time, it is broadly accepted that countries may adopt different timelines, reflecting their development challenges; for instance, 2060 for Indonesia and China, and 2070 for India.

We first explore the outcome of the climate policies to date and identify the causes of deficiencies in those policies to achieve their stated goal.

Despite the repeated negotiations and agreements including in Paris in 2015 and in Glasgow in 2021, the outcomes for emissions trajectories, potential temperature outcomes and financial resources are disappointing.

- Table 1 shows that Greenhouse Gas (GHG) emissions increased from 48.6 billion tons of CO2 equivalent GHGs in 2015 to 56 billion tons of CO2-equivalent GHGs in 2025, excluding land use, land-use change, and forestry.[2] The contribution to emissions growth varies across countries.

[2] Sourced from the European Commission Joint Research Centre's EDGAR database, a consistent global series covering fossil CO_2, methane, nitrous oxide and fluorinated gases (https://edgar.jrc.ec.europa.eu/report_2026).

Table 1: Change in Total GHG Emissions by G-Cubed Region, 2015–2025 (Mt CO2eq)

Region / Country	2015 (Mt CO2eq)	2025 (Mt CO2eq)	Change (Mt CO2eq)	Change (%)
United States (USA)	6,340	6,018	-322	-5.1%
Japan (JPN)	1,327	1,063	-264	-19.9%
Australia (AUS)	597	578	-19	-3.1%
Korea (KOR)	730	696	-34	-4.7%
Other Advanced Economies (OAE)	4,528	3,731	-797	-17.6%
China (CHN)	13,064	15,981	+2,917	+22.3%
India (IND)	3,296	4,508	+1,212	+36.8%
Indonesia (INO)	884	1,359	+474	+53.6%
Philippines (PHL)	196	270	+75	+38.2%
Vietnam (VNM)	348	548	+200	+57.6%
Thailand (THA)	399	401	+2	+0.5%
Malaysia (MYS)	291	337	+47	+16.1%
Other Asia (ROA)	972	1,188	+216	+22.2%
Africa (AFR)	1,614	1,828	+214	+13.2%
Middle East and North Africa (MEN)	4,148	5,122	+974	+23.5%
Rest of World (ROW)	9,818	10,521	+703	+7.2%
GLOBAL TOTAL	**48,551**	**54,149**	**+5,598**	**+11.5%**

Source: EDGAR, GHG Emissions of all World Countries, 2026 Report (JRC/European Commission). Red indicates emissions increased between 2015 and 2025.

- Annual global mean surface temperature was about 1.0°C[3] above the 1850–1900 pre-industrial average by 2015, and 1.44°C[4] above it in 2025.
- Developed countries collectively provided and mobilized US$79.9 billion in climate finance for developing countries in 2018, rising to US$136.7 billion in 2024. Officially comparable data for 2025 are not expected before 2027.[5]

[3] Hawkins, E., and Coauthors, 2017: Estimating Changes in Global Temperature since the Preindustrial Period. *Bull. Amer. Meteor. Soc.*, **98**, 1841–1856, https://doi.org/10.1175/BAMS-D-16-0007.1.

[4] World Meteorological Organization press release (https://wmo.int/media/news/wmo-confirms-2025-was-one-of-warmest-years-record).

[5] See Figure 1 in OECD (2026), *Climate Finance Provided and Mobilised by Developed Countries in 2013-2024*, Climate Finance and the USD 100 Billion Goal, OECD Publishing, Paris, https://doi.org/10.1787/ab5eb9ad-en.

Overall, outcomes have not met participants' expectations from COP15 onwards.

These disappointing outcomes are attributed to the following three "gaps". Negotiators and the climate change community refer to an "ambition gap" and an "implementation gap", but we focus on and analyze an "architecture gap".

- Ambition gap
- Implementation gap
- Architecture gap

Ambition Gap: The goal is set too low compared with what a substantial share of the scientific community argues needs to be achieved. This refers to the case where current proposed policies under Nationally Determined Contributions (NDCs) do not add up to what needs to be done to achieve a substantial reduction in emissions.

Implementation Gap; Countries have not implemented the policies that have been promised under the NDCs.

Architecture Gap: There are three parts to the architecture gap.

One, the entire negotiation process as well as agreed policy packages under NDCs are problematic. There is naivety shared among negotiators that once goals are agreed with scientific rigor, policies are formulated along the objectives, and projected transformation will take place. However, this ignores the magnitude of challenges of fundamental systems transformation (not only energy transition but production and consumption, food, cities and transport systems to be transformed). Some parts of the transformation can be addressed with financial resources, but a majority involves transformation of social systems, which is much stickier. Most important among the deficiencies is that cost of the green transformation is uncertain. Accordingly, both the speed and the scale of planned transformation tend to be grossly insufficient. The scale of the required systems transformation, and the uncertainty about its cost, are documented in the IPCC Fifth Assessment Report on mitigation (Edenhofer et al. 2014) and, for developing countries specifically, in Jakob et al. (2014).

Two, the negotiation process and agreed policy packages do not pay due attention to the regional differences in terms of challenges of decarbonization such as fossil fuel dependencies, industrial structure, development stage, institutional capacity and depth of the financial sector. The continued expansion of coal in fast-growing Asian economies illustrates this: coal is cheap, domestically available and embedded in existing development models, so a phase-out requires new development strategies rather than targets alone (Steckel, Edenhofer and Jakob

2015; Kalkuhl et al. 2019; Jakob et al. 2020). The importance of charting transition pathways tailored to specific regions is now widely recognized. This was clear at the TAFF (Transition Away from Fossil Fuel) conference held in April 2026 in Colombia. The TAFF process is outside the official COP process[6]. Asia needs to achieve development while gradually phasing out high dependency on fossil fuels. Africa, which has contributed very little to global greenhouse concentrations, also needs to develop with younger populations without much financial resources or institutional skill. Without support, planned coal investments risk locking parts of Africa into a carbon-intensive pathway (Steckel et al. 2020). Their development and decarbonization pathways need to be supported by the international community.

Three, the current fragmented geopolitics add further challenges by making collaboration among countries much tougher. There is deeply rooted resentment shared by the global south that climate change is caused by the global north and questions why the global south has to bear the burden of a green transformation by sharing obligations. The transition is likely to be guided by the global rule on finance, trade and investment[7], which was created by the global north while the voice of the global south is rarely heard. (WB and IMF Board chairs composition underrepresents voices of Africa, for instance). It is critical to incentivize major players to collaborate towards net zero goals. Finance alone is not a complete answer: Kornek and Edenhofer (2017) show that large international transfers can create a "climate rent curse" in recipient economies, which strengthens the case for building burden-sharing into the design of the pricing architecture itself.

We then propose policies and processes to address those deficiencies. Specifically, we present a framework to design policies or regulations to support those pathways towards decarbonization. We argue that pathways can be economically efficient and politically feasible, if the policy package is designed to handle uncertainty, reduce costs, and generate benefits. Using G-Cubed we present simulations in which countries can achieve growth and development while pursuing decarbonization. The simulations show how alternative pricing rules redistribute emissions reductions and aggregate-output effects. They do not establish

[6] The First Conference on Transitioning Away from Fossil Fuels was co-hosted by the governments of Colombia and the Netherlands, intended to provide a "safe harbour" for state and non-governmental actors to advance the fossil fuel transition. Its goals were to form a "coalition of the willing," establish a science-led coordination process, and produce a consolidated report on concrete transition solutions.

[7] The rule which governs the current international financial system such as framework of calculating debt sustainability, country rating, which leads to prohibitively high costs of capital for Africa, as well as inability of small island states to manage the adverse impacts of hurricanes

political feasibility, a welfare ranking or the effectiveness of institutions for handling uncertainty.

We show that the coordination among major players can produce better outcomes. Given the importance of Asia to the global transition, we analyze the impacts of coordination between Asia (Japan, China, India, ASEAN) and other regions.

The United Nations Framework Convention on Climate Change (UNFCCC) learnt from the failure of the Kyoto Protocol and generated a politically palatable model based on NDCs and regular monitoring, expecting a ratchet effect to take place. It does not have a strong enforcement mechanism and knowing that net zero requires a total transformation of the economic and social system, the Kyoto-style target bound system is impractical anyway. This NDC mechanism heavily relies on collective political will, which is seen to be another failure of the history of UNFCCC journey. An alternative approach focusing on regional pathways with limits on the costs of countries acting may incentivize coordination among groups of countries. Providing a framework for better coordination focusing on addressing the architecture gap of policies is the focus of this paper.

We extend the approach of McKibbin & Wilcoxen (2002b), McKibbin, Morris & Wilcoxen (2009c, 2011, 2014), Liu et al. (2020) and McKibbin (2020) by introducing an intensity-based price multiplier rule. We also provide substantial Asian regional disaggregation on a 2023 baseline. Our approach is in the spirit of price floors in Parry et al. (2021) and graduated pricing (Wolfram et al. 2025, 2026).

2. Projection of Global Greenhouse Gas Emissions

This section presents the quantitative G-Cubed model and updated greenhouse gas emission projections based on current policies.

2.1 The G-Cubed Model

Research using the G-Cubed model has examined the costs of climate change (Fernando et al. (2021)) and the costs related to mitigation efforts to reduce greenhouse gas emissions (Liu et al. (2020), McKibbin, Morris, and Wilcoxen (2011)).

The G-Cubed model used in this paper[8] partitions the world economy into 16 countries and regions, separating major economies and fossil-fuel-producing countries and regions (Table 2).

Table 2: Countries and Regions in the G-Cubed Model

Countries (11)	Regions (5)
United States (USA)	Other Advanced Economies (OAE)
Japan (JPN)	Other Asia (ROA)
Australia (AUS)	Africa (AFR)
South Korea (KOR)	Middle East and North Africa (MEN)
China (CHN)	Rest of World (ROW)
India (IND)	
Indonesia (INO)	
Philippines (PHL)	
Vietnam (VNM)	
Thailand (THA)	
Malaysia (MYS)	

Note: (a) Other Advanced Economies comprises Canada, New Zealand, Germany, United Kingdom, France, Italy, Spain, Netherlands, Belgium, Luxembourg, Ireland, Greece, Austria, Portugal, Finland, Cyprus, Malta, Slovakia, Slovenia, Estonia, Norway, Sweden, Switzerland, Denmark, Iceland and Liechtenstein. (b) Other Asia comprises Hong Kong, Singapore, Laos, Myanmar, Cambodia, Bangladesh, Nepal, Pakistan, Sri Lanka and the remainder of East, South East and South Asia. (c) Africa comprises Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Guinea, Nigeria, Senegal, Togo, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Tanzania, Uganda, Zambia, Zimbabwe, Botswana, Namibia, South Africa and the remainder of Western, Central and Eastern Africa and the South African Customs Union. (d) Middle East and North Africa comprises Egypt, Algeria, Morocco, Sudan, Tunisia, Libya, Iran, Bahrain, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Yemen, Türkiye, Iraq, Lebanon, the Palestinian Territory and Syria. € Rest of World comprises all countries not included in the other groups (including Latin America).

The model includes 22 sectors, with rich sectoral detail on energy sectors and power generation, including three key fossil fuel sectors—oil, gas, and coal—and renewables-based electricity generation sectors (Table 3). Input-output tables for the regions and sectors have been aggregated from 2023 reference year of the GTAP 12 database (Aguiar et al., 2025).

The structure of the core model is set out in McKibbin and Wilcoxen (1999, 2013), as well as Liu et al. (2020). An illustration of the production structure is contained in Figure 1. Within this model greenhouse gases including carbon dioxide, methane, nitrous oxide, and fluorocarbons, are generated by economic activity including production and consumption by households and government

[8] (version 22AEPR, build 200). Full documentation a equations and parameters can be downloaded from https://documentation.gcubed.com

Table 3: Sectors in the G-Cubed Model

No.	Sector
1	Electricity delivery
2	Gas Extraction and utilities
3	Petroleum refining
4	Coal mining
5	Crude oil extraction
6	Construction
7	Other mining
8	Agriculture – less 13,14
9	Durable goods
10	Nondurables
11	Transportation
12	Services
13	Crops
14	Livestock
15	Coal generation
16	Natural gas generation
17	Petroleum generation
18	Nuclear generation
19	Wind generation
20	Solar generation
21	Hydroelectric generation
22	Other generation

Greenhouse gas types covered

Abbreviation	Greenhouse Gas
CO2	Carbon Dioxide
CH4	Methane
N2O	Nitrous Oxide

Figure 1: Production Structure in the G-Cubed Model



The model's sectoral detail captures key asymmetries central to the analysis of the differences in the costs of GHG abatement. First, regions differ in the GHG intensity of economic activity. GHG intensity is higher in fast-growing emerging economies such as China and India, as their energy systems rely more heavily on coal. These economies also rely more on GHG-intensive industries. Less GHG-intensive advanced economies rely relatively more on gas and oil for energy generation. Second, regions differ in the importance of renewable energy for electricity generation. The renewables sector magnifies differences in GHG intensities across

countries and regions. Third, regions and countries differ in energy trade. MEN are the main fossil fuel exporters, while other countries, such as Japan, are fossil fuel importers, especially of oil and gas.

The G-Cubed model incorporates standard features of large macro models, including several that are worth highlighting: (i) intertemporal general equilibrium with standard optimization; (ii) rigidities, such as limits on the pace of investment (quadratic adjustment costs), that prevent economies from moving quickly from one equilibrium to another; (iii) cross-border capital and trade flows and bilateral cross-border input linkages; (iv) heterogeneous households and firms—besides conventional forward-looking agents, a fraction of households consume their current income, and a fraction of firms make backward-looking investment decisions; (v) monetary and fiscal policy rules.

Importantly, the model incorporates a full-fledged external sector. Intertemporal decisions of households and firms determine both saving and investment in response to the change in government policies. The gap between aggregate saving and investment determines the current account. A key variable that affects national saving, investment, and current accounts is the real interest rate, which directly affects both saving and investment decisions as well as human wealth through a discounting channel.[9] Flexible exchange rates and open capital accounts are assumed for the 16 countries and regions.

2.2 The Baseline Scenario

The baseline relies on population projections, projections of sectoral productivity growth rates differentiated by both sector and country, and projections of energy efficiency improvements based partly on historical experience and expected future developments. Details can be found in Liu and McKibbin (2026). The G-Cubed baseline in this paper starts from 2023 and projects subsequent dynamics using region- and sector-specific inputs. We solve the model from 2023 adjusting various constants in the model so that the model solution for 2023 replicates the database for 2023 (the latest reliable data we have). Sectoral output growth from 2023 onwards is driven by exogenous labor force growth and labor productivity growth and endogenous capital accumulation.

[9] Note that the precautionary saving motive is absent for the model. Given uncertainties associated with climate change and the green transition, precautionary considerations could provide an additional motive for saving.

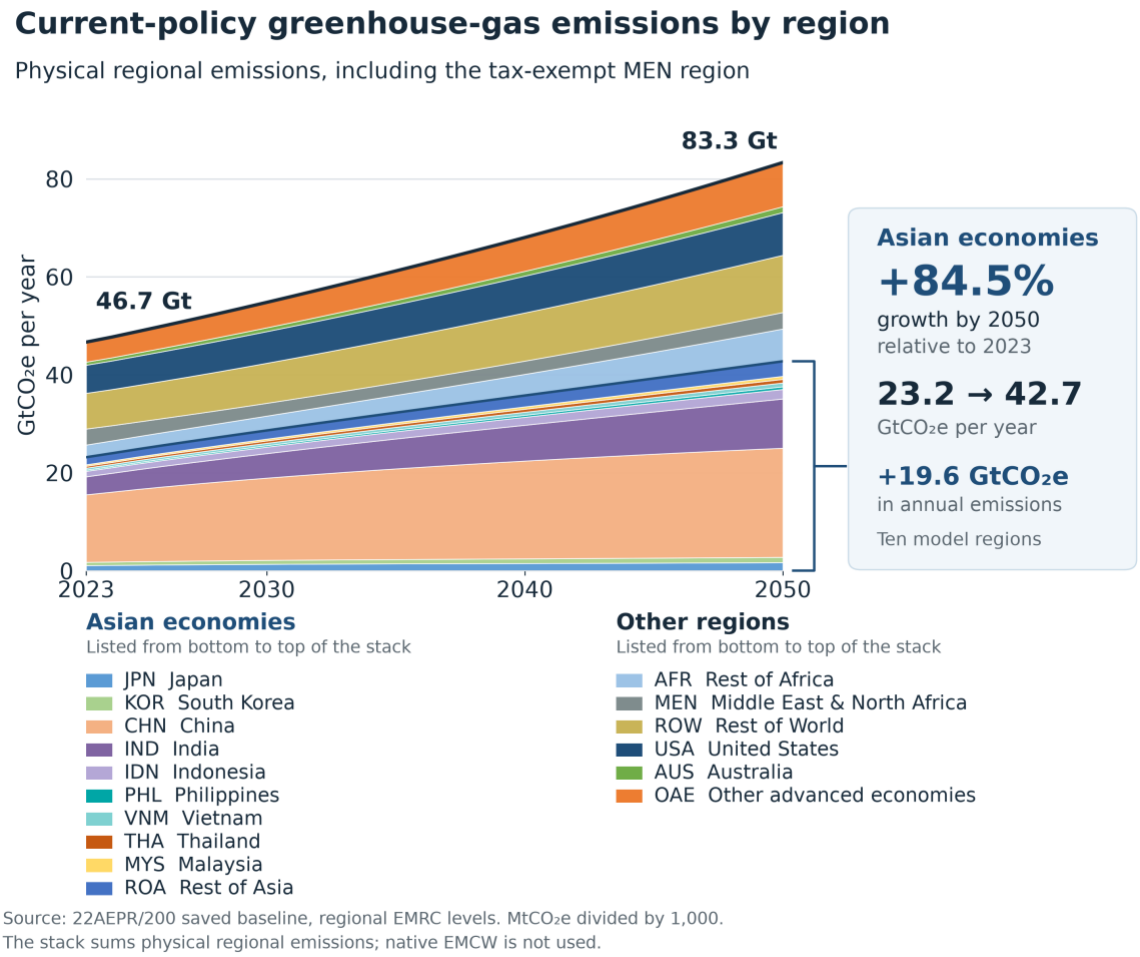
The labor force growth rate projections are derived from the working-age population projections from the UN Population Prospects 2024 to calculate the economy-wide labor growth rates for each region, adjusting effective labor supply to reflect the age distribution of the population in each year.

For labor productivity, we use a catch-up model to generate labor productivity growth rates (defined in terms of labor-augmenting technological progress). We assume that the technology frontier progresses at 1.4 percent per year in every sector, including renewable electricity generation. Each region's technology in 2023 is defined in terms of its gap from that frontier. Gaps can vary between sectors. Catch-up rates are calibrated by region and sector and vary smoothly over time; many approach 2 percent per year, but this is not a common constant or a universal terminal rate. We use the Groningen Growth and Development Database (Inklaar and Timmer, 2008) to estimate the initial productivity level in each sector of each region in the model and then take the ratio of the initial productivity to the equivalent sector in the US. Given this initial gap, we use the Barro catchup model to generate long-term projections of the productivity growth rate of each sector within each country. Where we expect that regions will catch up more quickly to the frontier due to economic reforms or more slowly to the frontier due to institutional rigidities, we vary the catchup rate over time. The calibration of the catchup rate attempts to replicate recent growth experiences of each country and region in the model.

In addition, we assume that autonomous energy efficiency in every sector increases at a constant rate of 1 percent every year for all economies.

Figure 2 contains the baseline emissions projections from the G-Cubed model under current policies.

Figure 2: Baseline emissions by region, 2023–2050



Global emissions in the baseline rise by 78.5 percent, or 2.17 percent per year on a compound basis between 2023 and 2050. Annual global real GDP growth declines from 2.7 percent in 2026 to 2.0 percent in 2050, a fall of 0.7 percentage points. The assumed productivity, population and efficiency paths therefore leave emissions growing substantially under the baseline. Whereas advanced economies have historically contributed the lion's share of emissions, China and India, as large and fast-growing emerging market economies, are significant emitters and are expected to continue to account for growing shares of carbon emissions. Their per-capita emissions, however, remain relatively small when compared with those of advanced economies.

3. A Framework for Cooperatively Reducing Greenhouse Emissions

Despite the challenges of achieving a meaningful reduction in global GHG emissions, climate change remains an issue where cooperation provides significant benefits to the broader international community.

Given the lack of progress in lowering global emissions and the potential scale of benefits, in previous work we have used the G-Cubed model to develop and test practical, economically feasible frameworks for international climate policy that account for uncertainty, manage costs, recognize differences in institutional capacity across countries, and create incentives for sustained action. Our policy frameworks, such as the McKibbin-Wilcoxen hybrid approach (McKibbin and Wilcoxen (1997, 2002a, 2002b, 2002c)) and the recent Climate Asset and Liability Mechanism (McKibbin (2020)), provide insights into alternative policy frameworks. A broader literature, surveyed in Stavins et al. (2014), reaches a related conclusion: cooperation is easier to build and verify around carbon prices than around quantity targets (Weitzman 2014; Edenhofer et al. 2015; Cramton et al. 2017; Clausing et al. 2024), and clubs of countries can sustain such agreements where universal participation is not achievable (Nordhaus 2015).

This paper examines opportunities for global climate policy cooperation, exploring how innovative policy mechanisms could facilitate global action on reducing greenhouse gas emissions particularly for reducing the uncertainty in costs for rapidly growing Asian economies.

3.1 The McKibbin-Wilcoxen Hybrid Policy: A Framework for Flexible Climate Action

At the heart of our alternative approach to cooperation on climate change is the hybrid model developed by McKibbin and Wilcoxen (1997,2002a, 2002b, 2002c). This framework, most thoroughly explained in McKibbin and Wilcoxen (2002b), provides a fundamental rethinking of how international climate agreements should be designed. The McKibbin-Wilcoxen Hybrid combines elements of emissions trading and carbon taxes to create a more adaptable and resilient global system. It balances the speed of reaching future greenhouse concentration goals with the economic costs during the transition.

The hybrid policy tackles the most important aspect of climate change as a policy issue: widespread uncertainty. From climate sensitivity science to future costs of emissions reductions and the pace of technological progress, nearly every part of climate policy involves

significant uncertainty. Traditional policy approaches, like the Kyoto Protocol's fixed “targets and timetables," ignore this uncertainty and carry excessive economic risks when actual outcomes differ from projections. This has led to international agreements that are either too costly or do not sufficiently protect the environment.

The hybrid approach recognizes that the scientific focus is on accumulated atmospheric levels of greenhouse gases rather than the precise annual emissions path. To reach a future GHG concentration goal, attention should be on the most cost-effective route to that target, even though this route cannot be predicted with certainty now. The purpose of the hybrid is to identify that route over time through economic incentives and markets. Additionally, the hybrid's second idea is that emissions prices in the short term are a cost to economic activity but also present an opportunity for innovators over time.

The hybrid approach works by establishing two distinct types of emissions permits. Long-term permits (called carbon bonds in the CALM approach) provide price signals for long-run investment decisions, reducing uncertainty for businesses planning infrastructure and technology investments over decades. These long term permits would be issued in quantities consistent with long-term emissions goals and could be traded in domestic markets, allowing firms to find the most cost-effective ways to reduce emissions. Crucially, governments would also issue short-term annual permits at a fixed price, effectively setting a carbon price ceiling (or floor if they buy permits). This safety valve prevents carbon prices from spiking unexpectedly due to economic shocks or policy miscalculations, addressing the legitimate concerns businesses have about uncontrolled compliance costs. McKibbin and Wilcoxen (1997a, 1997b, 2000) and Pizer (2002) formalized the economic case for combining price and quantity instruments in this way. Experience in the EU Emissions Trading System has since renewed interest in price floors and ceilings as protection against both price collapses and political backlash when prices spike (Flachsland et al. 2020; Pahle et al. 2022).

Using the G-Cubed model, McKibbin, Morris and Wilcoxen (2009b) and McKibbin and Wilcoxen (2004) demonstrate that this hybrid approach performs better than pure cap-and-trade or pure emissions tax systems when faced with macroeconomic volatility. During economic downturns, a rigid cap-and-trade system continues to impose high carbon prices even as emissions naturally fall due to reduced economic activity, causing unnecessary

economic pain. A pure emissions tax lacks the long-term price signals needed for major investment decisions. The hybrid policy combines the best features of both approaches.

For advanced and developing country cooperation, the hybrid framework offers several benefits. First, it allows each country to implement its policies domestically, based on its own circumstances, while coordinating on key parameters such as the long-term emissions trajectory and the safety valve price. This respects national sovereignty while ensuring aligned incentives. Second, the safety valve addresses developing country concerns about economic stability during rapid growth, while the long-term permits provide the price certainty businesses need to support investment. Third, the system's flexibility enables countries to adjust their approaches as technology advances and scientific understanding of climate impacts improves.

This research shows that coordinated action between major economies produces far better outcomes than unilateral policies. When countries cooperate in the pricing of GHG emissions, economic costs can decline substantially compared to isolated action, and the equity challenges of how those costs are distributed can be addressed.

3.2 The Climate Asset and Liability Mechanism: Advancing the Hybrid Approach

Building on the intellectual foundation of the hybrid policy, McKibbin (2020) has recently proposed a more refined framework called the Climate Asset and Liability Mechanism (CALM).

CALM represents an evolution of the hybrid approach, incorporating lessons from decades of climate policy experimentation and drawing on recent innovations in monetary policy management. Published by the Academy of Social Sciences in Australia, CALM offers a mechanism for pricing carbon that maintains flexibility while ensuring progress toward net-zero emissions in the future (the goal is 2050, but the target could be reached sooner if costs are lower than expected and later if costs are higher than expected).

Table 4: What is CALM?

The Core Concept

A hybrid: price and quantity control nationally

CALM combines a long-run quantity target (a declining emissions cap toward net zero) with a short-run price safety valve, drawing on the logic of inflation targeting in monetary policy.

The Carbon Bank

A Carbon Bank issues emissions certificates equal to annual emissions targets (the price of a certificate is the carbon price), bundles future-year certificates into tradable carbon bonds, and intervenes to stabilise short-run carbon prices.

Assets and Liabilities

Each major emitter must hold certificates (assets) matching its annual emissions (liabilities). The Carbon Bank records and enforces compliance, analogous to prudential banking regulation.

Key Innovations

Carbon bonds create a yield curve

Bundling annual certificates into long-dated bonds produces a market-derived carbon price curve extending to 2050 — exactly what long-run capital investment decisions require.

Initial free allocation builds support

Carbon bonds are distributed freely to households and firms at inception, creating a wealth transfer that offsets transitional costs and builds a political constituency for the policy.

Responsive to new information

Markets reprice carbon bonds as technology, geopolitics and scientific knowledge evolve — providing dynamic efficiency without requiring constant legislative revision.

Table 5: How CALM Works — The Mechanism

The Carbon Bank

Step 1: Government sets the trajectory

Government legislates an emissions pathway. The trajectory is enshrined in law, providing long-run certainty comparable to an inflation target.

Step 2: Carbon Bank issues certificates and bonds

Annual certificates equal to the target are created. Certificates for future years are bundled into carbon bonds and distributed freely to households and firms, generating a long-run carbon yield curve.

Step 3: Emitters comply and trade

All major emitters must hold certificates matching their annual emissions. Surplus or deficit emitters trade certificates, with the Carbon Bank selling additional certificates at a fixed price to cap short-run volatility.

The Carbon Market

Step 4: Markets set long-run prices

Carbon bond markets generate a forward price curve to 2050 (or beyond). This yield curve guides capital allocation toward low-carbon investment, analogous to how bond markets guide long-term interest rate expectations.

Step 5: Carbon Bank sets the short-run price

If short-run prices exceed the ceiling, the Bank sells annual certificates at the fixed price (a safety valve). If prices fall below a floor, the Bank buys. This bounds short-run carbon price volatility without abandoning the long-run emissions target.

Step 6: Policy adapts without legislation

As new climate science, technology breakthroughs or international agreements emerge, markets reprice carbon bonds automatically. The trajectory can be tightened by retiring bonds — no new legislation required.

The core innovation of CALM is its use of a government-created "Carbon Bank" that functions similarly to a central bank managing monetary policy. This Carbon Bank would have several key roles. First, it implements an emissions trajectory aimed at reaching an emissions target by a specific target date, such as 2050. Second, it would generate and issue annual emissions certificates aligned with the yearly emissions targets, which all major emitters in a country would be required to hold to match their annual emissions within the country. Third, it would package these annual certificates into tradable carbon bonds representing emission rights for future years. The presence of certificates with fixed dates and their trading in a market would establish a future market and create a yield curve of carbon prices extending into the middle of the century. If this was all the carbon bank did it would look like a traditional permit trading system. A related institutional proposal is the European Carbon Central Bank of Edenhofer et al. (2023), which would manage carbon dioxide removal certificates and their integration into the EU Emissions Trading System. CALM differs in giving the Carbon Bank responsibility for the whole emissions trajectory and for short-run price management.

The advantages of CALM lie in how it handles both short-term price volatility and long-term price signals. The Carbon Bank would initially allocate long-term carbon bonds at zero cost to households and firms at the start of the policy. This allocation acts as a wealth transfer that can offset the short-term economic costs of carbon pricing, making the policy more politically acceptable. Evidence on the political economy of carbon pricing suggests that visible compensation of this kind is central to public support (Klenert et al. 2018). These carbon bonds can be traded, establishing market-driven long-term carbon prices that influence investment decisions. At the same time, the Carbon Bank would be prepared to sell additional short-term certificates in the current year at a fixed price, serving as a safety valve against excessive price volatility while ensuring that longer term emissions targets are eventually met.

This approach offers several advantages, particularly relevant to global cooperation (see McKibbin and Wilcoxen (2007)). The free allocation of carbon bonds (to households and fossil fuel-intensive firms) addresses distributional concerns in many countries. For example, in countries where state-owned enterprises dominate key sectors (e.g. China), the allocation could support firms during the transition while maintaining emissions discipline. In the Global North, allocation to households and businesses could build political support and compensate those most affected by the transition. The mechanism's flexibility allows countries to adjust

to technological breakthroughs or unexpected costs without abandoning the long-term emissions trajectory.

The market-based nature of CALM encourages innovation, rewards efficiency, and minimizes administrative burdens. Unlike prescriptive regulations that mandate specific technologies, CALM allows firms to find the most cost-effective ways to reduce emissions. This is particularly important given the different industrial structures and technological capabilities of different countries; CALM allows these comparative advantages to emerge naturally.

Implementing the hybrid approach as a framework for a new global framework based on cooperation would require careful coordination but offers substantial benefits. Coordinating countries could begin by agreeing on compatible long-term emissions trajectories that limit global temperature rise to well below 2°C, ideally 1.5°C. These trajectories need not be identical—developing economies might have a somewhat different path than the Global North—but the paths should be mutually reinforcing and credible.

The countries could coordinate on the safety valve price or the fixed price at which additional short-term certificates are issued. This coordination is essential to prevent emissions leakage between economies. If one country sets its safety-valve price significantly lower than others, emissions-intensive industries would have strong incentives to relocate, undermining the policy's environmental effectiveness. By establishing a minimum emissions price floor that increases over time, all countries can ensure competitive conditions remain aligned.

A key aspect of cooperation involves mutual recognition of emissions pricing systems and coordination on border emissions adjustments. McKibbin and Wilcoxen (2016) and McKibbin, Morris, Wilcoxen, and Liu (2018) show that when major economies align their emissions pricing, the need for strict border adjustments decreases. Countries adopting compatible hybrid policies or CALM mechanisms could agree to exempt each other's products from border emissions adjustments, encouraging other nations to join the framework. Wolfram et al. (2026) propose a similar structure for heavy industry: coalition members recognize each other's carbon pricing as meeting an agreed floor, whatever the instrument, and apply border adjustments only to imports from non-members.

The coordination of measurement and reporting standards represents another essential area for cooperation. Both the hybrid policy and CALM require robust systems for monitoring

emissions, verifying compliance, and tracking permit holdings. Major countries could jointly develop technical standards for emissions measurement. Harmonized standards would facilitate trade, reduce compliance costs, and make it easier for other countries to join compatible systems.

Technology cooperation would be greatly enhanced under these frameworks. The long-term price signals created by tradable long-term permits or carbon bonds would drive investment in clean technology research and development. Joint research initiatives, technology demonstration projects, and intellectual property arrangements could accelerate innovation.

The sequencing of policy implementation matters enormously. Participating countries could begin with pilot programs in specific sectors or regions, testing the mechanisms and building experience before broader rollout. Emissions-intensive, trade-exposed industries are a natural starting point. Wolfram et al. (2026) estimate that a first-wave coalition pricing emissions from iron and steel, aluminum, cement and nitrogen fertilizers would reduce global GHG emissions by about 1.5 percent relative to 2023 levels, with output losses below 3 percent for coalition producers and about US$186 billion a year in domestic carbon-pricing revenue. Existing systems could serve as laboratories for testing hybrid features or CALM-like mechanisms. As countries gain confidence in the approaches, they could expand coverage and deepen coordination.

4. Climate Change Mitigation Scenarios and Results

In this section we compare three policy architectures aimed at a 50 percent reduction in covered GHG emissions from 2023 levels by 2050. Emissions pricing (via a carbon tax with revenue used to reduce fiscal deficits) begins in 2027. Scenario 1 calculates separate national price paths to regional targets. Scenario 2 fits a common real US-dollar price to the aggregate covered target. Scenario 3 uses a common reference price with fixed regional discounts (or premia) calculated from 2023 activity-value-weighted emissions intensities and specified policy overrides. It is a differentiated-pricing illustration relevant to Hybrid/CALM, not a simulation of the full institution. Differentiated price floors have also been proposed by Parry, Black and Roaf (2021), who set floors by income group among large emitters, and by Wolfram et al. (2025), who model graduated prices by income level within a climate coalition. Wolfram et al. (2026) apply income-tiered floors of US$25, US$50 and US$75 per ton to a first-wave

coalition covering iron and steel, aluminum, cement and nitrogen fertilizers, with border adjustments on imports from non-members. Graduated floors deliver almost the same emissions reduction as a uniform US$50 floor (about 1.5 percent of global GHG emissions) while cutting the output loss of lower-income members from about 2.2 to 0.6 percent. Our multiplier instead differentiates by emissions intensity, and our analysis covers all sectors in an intertemporal general equilibrium model rather than four industries in a trade model. Both sets of results show that differentiation changes who bears the adjustment far more than it changes the aggregate emissions outcome. The Middle East and North Africa (MEN) are assumed to be exempt from emissions pricing and excluded from the target in every scenario but are included in world emissions.

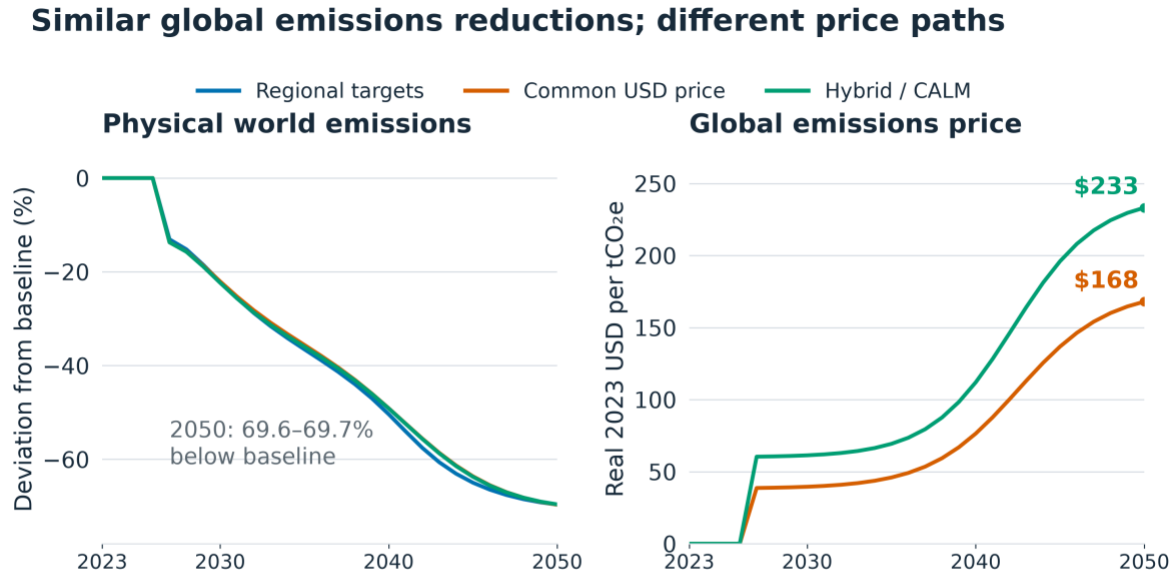
Table 6: Three pricing architectures and their numerical status

Scenario	Policy and achieved comparison
1. Regional targets	Separate regional emissions prices fitted towards a 50% reduction from 2023 by 2050 in each participating region.
2. Common price	A common real 2023 US-dollar price targets covered emissions outside MEN. Emissions are reduced by 49.2% from 2023 in 2050; its common emissions price is US$168.0 per ton in 2050.
3. Hybrid/CALM with Differentiated pricing	Fixed multipliers use moderated 2023 activity-value emissions intensities, with Australia/China at 0.65, India at 0.45 and MEN at zero. Emissions are reduced by 49.0% in 2050, relative to 2023; its reference emissions price is US$233.2 per ton in 2050.

4.1 Emissions outcomes and prices

Figure 3 shows physical all-world emissions of 25.25–25.32 gigatons in 2050, 69.6–69.7 percent below baseline. Emissions excluding the oil-based economies of the Middle East and North Africa (MEN) fall by 49.0, 49.2 and 49.0 percent relative to 2023 in Scenarios 1, 2 and 3 respectively, very nearly meeting the 50 percent target in all cases. The reduction relative to the 2050 baseline is larger than the reduction relative to 2023 because baseline emissions grow between those years. The key differences across scenarios lie in where emissions reductions occur and the regional distribution of transition costs.

Figure 3: Physical world emissions relative to baseline and reference price paths



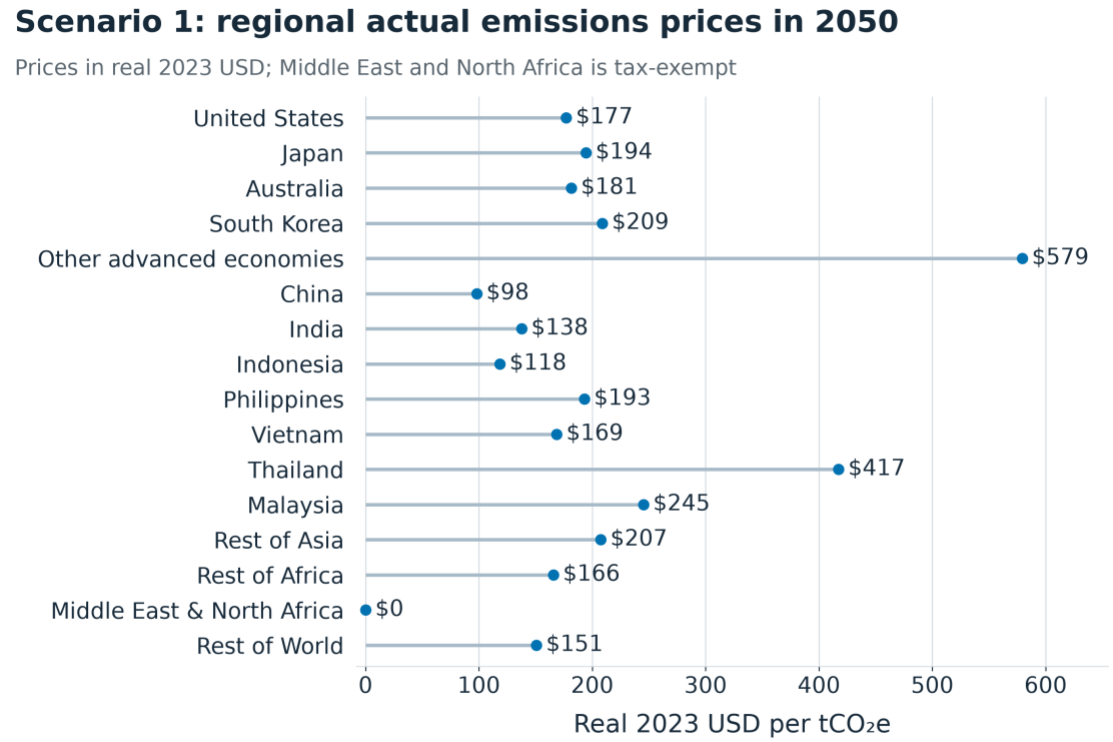
All-world emissions include MEN. The target instead covers 15 regions, excludes MEN, and seeks a 50% reduction by 2050 relative to their 2023 emissions.
Scenario 1 uses regional prices and has no global ETAXW price.

Source: 22AEPR/200 comparison, saved runs of 27–28 September 2026.
Physical world total: regional EMRC sum. Policy deviations start in 2027.

Under Scenario 1, national emissions prices[10] differ sharply (Figure 4). Among taxed regions in 2050, prices range from US$98.0 per ton of CO2-equivalent in China to US$579.3 in other advanced economies; India's price is US$137.6 and Thailand's US$417.2. Different energy systems, industrial structures and growth paths produce very different price responses to a common percentage target.

[10] Prices are expressed in real 2023 US dollars using the base-year currency anchor and the scenario's evolving real exchange rate.

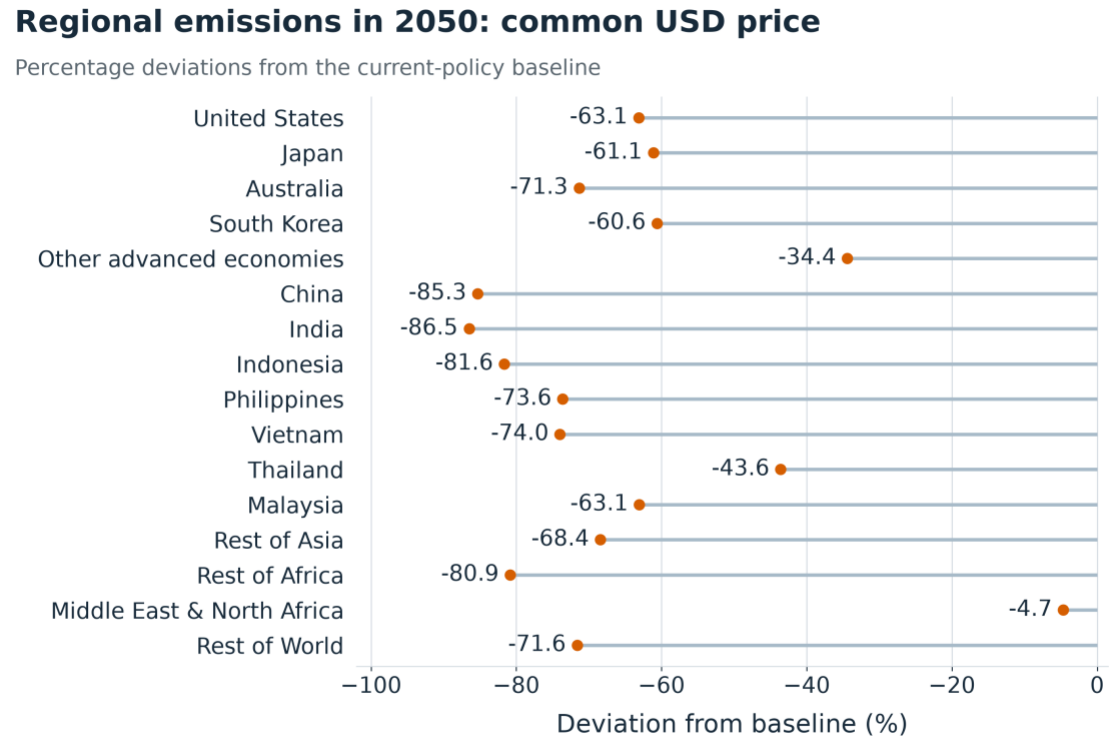
Figure 4: Scenario 1 regional emissions prices in 2050



Source: 22AEPR/200 comparison, ETAXR; saved run 27 September 2026.
Scenario 1 completed clean verification but did not pass its regional target-fit gates.

Scenario 2 allows the distribution of emissions reductions to respond to a common price, which reaches US$168.0 per ton in real 2023 dollars by 2050. Reductions are concentrated in economies where emissions respond most strongly to the price signal (Figure 5). India's and China's emissions are 86.5 and 85.3 percent below their respective 2050 baselines, compared with 34.4 percent in other advanced economies. Common pricing creates incentives to exploit differences in abatement opportunities, but it also places very different demands on national economies.

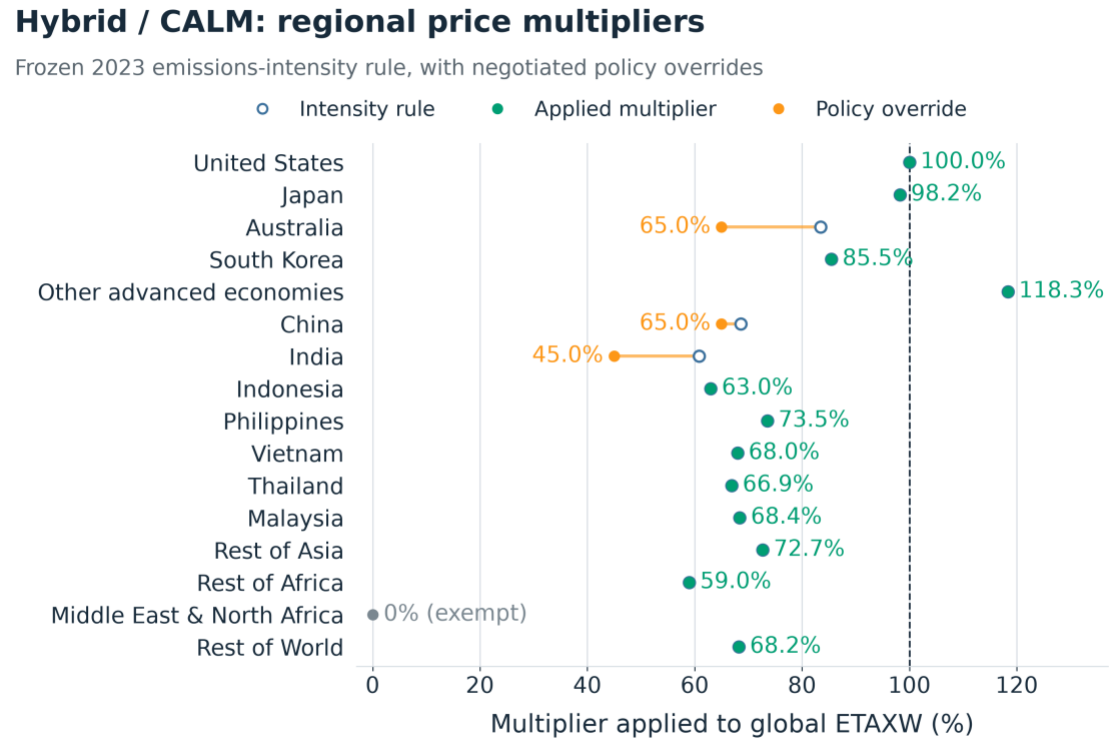
Figure 5: Scenario 2 regional emissions relative to baseline in 2050



Source: 22AEPR/200 comparison, physical regional EMRC; scenario 2.
MEN is tax-exempt; its emissions still respond to changes elsewhere.

Scenario 3 applies a fixed multiplier equal to 1 + 0.5 × (US 2023 emissions intensity / regional 2023 emissions intensity − 1), with specified overrides (assumed to be negotiated as part of the global emissions reduction cooperation efforts) of 0.45 for India, 0.65 for Australia and China, and zero for the Middle East and North Africa region (Figure 6). Emissions intensity is weighted by the value of emissions-generating activities. The multiplier for other advanced economies is 1.18, or 118 percent of the reference price. The common reference price reaches US$233 per ton in 2050, compared with US$168 under uniform pricing, while emissions outcomes remain similar. The higher reference price is the mechanism by which the discounts afforded to some regions by the multiplier transfer emissions-reduction responsibilities to other regions.

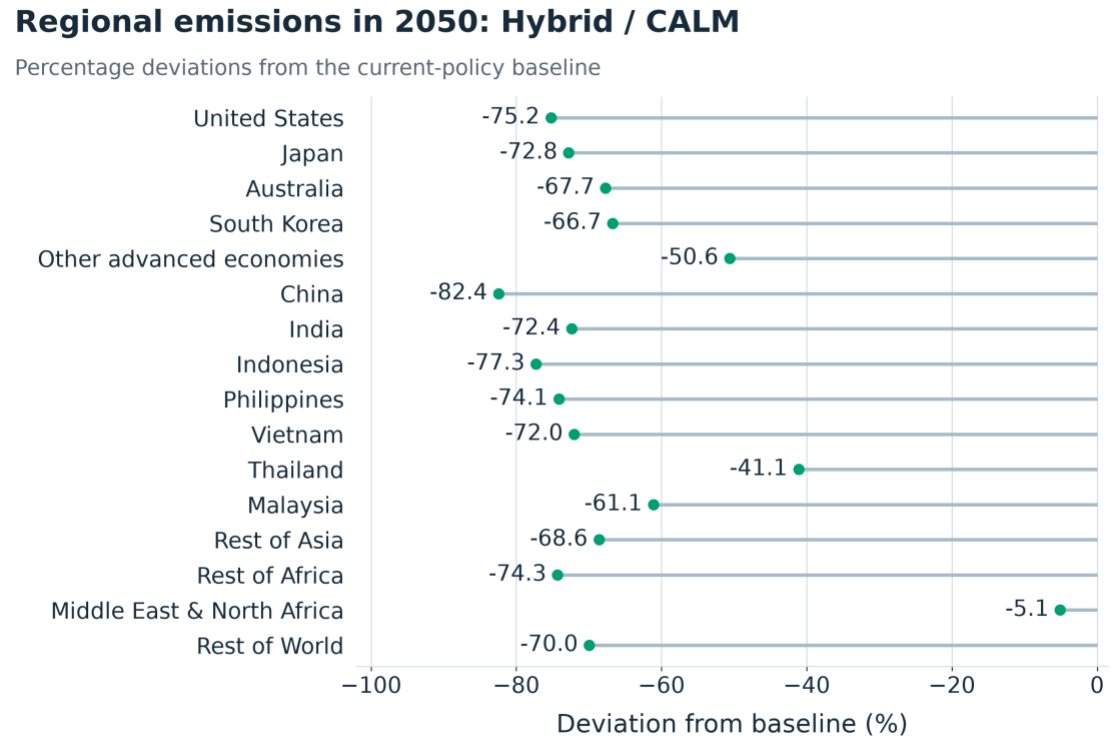
Figure 6: Scenario 3 intensity-based regional price multipliers



Source: experiment 3 saved calibration, run 20260928T002640.493028Z.
Rule: 1 + 0.5 × (USA intensity / regional intensity − 1). Overrides: AUS/CHN 0.65; IND 0.45.

Figure 7 shows how differentiated pricing shifts abatement towards several advanced economies. US emissions fall 75 percent below baseline, compared with 63 percent under common pricing; the reduction in other advanced economies increases from 34 to 51 percent. India's reduction moderates from 87 to 72 percent, and China's from 85 to 82 percent. Similar aggregate emissions outcomes can therefore coexist with quite different national transitions.

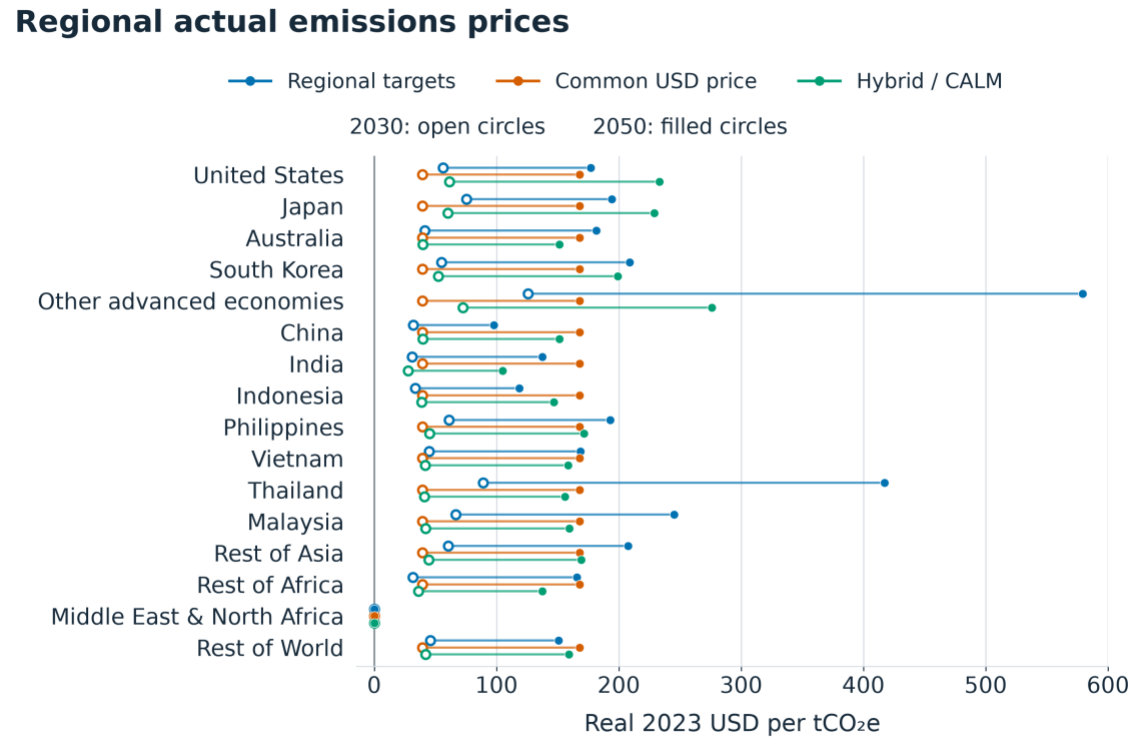
Figure 7: Scenario 3 regional emissions relative to baseline in 2050



Source: 22AEPR/200 comparison, physical regional EMRC; scenario 3.
MEN is tax-exempt; its emissions still respond to changes elsewhere.

Figures 8 and 9 compare regional emissions prices and emissions outcomes in 2030 and 2050 across all three policy architectures. They bring together the different national transition paths underlying the similar global emissions outcome.

Figure 8: Regional emissions prices in 2030 and 2050 (real 2023 US dollars)



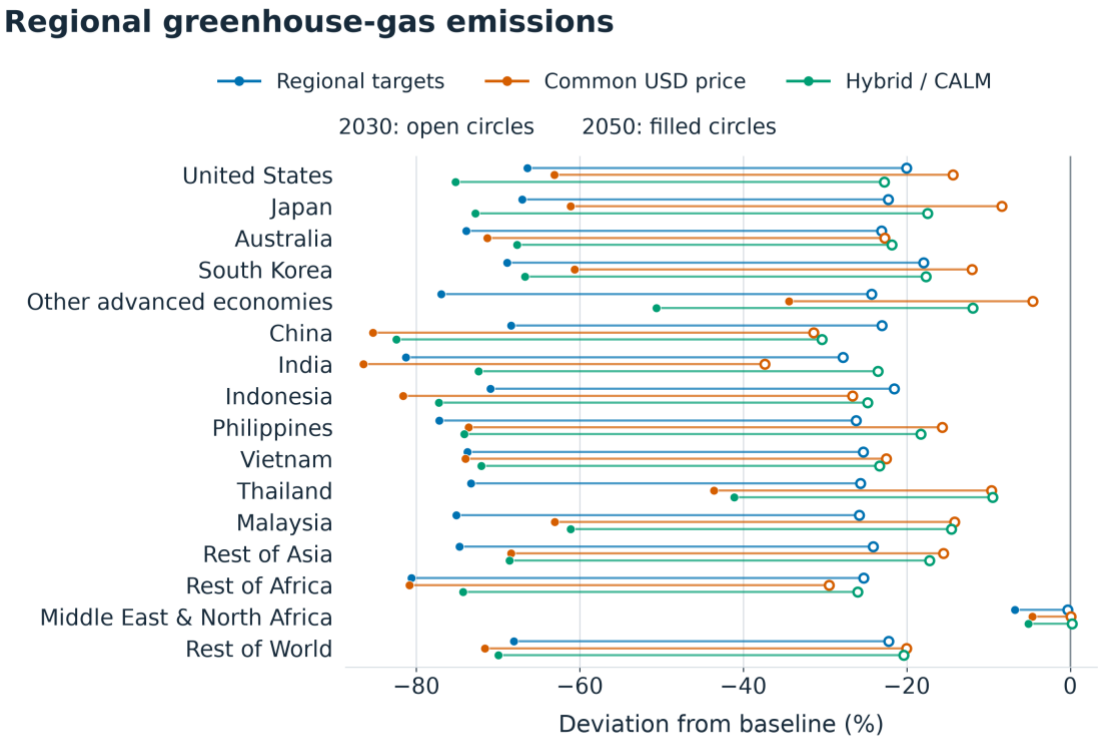
Source: 22AEPR/200 comparison, ETAXR; saved runs of 27–28 September 2026.
ETAXR is converted from local currency into real 2023 USD; MEN is tax-exempt.

In Figure 8, each row represents a country or region, with blue for the individual regional-target scenario, orange for the common US-dollar price scenario and green for Hybrid/CALM pricing. Open circles show 2030 and filled circles 2050. The horizontal axis measures regional emissions prices in real 2023 US dollars per ton of CO2-equivalent, allowing for the scenario's evolving real exchange rate, so points farther right indicate higher prices. Comparing colors within a row shows scenario differences for that region. Figures 9 and 10 use the same colors and symbols for emissions and output.

The other advanced economies provide the clearest example of the differences between policies. Their blue 2050 dot lies far to the right, showing the high price required under matched regional targets; both alternative frameworks substantially reduce that price. In India's row, the green 2050 dot lies to the left of the orange dot, showing the price relief provided by differentiated pricing relative to common pricing. In the United States, Japan and South Korea, the ordering is reversed. Differentiated pricing redistributes price incentives, easing the adjustment in some economies and increasing it in others while maintaining the collective emissions objective. These differences provide a basis for negotiations; the simulations do not test whether a resulting agreement would attract or retain participation.

A multiplier below one does not guarantee a price below Scenario 2, because the Scenario 3 reference price is higher. In 2050 the Philippines faces US$171 and the rest of Asia US$169, both above the uniform US$168 price despite multipliers of 0.735 and 0.727.

Figure 9: Regional GHG emissions relative to baseline in 2030 and 2050



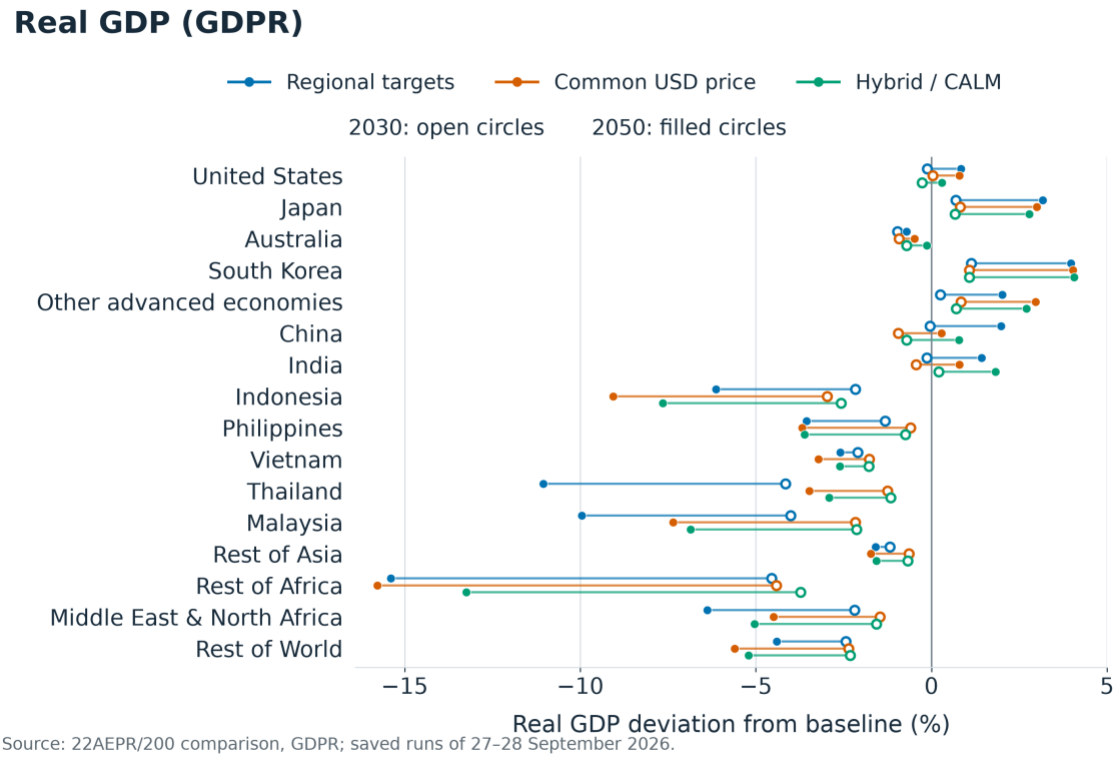
Source: 22AEPR/200 comparison, EMRC; saved runs of 27–28 September 2026.
EMRC is physical regional emissions; all 16 regions are included.

4.2 The distribution of transition costs

Figure 10 reports changes in real GDP levels relative to each region's baseline. By 2050, real GDP is above baseline in the United States, Japan, South Korea, other advanced economies, China and India under all three scenarios. The distribution of real GDP losses elsewhere depends on the scenario. Under the provisional national-target scenario, Thailand's and Malaysia's GDP is 11.1 and 10.0 percent below baseline; these shortfalls fall to 3.5 and 7.4 percent under common pricing, and 2.9 and 6.9 percent under the hybrid/CALM implementation. The rest of Africa faces a different ordering: its shortfall rises from 15.4 percent under national targets to 15.8 percent under common pricing, before falling to 13.2 percent under CALM pricing. Common pricing therefore does not reduce GDP losses in every developing region.

Compared with common pricing, differentiated pricing improves 2050 real GDP in twelve of the sixteen regions. The largest improvements are in the rest of Africa, Indonesia and India: 2.54, 1.41 and 1.03 percentage points respectively. India's GDP gain relative to baseline rises from 0.8 to 1.8 percent, and China's from 0.3 to 0.8 percent. Outcomes deteriorate in the United States, Japan, other advanced economies and the tax-exempt Middle East and North Africa; the latter's GDP shortfall rises from 4.5 to 5.0 percent. South Korea and the Philippines record small GDP improvements.

Figure 10: Real GDP changes (% of baseline), 2030 and 2050



Source: 22AEPR/200 comparison, GDPR; saved runs of 27–28 September 2026.
Changes in real GDP levels relative to baseline, not annual growth-rate changes.
Scenario 1 remains a provisional fit.

The timing of adjustment also matters. In Scenario 3, China moves from real GDP 0.7 percent below baseline in 2030 to 0.8 percent above it in 2050. Indonesia's shortfall instead widens from 2.6 to 7.6 percent, and the rest of Africa's from 3.7 to 13.2 percent. Relative to common pricing, the Philippines, Vietnam and the rest of Asia have lower GDP under differentiated pricing in 2030 but higher GDP in 2050. Price differentiation can therefore ease important regional burdens without improving every region's outcome at every date. This supports attention to regional circumstances and adjustment over time when designing cooperation; GDP comparisons alone do not establish welfare gains or political feasibility.

4.3 Implications for cooperation and Hybrid/CALM

These results give substance to the architecture gap identified earlier in the paper. Negotiations must address the economic consequences of commitments as well as their emissions arithmetic. Identical national targets overlook differences in adjustment costs, while a common US-dollar price leaves substantial differences in economic exposure. Durable cooperation requires a common direction of travel and an agreed way to accommodate these differences. This is consistent with Edenhofer et al. (2015), who argue for agreements built on differentiated national prices that reflect domestic incentives, and with Kornek et al. (2021), who show that how countries redistribute internally shapes the globally appropriate carbon price.

Hybrid/CALM is a proposed institutional framework for doing so; the simulations assess differentiated pricing rather than the institution itself. Countries can coordinate the reference safety-valve price, regional adjustments, emissions accounting and compliance standards while retaining national Carbon Banks and domestic implementation. This gives major emitters a basis for cooperation that respects differences in development and institutional capacity. National flexibility becomes part of the agreement, with transparent rules that keep individual commitments consistent with the collective objective.

The distribution of costs also provides a rationale for Hybrid/CALM's carbon bonds. Initial allocation to households and firms can distribute valuable assets towards those bearing transition costs and give them a stake in the policy's continuation. International cooperation over allocation and finance can complement regional price adjustments, while long-term carbon prices guide investment and the safety valve limits short-term emissions prices. Together, these features address the distributional and cost concerns that make participation difficult. The simulations establish a redistribution of production and emissions effects under differentiated pricing. Whether Hybrid/CALM’s bonds, allocation rules and safety valve improve welfare or sustain participation remains a separate institutional and empirical question.

5. Conclusion

Global climate policy needs to connect ambition with an economically and politically workable transition. While the baseline has physical emissions rising between 2023 and 2050, the scenario comparisons show that substantial reductions are possible under different architectures for regional cooperation, but the regional distribution of costs depends strongly on how commitments are designed.

The provisional national-target fit produces very large aggregate-output adjustments in some countries. A common global emissions price reduces several of these losses but leaves a heavy burden on several developing economies. The Hybrid/CALM scenario shows how negotiated differences in national prices (through safety valves that limit costs of abatement) can ease important regional pressures while maintaining a similar global emissions outcome. Some countries take on more adjustment so that others face a more manageable transition. This is the practical bargain at the center of cooperation.

The policy priority is to build agreements that combine a shared long-term objective with flexibility in national implementation. Hybrid/CALM offers a way to organize that cooperation through national Carbon Banks, coordinated pricing rules and a safety valve, supported by common accounting and verification. Carbon bonds add a means of distributing transition assets within countries and building domestic support. Finance and technology cooperation can further assist countries facing the largest adjustments.

A credible international agreement must give countries reasons to join and remain engaged. Recognizing differences in economic structure, development needs and transition costs is essential to that task. Cooperation and flexibility are complementary: accommodating national circumstances can make collective ambition more sustainable.

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