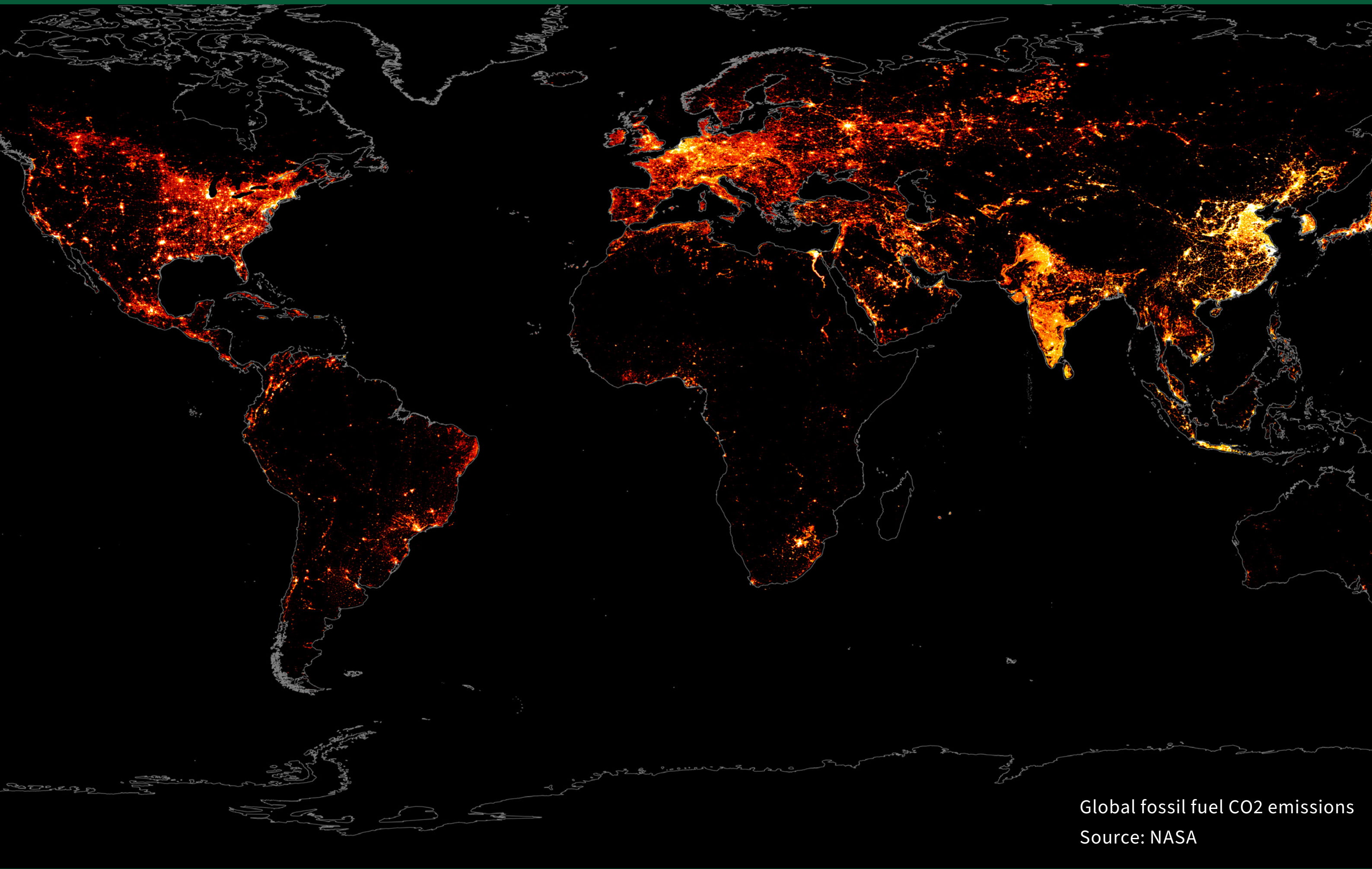

Global fossil fuel CO2 emissions
Source: NASA

Draft Proposal for a Unified Carbon Market

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All members of the Working Group serve in an individual capacity. This report does not necessarily represent the views of the institutions to which they are affiliated.

The latest version of this brief and supporting materials can be found at: https://egc.yale.edu/carbon-markets

The content of this paper was discussed in the context of an independent council convened by the COP30 President-designate, Ambassador André Corrêa do Lago, to inform on some economic dimensions of COP30, including contributions to the 'Baku to Belém Roadmap to 1.3T', to be presented by the President of COP29 and the President-designate of COP30, and to the COP30 Action Agenda.

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About the Authors

Rohini Pande is the Henry J. Heinz II Professor of Economics, Director of the Economic Growth Center and Faculty Director, Inclusion Economics, all at Yale University. Pande's research, which has influenced policy in South Asia and globally, focuses on how institutions shape power relationships and patterns of economic, political, and environmental advantage in low- and middle-income countries. She and colleagues collaborate with state and national governments to build innovative, evidence-informed environmental regulation resulting, among others, in the adoption of independent environmental auditing policies and launch of the world's first emissions trading market for particulate matter in Gujarat, India. She has also studied digital governance innovations and how AI-enabled predictions, supported by last-mile outreach by local communities, can support climate adaptation and mitigation policy in India.

Robin Burgess is a Professor of Economics, co-Founder and Director of the International Growth Centre (IGC) and Director of the Economics of Environment and Energy (EEE) Research Programme, at the London School of Economics. The International Growth Centre works across Africa, Asia, and the Middle East, partnering with local governments to develop new approaches to sustainable growth. Burgess's research focuses on environmental economics, development economics and political economy. He has worked on policies to combat illegal deforestation in Brazil and Indonesia, and with Bangladeshi and Indian government and NGO counterparts on anti-poverty programs that also strengthen climate resilience. He has also studied diffusion of solar energy in China and the growth of renewable energy globally.

Maryam Farboodi is the Jon D. Gruber Career Development Associate Professor of Finance at the MIT Sloan School of Management. Her research focuses on the economics of big data and data market design with applications to finance and macroeconomics. She has collaborated with multiple industry partners on internal and industry-wide data market design, including as a speaker in the Edward Jones Wealth Management Summit (WMAS) and Gartner Research Board meeting and a participant in the Goldman Sachs Global Markets Institute (GMS) Academic fellowship program. Her work has been cited in the testimony to the US House Financial Services Committee Subcommittee on Digital Assets, Financial Technology and Inclusion.

Agnes Norris Keiller is an Economics MRes/PhD candidate at the London School of Economics. She worked at the Institute for Fiscal Studies, the UK's leading economic policy think tank on the distributional impacts of policy changes and engaged with government departments on issues ranging from minimum wages to the economic effects of Brexit. Her research has focused on how innovation and productivity improvements can improve climate resiliency for firms and individuals. She has modeled general equilibrium effects for carbon markets in international contexts, and how to use measurement to reduce leakage and ensure additionality.

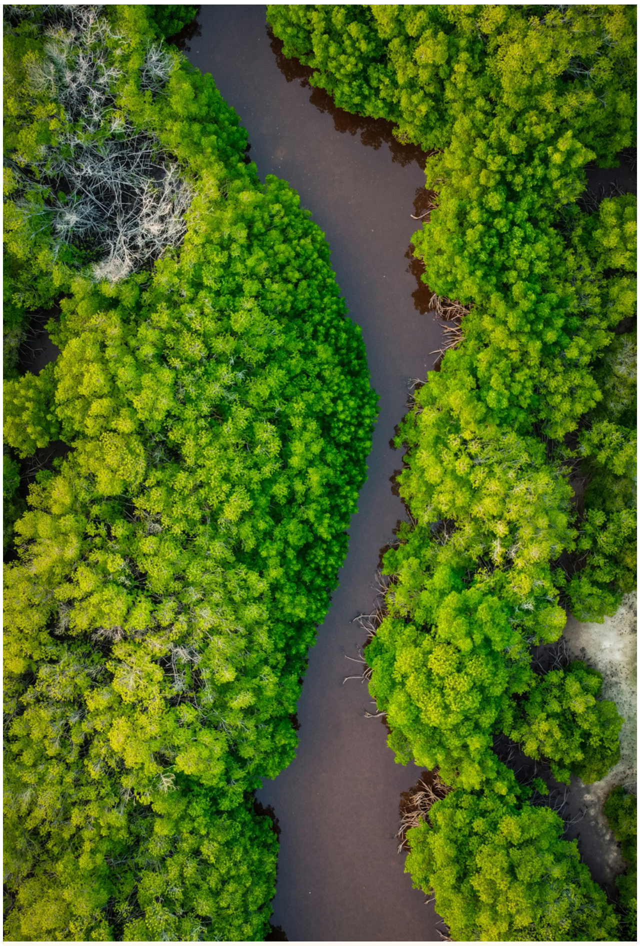
Lucy Page is an Assistant Professor of Economics at the University of Pittsburgh and an Inclusion Economics research affiliate. Her work focuses on political economy and behavioral aspects of environmental economics, with lines of work focusing on collective action on climate change and on payments for ecosystem services. She has experience designing payment for ecosystem services policies in partnership with state governments in northeastern India, and in using remote sensing data to effectively monitor programs designed to reduce deforestation.

Foreword

Between us, we have spent decades researching and implementing evidence-based development policies to better the lives of the poorest citizens in emerging markets and developing economies. Increasingly, our work on sustainable development has collided with the harsh realities of climate change. We have seen populations battle with new weather patterns that ruin their crops, water scarcity, extreme heat that makes work dangerous and exhausting, and increasingly unpredictable and intense floods and forest fires that endanger their livelihoods. Our work has led us to see climate breakdown as an existential threat to long-term growth and prosperity.

Over time, therefore, our focus has shifted to climate mitigation and adaptation. Members of our team have worked with regulators in the Indian state of Gujarat to set up the world's first cap-and-trade system for particulate emissions, potentially improving air quality for more than 75 million people, and developing institutional expertise that will facilitate future carbon trading. We have collaborated with government counterparts in Meghalaya, India, to provide landowners adequate funds to desist from deforestation. We have also assessed whether upfront payments deter Punjabi farmers from burning crop residue more effectively. In Bihar, we have worked with community workers to strengthen last mile delivery of flood warnings in Bihar. In Bangladesh, we have collaborated with non-governmental organizations to identify how providing poor households assets can help them weather climate shocks better. In Indonesia and Brazil, we have studied the political economy of deforestation. Alongside this, members of our group have worked with policymakers and other researchers to identify and remove impediments to large-scale renewable energy innovation and takeup.

In the process, we have understood the enormous global benefits of investing in climate resilient economies—which must include large-scale, rapid investment in climate mitigation in emerging markets and developing economies. There is an opportunity to enable these countries to achieve the economic growth and welfare gains that their populations expect and deserve, while avoiding the high-emissions, climate-vulnerable trajectory that would imperil this progress. The challenge we see is the lack of institutions capable of mobilizing capital at scale for global decarbonization.



> "One of the tasks of a market designer is to create a marketplace that people want to come and transact in. They should not be able to do better by transacting outside of the marketplace."
>
> ALVIN ROTH, NOBEL PRIZE LECTURE, DECEMBER 8, 2012

Institutional design is a technology much like any other. In recent years, we have seen many technological advances—in solar power, in energy storage, in green lighting, heating, and transport—being put into service to help prevent climate breakdown. But we've also seen repeated institutional failure—both at the level of climate politics, and of implementation. Our aim in this report is to make use of the latest research in institutional design to propose a credible, robust, and politically feasible set of market institutions to fund efficient and effective investment in rapid decarbonization on a planetary scale.

We set out to reimagine carbon markets starting from the first principles of market design and settled on two institutional pillars. First, an opt-in compliance market with a global cap; without a cap and a commitment to reduce this cap on a known trajectory, we do not see a pathway for a market to either bring participants to global targets, or offer the stability and predictability of demand that will keep prices high, and enable trade at the volumes needed. Second, an independent measurement, accounting, risk-management, and verification institution which enables our unified carbon market to credibly encompass all emissions reductions projects wherever they are on the planet. In particular, we leverage financial innovations to bring riskier projects to market that would otherwise be excluded without increasing risk to buyers. When combined these two pillars offer a politically feasible path to scale.

In the preparation of the report, we have benefited from wide consultations with governments, multilateral and bilateral organizations, and non-profit and for-profit actors in the carbon market space.

Scaling best practices from the research and implementation frontiers, collaborating across sectors and jurisdictions, and building capacity to implement proven solutions will be key in addressing this global challenge. This approach has been valuable in tackling other global challenges, including the eradication of extreme poverty. And this effort is clearly aligned with the long-term growth and prosperity of both high income countries and emerging market and developing economies. Building on this shared interest and track record of successful collaboration, we hope that this report can contribute to the global effort to build an effective, equitable carbon market to tackle global climate change. We see this very much as a proposal that we hope will be engaged with and iterated on by all stakeholders.

We welcome feedback at EGC@yale.edu

Acknowledgements

This report would not have been written without the able support of Jenna Allard, Ódran Farell, Harnoor Kaur, and Alina Zeltikova. Jeff Mosenkis kept us all on track and led on the final report compilation and production.

We are grateful for discussions with members of the COP30 Economic Advisory Council. José Scheinkman provided invaluable support during the process. Juliano Assunção, Lars Hansen, and Catherine Wolfram have provided vital input at several points. Thanks also to Esther Duflo, Michael Greenstone, Vera Songwe, Patrick Bolton, Nick Ryan, Bård Harstad (Stanford), and Winston Frisch for engaging with our arguments.

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LSE Global School of Sustainability Yale Planetary Solutions

I. Executive Summary

From heat and drought endangering food systems and straining insurance markets, to floods disrupting global supply chains, the economic costs of climate impacts are rapidly piling up. Emerging market and developing economies face particularly punishing effects—escalating climate damages that threaten growth, stability, and human welfare. Achieving global net zero and strengthening climate resilience are becoming increasingly critical.

Rapid and substantial investment is necessary to decarbonize economies globally and transition them to a more sustainable path. In a context of constrained climate finance, the emphasis must be on effective, credible, and fair deployment that enables scale. Since the climate system operates on a global scale, investments should prioritize areas where emissions can be eliminated or reduced most cost-effectively, regardless of the location. For high-income countries, such investment supports global equity and is increasingly in their best interests: it reduces the global cost of emissions abatement, mitigates climate risks that are increasingly hurting their domestic economies, and helps prevent systemic disruptions in finance, trade, and migration. For emerging markets and developing economies, this means unlocking new sources of capital to drive clean growth, enhance resilience, and ease pressure on constrained domestic public budgets.

A two-part proposal

To finance the investments necessary for global decarbonization, we propose a **unified carbon market** which would allow for participants from anywhere in the world and offer credible assurances of overall emissions reductions. Our proposal rests on two pillars:

Pillar 1: An opt-in compliance market with a global cap on emissions

This market would comprise multiple jurisdictions serving as conduits for individual firms, and for emissions avoidance, reduction, and removal projects that will receive finance from the sale of emission permits in the global market. Industrial, renewable, and nature-based emissions avoidance, reduction, and removal projects would all be eligible to participate in the market. This will link to or merge with existing compliance markets. Firms in non-participating jurisdictions that are large emitters could also independently enter the market. All entrants would agree to binding rules and long-term participation, and the market would be governed by an independent regulator that includes representatives from all participating jurisdictions.

Pillar 2: MARVIN — An independent Measurement, Accounting, Risk-Management, and Verification Institution

MARVIN would be a utility designed to ensure market credibility. It would operate independently of the market regulator, working with jurisdictions to standardize accounting and measurement, set pricing and financial standards to cope with risk, create monitoring and verification protocols that prevent any conflict of interest, and assure that allowances accord with market goals.

Five developments make the proposed unified carbon market feasible.

1 Over fifty carbon compliance markets are operational or in development throughout the world, and a wide array of emissions avoidance, reduction, and removal credits are traded globally through the voluntary carbon market. There is tremendous opportunity for these markets to standardize their protocols and then link with one another to create the global financial architecture required for large-scale global decarbonization investments.

2 Clean energy innovation is accelerating, and renewables are often cheaper than fossil fuels. Yet deployment in emerging markets and developing economies is lagging, since many efficiencies rely on investment at scale. Integrating renewable projects into a global market will give developers access to the necessary capital while also offering funders the credible, predictable conditions required to invest.

3 Advances in remote sensing, artificial intelligence, and big-data now enable high-precision measurement and verification of carbon fluxes, especially for nature-based projects. In the past, it has been difficult to estimate counterfactuals—what would have happened in the absence of a project—for nature-based projects. Today, new measurement and analytical tools make these estimates more credible. Combined with financial tools and instruments such as risk-based pricing, performance-linked contracts, and collateralization, these advancements support the credible inclusion of industrial, renewable, and nature-based projects in carbon markets worldwide, ensuring that traded permits reflect genuine and durable climate benefits.

4 A growing body of market design research has identified how markets can be structured to use incentives and information to maintain credibility and align market participants' incentives with the goal of the market, and to ensure that they can sustain participation, avoid congestion, and ensure safety and simplicity to participants.

5 EU ETS and similar systems show how emissions trading can incorporate mechanisms for fairness—through free allocations, modernization funds, and cross-jurisdictional transfers—without undermining efficiency. These design features provide a model for integrating low-income countries into a unified carbon pricing structure that both preserves development priorities and ensures global environmental integrity.

Building on existing markets to get to global net zero

Building on these developments, our proposal unifies and strengthens the best features of existing carbon markets. Existing compliance markets have achieved credible emissions reductions within national or regional boundaries but have limited scope in the types of mitigation activities they can fund. The voluntary carbon market, by contrast, has expanded participation to a wider range of project types, including nature-based ones across the world, but struggles with establishing project credibility due to inconsistent measurement, verification, and weak institutional incentives for truth-telling. Our framework combines the strengths of both—**binding emissions limits, robust accounting, and broad project inclusion**—while introducing improved contract structures and risk-pricing tools to enhance credibility and scale. Thus, aligned with the Paris Agreement, we propose a voluntary opt-in participation model.

The potential gains in efficiency from linking markets, standardizing rules, and including diverse project types will be key to unlocking investment at scale. The market we propose is designed to be compatible with achieving *global net zero* while upholding the principle of common but differentiated responsibilities. It has the potential to unleash large-scale private and institutional investment for emissions mitigation across the world. A unified carbon market that is credible, inclusive, fair, and operates at scale offers a practical path to mobilize capital where it has the biggest impact—aligning the self-interest of high- and lower-income countries in a shared effort to secure climate stability and sustainable growth for all.

Abbreviations

ETS
Emissions Trading Scheme

VCM
Voluntary Carbon Market

VCMI
Voluntary Carbon Markets Integrity Initiative

ICVCM
Integrity Council for the Voluntary Carbon Market

CCP
Core Carbon Principles

MRV
Measurement, Reporting, and Verification

CO_2e
Carbon-dioxide equivalent

CO_2
Carbon dioxide

SO_2
Sulfur dioxide

GHG
Greenhouse gas

Gt
Gigatonne

$GtCO_2e$
Gigatonnes of CO_2-equivalent

t
Tonne

tCO_2e
Tonnes of CO_2-equivalent

UN
United Nations

ITMOs
Internationally Transferred Mitigation Outcomes (Article 6 units)

CORSIA
Carbon Offsetting and Reduction Scheme for International Aviation

IMO
International Maritime Organization

DG CLIMA
European Commission's Directorate-General for Climate Action

EUTL
EU Transaction Log

NDCs
Nationally Determined Contributions

MARVIN
Measurement, Accounting, Risk management, and Verification Institution

CBAM
Carbon Border Adjustment Mechanism

TFEU
Treaty on the Functioning of the European Union

II. Introduction: The Need to Efficiently and Equitably Reduce Emissions

Historically, economic growth has been associated with environmental pollution, which has exacerbated global warming. We find ourselves at a pivotal moment where conventional means of economic growth and climate damage are perilously colliding.

The international development discourse and global policy-making during the second half of the twentieth century were largely focused on the objective of enhancing human welfare through rapid economic growth and poverty alleviation. An impressive evidence base on what works was constructed on the back of more accurate measures of living standards, as well as via collaborative evaluations between academics and policymakers, frequently utilizing innovative approaches. This evidence base, along with a commitment to eradicating poverty and fostering economic growth through collaboration among government, civil society, bilateral and multilateral institutions, and active participation from both public and private sectors in implementation helped slash extreme poverty from 43.4% of the world's population in 1990 to 10.3% in 2024 (Besley and Burgess, 2023; Deaton, 1997; Deaton, 2006; Deaton, 2013; Banerjee and Duflo, 2011; Page and Pande, 2018; Ravallion, 2015; and World Bank, 2025).

> "How to balance the need for economic growth with the damages it creates has become the central tension in economic policy making in the 21st century. Limiting global warming to safe levels requires policies that cap atmospheric greenhouse gases and put the world on a pathway to global net zero."

However, the accelerated economic growth that drove this progress also brought about climate change, which is now having far-reaching negative impacts on both humans and the natural environment and could eventually derail this path to prosperity. Rising damages come not only from heat, fires, droughts, storms and pollution but also from the breakdown of insurance markets, disruption of trade and increases in conflict. How to balance the need for economic growth with the damages it creates has become the central tension in economic policy making in the 21st century. Limiting global warming to safe levels requires policies that cap atmospheric greenhouse gases and put the world on a pathway to global net zero.

Many view global decarbonization as the way forward, but progress to date has been modest. Many high-income countries have begun industrial decarbonization, but the costs of further domestic reductions are rising as the lowest-cost opportunities are exhausted. In contrast, low-cost investment opportunities in decarbonization are relatively abundant in emerging and developing economies. These include projects that expand renewable energy, deploy cleaner industrial processes, and restore or conserve natural ecosystems that store carbon. In these contexts, land, labor, and new infrastructure investment costs are typically lower, meaning that each dollar of investment can deliver larger climate gains (Glennerster and Jayachandran, 2023). However, these investment opportunities remain underfunded because many emerging market and developing economies face substantial barriers to accessing climate finance at the scale necessary to drive efficient, economy-wide decarbonization.

Limiting global warming to safe levels requires policies that cap atmospheric greenhouse gases and put the world on a pathway to global net zero. Because greenhouse gases mix uniformly in the atmosphere,

the location of emissions reductions is irrelevant to the climate outcome—but critical to cost and speed. In a world of constrained climate finance, the most efficient strategy is to direct investment first to where abatement is most cost-effective, regardless of geography. Emissions removal projects, which remove CO_2e from the atmosphere, and emissions reduction and avoidance projects, which prevent the CO_2e emissions, can both slow the accumulation of atmospheric greenhouse gases. Put differently, because climate damage from greenhouse gases depends on the excess quantity of CO_2e in the atmosphere at any given time, preventing 1 tonne of CO_2e from entering the atmosphere has the same climate benefits as removing 1 tonne of CO_2e at the same time. We describe this overall category as emission reduction, avoidance and removal projects. This includes industrial projects, renewable projects which accelerate the rate of diffusion of renewable energy into power and transportation systems, and nature-based projects. An efficient carbon market should fund emissions avoidance, reduction, and removal projects based on cost per tonne, not type. Recent years have also seen expansion in the design of markets and exchanges with institutions and rules designed to advance broader social goals, including the world's largest emissions cap and trade market, the EU Emissions Trading System (ETS).

We are proposing a set of evidence-backed institutional reforms essential for achieving decarbonization at a scale that current institutional structures cannot support. Similar to the poverty-eradication agenda of the twentieth century, our proposal is undergirded by a detailed evidence base on what works. We also pay attention to incentives; the fact that high income and emerging market and developing economies alike can benefit from this market makes this scale feasible.

For emerging market and developing economies, the market will mobilize global capital to fund decarbonization by directing finance efficiently toward the lowest-cost emissions reductions worldwide. The market would fund emission avoidance, reduction, and removal projects in all sectors—industrial, renewable, and nature-based—based on the cost per tonne of verified abatement—including the costs of verification—rather than project type or location. It would adhere to the principle of common but differentiated responsibilities: ensuring that high-income countries contribute proportionally more to financing decarbonization and emerging market and developing economies gain access to capital and technology for clean growth. This is particularly welcome against a background of limited local public finance in these countries. The Baku to Belém Roadmap highlights the enormity of this financing challenge, calling on all actors to work together to enable the scaling up of financing to emerging market and developing economies from public and private sources to at least $1.3 trillion per year by 2035 (Bhattacharya et al., 2024).

The proposed framework builds on the strengths of current carbon markets—domestic compliance systems, the VCM, the emerging Article 6.4 mechanism under the Paris Agreement and the EU ETS (see Appendix 1). From domestic compliance markets, it adopts the discipline of a binding emissions cap and the efficiency of permit trading, ensuring that emissions reductions are achieved credibly and at lowest cost (see Box 8). It builds on the inclusiveness of the VCM by expanding participation to a wider range of emissions avoidance, reduction, and removal projects, where the potential for cost-effective abatement is greatest. From Article 6.4, it incorporates uniform international standards for project authorization, accounting, and transparency. From EU ETS it adopts the concept of economic transfers from higher to lower income locales via permit allocations, to fulfil the principle of common but differentiated responsibilities among participating countries.

III. Our Proposal: Two Pillars for a Unified Carbon Market

Our proposed unified carbon market is based on two complementary institutional pillars that, when combined, can unlock the capital needed for large global decarbonization initiatives in emerging market and developing economies. The framework enables buyers to purchase credible, verified emissions reductions from any source—industrial, renewable, or nature-based—while integrating measurement, verification, and risk management. By introducing risk-adjusted pricing, standardized verification protocols, and a binding global emissions cap, all regions and project types can participate, directing large-scale investment toward the most efficient mitigation opportunities worldwide. Only by combining the best aspects of all existing approaches can we get to scale and on a realistic path to global net zero.

III.1. Pillar I: A Unified International Compliance Market

The first pillar is a global cap-and-trade system with an independent regulator that sets a binding emissions cap and establishes a single, transparent carbon price. Permits representing permission to emit one tonne of CO_2e would be tradable across all participating jurisdictions, ensuring that mitigation finance flows to the lowest-cost opportunities worldwide.

The market will be open to both jurisdictions and major corporate emitters, with participation voluntary but binding once entered. Each participant will face an emissions limit and will be able to trade permits as needed to remain compliant (see Box 1). The total cap will decline over time, driving aggregate emissions toward net zero.

Initial permit allocations will follow the principle of common but differentiated responsibilities, recognizing the differing capacities of high- and low-income countries. High-income participants will contribute more to financing global abatement, while emerging market and developing economies will gain access to the finance and technology needed to drive decarbonization and sustainable growth. The market will reward verified emissions avoidance, reduction, and removal across all sectors, allowing project developers to trade standardized permits tied to their verified performance. Industrial, renewable, and nature-based projects will be eligible to join the market, but project co-benefits—such as enhancing biodiversity and poverty reduction—will not influence permit allocations or prices.

The regulator, an independent international body governed by participating jurisdictions, will oversee market operations and manage compliance. By integrating risk-adjusted pricing into the trading mechanism, the system will expand participation to projects previously excluded, while maintaining environmental integrity. Section V of the proposal contains more details on the contractual design, permit allocation and risk management features that will be used to achieve this.

III.2. Pillar II: MARVIN — Measurement, Accounting, Risk Management, and Verification Institution

The second pillar, MARVIN, is an autonomous international institution dedicated to maintaining market integrity and ensuring that every traded permit represents a genuine and durable emission reduction. Governed by participating jurisdictions, and funded by market revenues, MARVIN will set universal standards for ex-ante additionality measurement, ex-post verification, risk management structures, and audits. Leveraging recent advances in remote sensing, AI, and digital measurement, reporting, and verification (MRV) systems, MARVIN will standardize how projects are monitored and verified, ensuring comparability and eliminating double counting across jurisdictions. We anticipate that MARVIN will directly commission monitoring, auditing and verification services using a fixed payment schedule. The payments themselves will be made by projects. Independent financing of MARVIN from market proceeds eliminates conflict of interest concerns. By linking high-precision measurement to robust contract and market design, MARVIN will provide the institutional backbone required to scale climate finance and deliver verifiable progress toward global net zero.

Crucially, MARVIN's standards will integrate risk management directly into market design. Instead of excluding projects with higher uncertainty MARVIN will enable their inclusion in the market via a combination of conservative ex-ante additionality assessment, ex-post verification, and transparent performance monitoring. This ensures that the most cost-effective abatement opportunities can attract investment while maintaining market integrity. MARVIN will also require market participants to apply approved risk management mechanisms, such as posting collateral upon market entry and purchasing insurance against some types of reversal risk (see box 11).

MARVIN will also stipulate auditing and governance standards, contracting independent project verifiers under fixed payment schedules to remove conflicts of interest and uphold consistency. It will collaborate with jurisdictions to identify governance structures for emissions avoidance, reduction, and removal projects that ensure project prices reflect adequate financial compensation for impacted communities. Reinforcing fairness and durability in this manner will incentivize durable emissions avoidance and reduction behavior by aligning carbon market participation with inclusive and sustainable development.

Overall, MARVIN will ensure that buyers or traders of a one-tonne CO_2e permit receive the same standardized unit with the same expected risk, regardless of whether it originates from emission reduction in a high income country or nature-based, renewables, or industrial projects in an emerging market or developing economy.

BOX 1

What do carbon markets trade?

Carbon markets trade two different products.

Permits, or Allowances, represent permission for an entity to emit a tonne of CO_2e, and are traded between market participants in ETS markets up to the level of the market cap. If entities' actual emissions exceed held permits, they must purchase additional permits or face sanctions. Entities that emit CO_2e below their permit limit can sell excess permits. Permit value, and the expectation of continued demand for them, is constructed by market regulatory structure, and regulator commitment. The regulator, which distributes permits up to the cap-level, and its continued shrinking of the cap towards a known target helps create predictable demand. Permits trade on a transparent exchange within the market at a single price.

Carbon Credits, or Offsets are tradable assets that represent a reduction of a tonne of CO_2e. These tokens obtain their value not from any formal legal or regulatory system, but because entities can improve their reputation with customers and shareholders by using them to claim they are reaching their voluntary emissions reduction targets, without reducing their direct emissions. The production of credits/offsets is measured and verified by private sector entities. There are no legal or regulatory consequences where entities fail to reach voluntary targets or purchase credits/offsets that do not correspond to actual emissions reductions. Credits/offsets are traded both on exchanges and in bilateral trades with uncertainty about future demand and credit quality leading to low prices.

Permits/allowances and credits/offsets are not fungible because their values are established in completely distinct ways.

IV. Five Developments That Support a Unified Carbon Market

Five recent developments make a unified carbon market at global scale feasible.

IV.1. The rise of carbon compliance markets

An important post-Kyoto Protocol development is the rapid proliferation of domestic ETSs. An ETS operates as a centralized cap-and-trade market, enforced by a regulator, where covered entities trade emission allowances permits (see Box 1).

These cap-and-trade systems, especially the EU ETS, have shown robust market performance and effective emission abatement within their jurisdictions. The launch of the Chinese national market and its rapid global expansion has significantly expanded market coverage. By 2025, there are 38 operational ETS—with 20 more in development or contemplation—covering over 23 percent of global greenhouse gas emissions (ICAP, 2025) (see Box 3). The Carbon Border Adjustment Mechanism (CBAM) is expected to accelerate the development of domestic compliance markets, paving the way for the eventual linkage of these systems across both high-income and emerging economies (GCPP Working Group on Climate Coalitions, 2025). Cap-and-trade systems have also been shown to be highly successful in settings where regulatory capacity is limited (see Box 4).

BOX 2

EU ETS—Demonstration that Carbon Compliance Markets Reduce Emissions

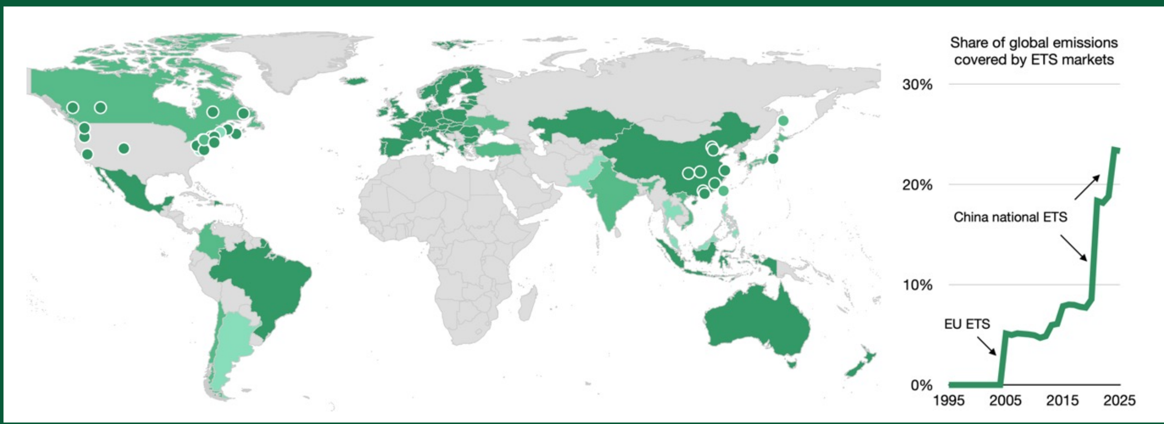
The 1997 Kyoto Protocol was the first international agreement to set legally binding emissions reduction targets for 37 industrialized countries, which policymakers developed instruments to meet. Launched in 2005, the EU ETS is the world's largest "cap-and-trade" carbon market. A cap limits total emissions, reduced annually to align with the EU's goal of achieving net-zero greenhouse gas emissions by 2050. The cap is expressed in emission allowances, which are auctioned or traded. Some allowances are allocated for free to the manufacturing and aviation sectors (with a gradual phase-out) to prevent carbon leakage (discussed later), and to 16 lower-income member states to mitigate potential economic strain during the transition.

The scheme covers about 40% of the EU's greenhouse gas emissions, including from the power, industrial, aviation, and maritime sectors. EU member states, along with Iceland, Liechtenstein, and Norway participate. Since January 2020, the EU ETS has been linked with Switzerland's ETS, and further linkage with the UK ETS is being developed following the EU–UK May 2025 summit, demonstrating the growing potential for expanding carbon markets globally through the systems with compatible regulations.

Overall, research finds that EU ETS functions as a well-regulated carbon market that has reduced emissions across Europe without harming local industries or inducing carbon leakage. By 2023, emissions from European power and industrial plants had fallen by 47% compared to 2005 levels, while generating over €200 billion in revenue. From mid-2023, member States are required to use all EU ETS revenues (or equivalent amounts) to support the green transition, including measures addressing its social impacts (European Commission). The system is estimated to have averted 1.2 billion tonnes of CO_2e between 2008 and 2016 (3.8%), fulfilling nearly half of EU countries' Kyoto Protocol emission reduction commitments (Bayer and Aklin, 2020). French regulated manufacturing cut emissions by 14–16% without affecting economic activity or causing outsourcing to unregulated markets (Colmer et al., 2025). Installation-level evidence from France, the Netherlands, Norway, and the United Kingdom shows a 10% abatement between 2005 and 2012 without economic harm to firms (Dechezleprêtre, Nachtigall, and Venmans, 2023). See Appendix 3 for details.

BOX 3

ETS markets and growth over time

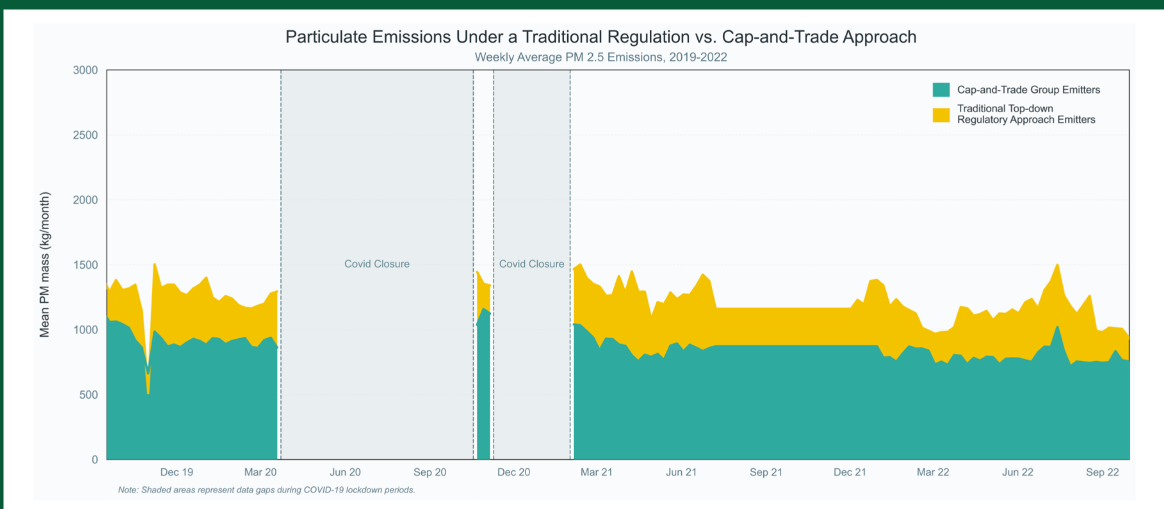


The map shows ETS markets implemented (dark green), under development (green), and under consideration (light green). (Adapted from the World Bank Carbon Pricing Dashboard)

BOX 4

Well-designed cap-and-trade markets cut emissions effectively in emerging market and developing economies

In 2019, with the help of researchers, the Gujarat Pollution Control Board (GPCB) launched the world's first particulate-matter emissions market in a cluster of industrial plants in a large Indian city. The program was highly cost-effective, and the health benefits from reductions in pollution exceeded the costs of implementation by at least 25 times. Plants reduced pollution emissions by 20%–30%, and reduced pollution abatement costs by 11% (Greenstone, Pande, Ryan, and Sudarshan, 2025)



Domestic ETSs showcase the potential for emission caps to drive demand for low-cost abatement options, yet they fall short of being a complete solution for achieving global net zero. First, participation is restricted to firms in a single country or a group of countries (as with the EU ETS). Second, these markets typically only cover industrial emission sources, leaving out global renewable energy and nature-based projects. This exclusion reflects the perception that these projects lack credible mechanisms for measuring, verifying, and managing risk while also ensuring durability. However, it precludes the mobilization of capital for numerous cost-effective abatement opportunities around the world. Thus the current limited scope of ETSs ensures credibility at the expense of inclusivity, limiting efficiency advantages and scale.

IV.2. The surge in clean energy innovations

Complementing the efficiency gains associated with a unified carbon market expansion is the remarkable expansion of clean energy technologies. But without targeted investment in the countries best suited to deploy them, often emerging market and developing economies, the full global benefits of these breakthroughs will go unrealized. The innovation, substantially driven by green industrial policies (Banares-Sanchez, Burgess, Laszlo, Simpson, Van Reenan, and Wang, 2025), has created enormous potential for rapid, worldwide diffusion. A unified carbon market can play a vital role in accelerating the integration of renewables into the power, transportation, and production sectors globally.

Experience from the US state of California underscores this potential—the state's carbon pricing policies have significantly increased the share of renewables in its energy mix. Beyond reducing consumption and encouraging fuel-switching, carbon pricing has aligned incentives to spur renewable investment within California, while the CBAM has increased the renewable capacity of neighboring states (Dilek, Teixido-Figueras, and Serrano, 2024). Combining the scale of a unified global market with thoughtful market design can help direct investment in renewables to where it can do the most good.

Rapid transition is particularly urgent in emerging market and developing economies, which are projected to drive the majority of future emissions. Investment choices made today—such as building new high-emitting infrastructure—could lock in those emission pathways for decades. Decisive action is needed to phase out existing coal and fossil fuel infrastructure while supporting economic growth and rising living standards these countries seek. To achieve global net zero by 2050, replacing fossil fuels with renewables in the power sector is an essential and achievable goal. The estimated global investment required for this energy transition stands at $23.5 trillion, with 71% of that capital needed in emerging market and developing economies. This shift would secure an estimated abatement of 459.2 Gt CO_2 (Bolton, Kleinnijenhuis, and Zettelmeyer, 2024).

Existing carbon markets typically exclude renewables, arguing that their financial viability disqualifies them from meeting the additionality criteria. However, there is evidence that other barriers to adoption are causing global inefficiencies in renewables deployment. Such inefficiencies are particularly evident in the global solar market: higher levels of solar irradiation (which are concentrated in emerging market and developing economies) are inversely related to solar installations: As Box 5 shows, countries such as the UK and the Netherlands have seen the highest growth in solar, while countries such as Botswana and Libya have seen the least.

This highlights a major decarbonization opportunity: accelerating solar and other renewable installations in emerging market and developing economies. However, financing for such installations in the poorest countries is often held back by implementation risks (Ryan, forthcoming), while concerns over the reliability of renewable power make households and firms less willing to pay for off-grid generation (Burgess et al., 2025; Lee et al., 2020). Another important consideration is cost of capital: Many renewable energy solutions are capital-intensive. Wind and solar power don't need fuel and don't need much upkeep, so their levelized cost of electricity depends substantially on the money they cost to install. This differs from fossil fuel power plants, where fuel costs dominate lifetime expenses. So, even a small increase in the cost of capital can make green energy sources much more expensive, making them less competitive with fossil fuels. And, given the riskier political and economic environment in many emerging market and developing economies, the cost of capital is typically much higher in these countries (IEA, 2024; Sachs et al., 2025).

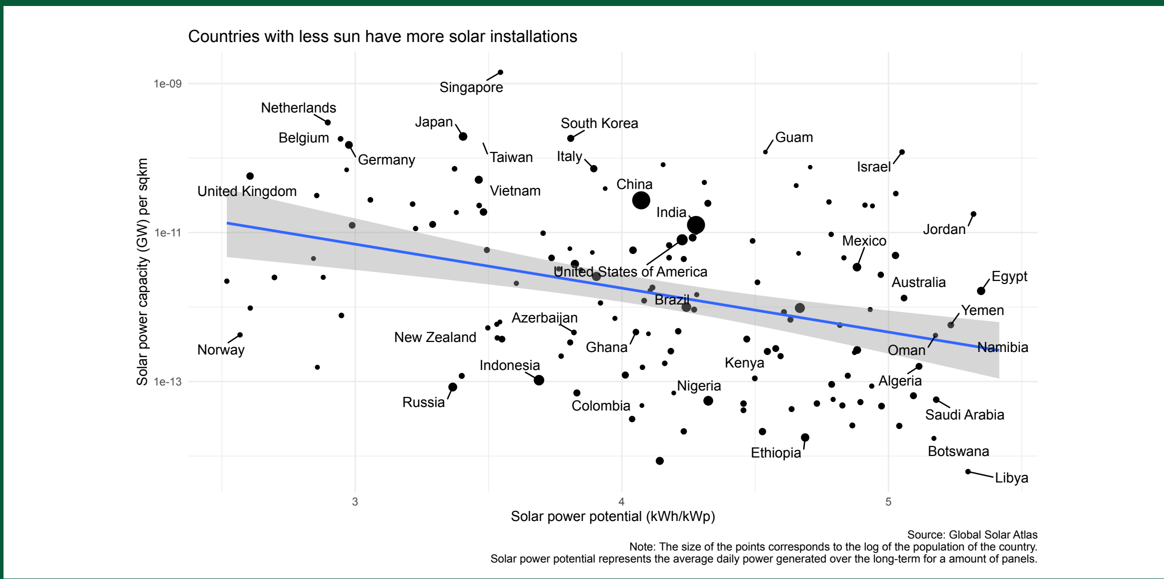
New additionality measurement protocols that take into account the financial costs of overcoming implementation barriers and the domestic capital costs of incorporating renewables into the grid can enable credible introduction of renewables into carbon markets. In particular, it is now possible to measure counterfactuals for prospective solar sites and estimate additionality. We can quantify both the abatement attributable to new installations—allowing for feasible inclusion of solar installations in carbon markets—and the acceleration in installation that additional financing can make feasible. Including renewables in carbon markets will help unlock this potential and keep established climate goals within reach.

“Decisive action is needed to phase out existing coal and fossil fuel infrastructure while supporting economic growth and rising living standards these countries seek. To achieve global net zero by 2050, replacing fossil fuels with renewables in the power sector is an essential and achievable goal.”

BOX 5

The mismatch between solar suitability and installed solar capacity

Between 2004 and 2019 there was a 91% decline in solar module prices coinciding with a 173-fold increase in installed capacity over the same period. Solar is now not only financially viable but the cheapest form of energy as measured by levelized cost of electricity—especially so in countries with higher levels of solar irradiance (IRENA, 2025). However, higher levels of solar irradiance is inversely correlated with solar installations.



IV.3. Advances in measurement, evaluation, and contract design

Recent advances in monitoring technology and evaluation methodologies, along with insights from financial contract design have transformed how emission reduction, avoidance and removal projects can be assessed, verified and remunerated. This is especially true for nature-based projects such as forest restoration, soil carbon enhancement, and peatland and wetland conservation, where concerns related to measurement uncertainty, additionality, and permanence have historically precluded their inclusion in carbon markets.

The tide is turning on this. Thanks to breakthroughs in big data, machine learning, and remote sensing, carbon sequestration can now be tracked with unprecedented accuracy and temporal resolution. Continuous monitoring of biomass and land-use change is made possible by high-frequency data from satellites, drones, and in-situ sensors. In Brazil, for example, research has found that the DETER system, which processes satellite imagery and issues near-real-time deforestation alerts to target environmental enforcement in the Amazon, in combination with appropriate regulatory actions, curbed illegal deforestation (Assunção, Gandour, and Rocha, 2023). Complementary developments in AI-driven analytics and geospatial modeling enable the detection of subtle variations in vegetation density and soil organic carbon, supporting dynamic, evidence-based project verification systems (Jack and Walker, 2025).

These powerful data resources are complemented by advances in counterfactual estimation—the ability to estimate what would have happened in the absence of a project—which adds to the credibility of project evaluation (Angrist and Pischke, 2010). Analysts can estimate fine-grained counterfactuals using large-scale datasets, synthetic controls, and quantitative methodologies to determine what would have happened in the absence of a policy. Such data-driven counterfactuals can be integrated with economic models to analyze alternative policy scenarios and can ensure that project developers are fairly compensated for the additional reduction in carbon emissions they achieve.

Importantly, these methodological advancements extend beyond nature-based projects. Improved data integration and modeling capacity allow credible evaluation of renewable and industrial projects, ensuring that credit issuance represents the true net climate impact.

These new possibilities for project evaluation can be integrated with insights from financial markets, implementation science, and development economics to create contractual structures that mitigate project risks. Drawing on principles of risk pricing, diversification, and performance-based incentives, contracts can explicitly account for the uncertainty inherent in nature-based projects rather than exclude them from the market (see, for example, Jack, Jayachandran, Kala, and Pande, 2025). They can also account for uncertainty in program performance stemming from implementation concerns in lower income settings (Finan, Olken, and Pande, 2017). Ex-ante, project and implementation risks can be factored into initial permit allocations, so that permit prices reflect expected emission reductions after adjusting for the probability of reversal or non-additionality. Ex-post, monitoring and outcome-based adjustments can align project compensation with verified performance, rewarding projects that exceed expectations while penalizing those that fall short. Innovations along these lines include forest carbon offset protocols that require sellers to maintain a 'buffer pool' to insure against risks that may compromise durability (Anderegg et al., 2024).

Integrating these mechanisms—risk-adjusted allocations, verification on an ongoing basis, with frequency determined by project type, and outcome-linked compensation—allows the carbon market to incorporate a wider range of projects while maintaining environmental integrity. This approach converts uncertainty about the additional mitigation a project will achieve from an exclusion criterion to an attribute that can be priced and managed, resulting in a credible and inclusive market architecture that mobilizes capital for the most cost-effective and durable emissions reduction opportunities globally.

BOX 6

Advances in measuring, monitoring, and implementation

Accurate emissions measurement is central to any effective carbon policy. Recent innovations are facilitating a shift from the traditional, labor-intensive, and error-prone calculation-based method (CBM) to the continuous emissions monitoring system (CEMS), which provides real-time, high-precision data (Greenstone, Pande, Ryan, and Sudarshan, 2025). These measurement advances have been critical in a range of countries, such as India and China, in allowing regulators and citizens to accurately track emissions and to design and impose policies to ensure that firms are in compliance (Buntaine et al., 2024). Complementary technologies such as the Internet of Things (IoT), blockchain, machine learning, and remote sensing further enhance data accuracy, transparency, and reliability in environmental assessments. (Zou, 2021; Greenstone et al., 2022; Mu, Rubin, and Zou, 2024; Fowlie, Rubin, and Walker, 2019; Song et al., 2025; Ding et al., 2025).

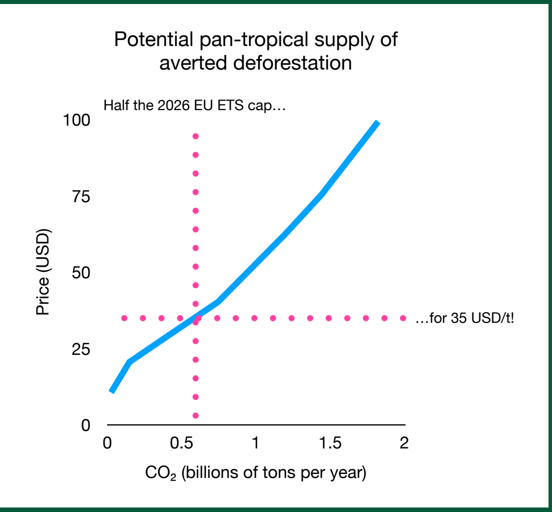
Satellite imagery, in particular, has become increasingly accessible at high resolutions, allowing for data collection at low marginal cost and simultaneously at large scale. Remote sensing data has already been effectively applied by researchers for monitoring purposes. Assunção, Gandour, and Rocha (2023) and Burgess, Costa, and Olken (2024) successfully used satellite-based data to track deforestation in the Brazilian Amazon.

Finally, in recent years, development economists have collaborated with government partners to conduct large-scale evaluations of governance innovations. Many successful evaluations were shown to be cost-effective, and several have since been scaled up by government partners (Duflo, 2017). Examples in environmental regulation include experimental evaluations of innovations that reduce conflict of interest by changing how auditors are assigned to firms and financed (Duflo, Greenstone, Pande, and Ryan, 2013), and changing the contract structure of payment for ecosystem contracts to include an upfront component to address liquidity and trust concerns (Jack, Jayachandran, Kala, and Pande, 2025).

BOX 7

The promise of including nature-based projects

Deforestation and other ecosystem destruction cause up to 20% of global excess carbon emissions: In 2023, global tropical primary forest loss produced 2.4 gigatonnes of CO_2e emissions, half of the United States' annual fossil fuel emissions (Weisse, Goldman, and Carter, 2024; Watson and Schalatek, 2020). Typically, the economic benefits of deforestation and other ecosystem destruction are low, compared to greenhouse gas released, so averting deforestation offers relatively cheap abatement opportunities. Griscom et al. (2017) consider nature-based projects that include conservation, restoration, and improved management practices in forest, wetland and grassland biomes and show that, as of 2016, these projects could provide over one-third of cost-effective mitigations needed through 2030 for a two-third chance of holding warming between 2 degrees C. More conservatively, Busch and Engelmann (2017) show that forest-based emerging market and developing economies projects alone could eliminate 0.6 billion tonnes of emissions—half of the entire EU ETS cap in 2026—at a maximum price of $35/tonne (net measurement, reporting, and verification costs), half of the current ETS permit price of $70/tonne. In other words, while the cheapest emissions cuts among EU participants cost $70/tonne or more, 0.6 billion tonnes of emissions could be averted at less than half that cost via nature-based projects in emerging market and developing economies.



IV.4. Market design for broader good

In recent decades, researchers have expanded their understanding of how markets work and developed a powerful 'market design' approach. Rather than simply analyzing existing markets, this employs an "engineering" approach by actively constructing rules, algorithms, and institutions that determine how buyers and sellers (or other economic agents) are matched and resources are allocated, so that incentives, information, and constraints align to produce good outcomes. This approach is particularly valuable when the production of goods traded in the market entails substantial externalities, either positive or negative. The aim is to achieve properties like efficiency, stability, fairness, and strategy-proofness, while handling practical issues such as transparency, and congestion, and enabling the market to support the public good.

These approaches have been applied to improve matching medical residency applicants with the optimal position in the United States (Roth, 1984; Roth and Peranson, 1999; Kojima, Pathak, and Roth, 2013), school choice policies that produce more better and more fair outcomes for families (Abdulkadiroğlu, Pathak, and Roth, 2005; Abdulkadiroğlu et al., 2006; Abdulkadiroğlu, Pathak, Roth,, 2009; and more recently Abdulkadiroğlu, Agarwal, and Pathak, 2017). The market design approach has also improved organ donation systems (Roth, Sönmez, and Ünver, 2004; Roth, Sönmez, and Ünver, 2005; Roth, Sönmez, and Ünver, 2007; and more recently Agarwal, Ashlagi, Azevedo, Featherstone, and Karaduman, 2019), and made anti-hunger efforts more effective (Prendergast, 2017). These insights were recognized in the Nobel Prize's 2012 award to Shapley and Roth. Economists, including us, have been applying these approaches to curbing pollution in India (see Box 4), and to setting up effective payment for ecosystem services systems for landowners in emerging market and developing economies (Kelsey, Jayachandran, Kala, and Pande, 2025; Izquierdo-Tort, Jayachandran, and Saavedra, 2024). The EU ETS is another example of a market designed to incorporate, among other features, principles of equity across participants.

IV.5. The EU ETS as an example of equity through allocation

Markets and exchanges can be designed to integrate broader social goals, such as equity. One example of this is how the EU ETS uses free permit allocations to balance environmental integrity with economic fairness. This is an example of a policy that ensures that a unified carbon market upholds the principle of common but differentiated responsibilities.

The EU ETS caps the total quantity of emissions and then distributes permits among participating entities, either via auctions or free allocations. The EU ETS initially relied heavily on free allocation, distributing permits based on historical emissions to ease the transition for industries and regions exposed to competitiveness risks. Over time, the share of permits auctioned has increased—reaching nearly 60% of total allowances in Phase IV (2021–2030)—yet free allocation continues to play a critical equity function (ICAP, 2025).

The free allocation of permits is strategically differentiated. Lower-income member states, such as Poland, Romania, and Bulgaria, receive a larger share of free allowances under the solidarity provisions of the EU ETS Directive, which recognize disparities in income levels, energy mix, and industrial structure across the Union. For example, Article 10c allows certain member states to allocate part of their emission allowances for free to the power sector, provided the equivalent value is reinvested in projects that modernize energy infrastructure and reduce carbon intensity. By tailoring the allocation of permits to reflect national circumstances, the EU has maintained broad participation across member states while progressively tightening its overall emissions cap.

The EU ETS experience thus provides a blueprint for equitable integration: it shows that free allocation of permits can be used as a structural instrument for fairness, enabling participation by economies at different stages of development. The same principle holds a global carbon market.

A unified system could build on the EU example by introducing differentiated allocation mechanisms that allow low- and middle-income countries to participate in an international compliance market without compromising their economic development. Under such a framework, free or preferential permit allocations could channel investment toward energy modernization and green industrialization within emerging market and developing economies. By combining environmental integrity (through an overall cap) and economic differentiation (through targeted free allocation) a unified carbon market has the potential to be both effective and politically resilient.

These five developments —(i) global expansion of compliance markets, (ii) the surge in clean energy innovations, (iii) advances in measurement, evaluation, and contract design, (iv) market design, and (v) achieving equity through permit allocations—can enable and expand the scale of a unified carbon market. This will enable considerably larger flows of the capital for decarbonization investments to enter emerging market and developing economies. This expansion in investment is critical both because these economies are suffering the biggest damages from climate change and because their emissions are growing at the highest rates (Adom, P. K., 2024; IEA, 2025). High income countries, in turn, will benefit from access to lower cost abatement opportunities than are available locally. Taken together these two forces benefit all countries via lower global emissions (see Box 8).

The two challenges that must be addressed for a unified carbon market to fulfill its promise are assuring the credibility of project types entering the market and ensuring scalability. We now describe how our market is designed to tackle these challenges.

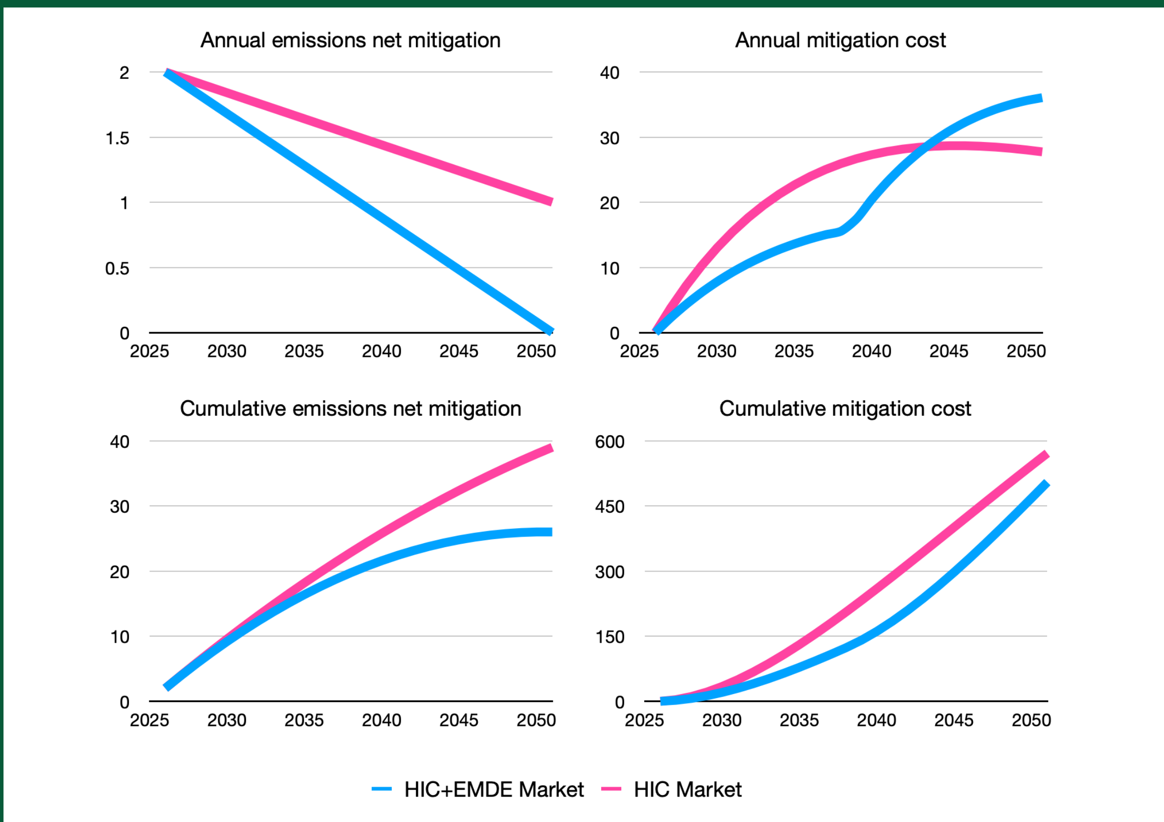
BOX 8

Market simulations to compare gains from unified carbon market

To illustrate the transition dynamics and potential efficiency gains from a unified carbon market, we simulate outcomes for a representative high-income and low-income economy under two scenarios: one where only the high-income economy participates, and one where both economies are included.

The results show that when both economies participate, cumulative global emissions fall more rapidly and at lower overall cost. Early investment flows to lower-cost mitigation opportunities in the low-income economy accelerate global decarbonization while channeling finance toward projects that restore ecosystems, expand clean energy, and strengthen resilience. As those opportunities are realized, mitigation shifts progressively toward higher-cost reductions in the high-income economy, ensuring that both decarbonize along a cost-efficient and equitable trajectory.

In this way, the unified carbon market is not about delaying abatement in richer countries—it is about achieving faster and broader global emissions reductions. By combining low-cost mitigation in developing regions with continued decarbonization in advanced economies, the system delivers a double dividend: speeding progress toward net zero and transferring resources to where they are most needed.



Assumptions and parameters of this simulation: the market covers high-income country firms that emit 10 gigatonnes CO_2e/year and optionally emerging market and developing economy firms that emit 5 gigatonnes CO_2e/year in 2025, firms are initially allocated tradable permits equal to their 2025 emissions, mitigation costs in high income country are 100 USD/tCO_2e, and in emerging market and developing economy are 30 USD/tCO_2e in 2025, mitigation costs fall 5% annually, and permits are tapered to achieve zero emissions for the combined market in 2050. The website for this report (noted on the cover) will contain an interactive version of this model with changeable parameters for testing different assumptions.

V. The Promise of Markets to Address Scalability and Credibility

The goal is to establish a unified carbon market that functions as a compliance market that reduces emissions efficiently and equitably while paving the path for global net zero. The unified carbon market seeks to achieve this by including industrial, renewable, and nature-based projects and linking compliance markets across jurisdictions. To achieve this, two major challenges need to be faced: credibility and scalability . Below, we describe these challenges and explain how specific aspects of the proposed unified carbon market will address them.

V.1. How MARVIN ensures credibility

This section deals with the details and financial structure of the contracting, accounting, and market design requirements of a market that reliably and durably reduces emissions.

A credible emissions avoidance, reduction, and removal project is one that results in additional and durable emissions reductions (see Box 9). If all emission reduction projects within the unified carbon market are additional and durable, the market as a whole can be deemed credible. When a participant in a carbon market buys a permit, they buy the right to emit one tonne of CO_2e within the permit's validity period. Conversely, when a market participant sells a permit, they give up this right and must reduce their emissions accordingly. A carbon market can efficiently channel finance toward the lowest-cost abatement options when CO_2e permits traded in the market represent a single, transparent and agreed upon product.

Under the status quo, renewable energy and nature-based projects are largely excluded from compliance markets due to challenges in guaranteeing that emissions reductions generated by such projects are credible. Developers of these projects are left to seek funding from VCMs, and when they do, the projects are typically small and fragmented. This undermines their ability to make transformational decarbonization investments, such as grid expansion to facilitate renewables integration, or forest restoration across large areas.

Under our proposal, the unified carbon market would include credible industrial projects alongside renewable energy and nature-based projects to allow investments in the most efficient forms of abatement at scale. The structural aspects of the market, as described below, will seek to ensure that all permit sales within the market represent credible emissions reductions, giving the overall market credibility. This will facilitate the funding of large-scale, transformational abatement projects by improving confidence among market participants that their investments will achieve the long-term climate benefits they expect (Macintosh et al., 2025).

BOX 9

Additionality, Durability, and Risk

PROJECT ADDITIONALITY

What it means: A project's emissions reductions, avoidances, or removals are 'additional' if they would not have occurred without the funding given to enable the project.

Why it matters: A market participant who buys a permit in the market acquires the right to increase their carbon emissions by one tonne. To be consistent with the market goal of maintaining an emissions cap, the permit seller must lower their emissions by the same amount, over and above the reductions that the regulator forecasts they would have achieved without the permit sale proceeds. These 'additional' emissions reductions prevent permit trading from exceeding the market's overall emission cap.

Examples of additionality:

- In a Payment for Ecosystem Services program to prevent deforestation, emissions reductions are additional if the CO_2e tonnes not emitted due to changes in participants' behavior, are driven by the financial incentives provided to stop deforestation.
- In a renewable project, emissions reductions are additional if the avoided CO_2e tonnes resulting from buyers' decision to transition from fossil fuel to renewable sources, are due to incentives of the program.

DURABILITY

What it means: durability refers to the length of time that the [mitigation] project or program causes emissions to remain out of the atmosphere.

Why it matters: when a market participant buys a permit, they buy the right to increase their carbon emissions. For this to be consistent with the goal of global net zero, the seller of the permit must reduce their emissions beyond the duration of the market trading period. If mitigation merely delays emissions, so that a permit sale in one period leads to higher emissions in future periods beyond the market lifetime, then staying within the market's total emissions cap may be insufficient to attain global net zero.

Durability vs. permanence: Some favor the concept of 'permanence' over durability. This preference is based on a rigid "like-for-like" accounting, which requires permanence or millennial scale removals to offset fossil carbon emissions. Quadri et al. (2025) discuss why climate action should prioritize durability: nature-based projects, such as forest restoration, soil carbon enhancement, and avoided ecosystem conversion, can deliver gigatonne-scale mitigation now while providing biodiversity, water, and social co-benefits. Excluding projects due to imperfect permanence forfeits up to 13 gigatonnes CO_2e of annual mitigation potential and risks destabilizing natural carbon sinks, which absorb nearly half of the annual fossil fuel industry carbon emissions.

RISK

What it means: In the context of an opt-in global cap-and-trade market which includes emissions reduction, avoidance and removal projects it includes:

Project-level:

- ***(i) Exogenous risk:*** is the risk that projects are exposed to and cannot be controlled by developers. It can be aggregate (climate risk, risk of flood, etc) or idiosyncratic (tree disease).
- ***(ii)Endogenous risk:*** is the risk arising from developer behavior in a setting with asymmetric information, where MARVIN and the regulator have less project information than the developer. This encompasses risks arising from developer behavior including lack of effort to ensure durability (moral hazard) and outright misconduct resulting in project non-additionality (adverse selection) (Aspelund and Russo, 2025; Chen, Ryan, and Xu, 2025).

Jurisdiction-level:

Attrition risk: is the risk of jurisdictions, individual developers or individual company ex-post withdrawal from the market, while in violation of rules set by MARVIN.

Why it matters: Project credibility depends on managing this risk such that the project delivers the expected additionality and durability and this is reflected in the permit price.

V.1.a. Risk management via conservative ex-ante permit allocation and ex-post monitoring

It is common for contracts to have provisions to protect buyers should the seller fail to deliver. For the most part, buyers of credits for nature-based or renewable projects through the VCM or Article 6 hold all the risk should a nature-based project fail to deliver on its promise—and need to invest significant effort to evaluate this risk before buying. Under the proposed system, MARVIN would mitigate buyer risk (see Box 9), and together with the regulator, price in remaining risk through conservative issuance of permits to emit. A key feature of this unified market is that a permit for 1 tonne of CO_2e is a permit for 1 tonne of CO_2e, and once issued, the buyer no longer holds any residual risk from any particular project or seller.

MARVIN will design contracts to manage various risks that are described in Box 9 and can undermine the credibility of emission reduction projects. It will rigorously assess and incorporate these risks into project price, through the number of permits issued to a project, enabling their inclusion in the market. This approach recognizes that relatively risky projects are frequently the most cost-effective abatement options, even after accounting for the necessary risk adjustment. We propose implementing risk adjustment using a combination of three methods.

1 Monitoring and ex-post monetary penalties The first risk management strategy, specifically targeting endogenous risk of asymmetric information due to (ex-ante) adverse selection and (ex-post) moral hazard, is ex-post monitoring and fines. Conservative ex-ante baseline calculations can inform initial additionality estimates (as outlined in Core Carbon Principles of ICVCM, which set forth guidelines for identifying high-quality carbon credits (ICVCM, 2024). However, recent research highlights that ex-post evaluations are essential for robust additionality estimates (Appendix 3). This necessitates contractual structures that guarantee that ex-post additionality assessments impact project compensation: if a project achieves a greater reduction in emissions than their ex-ante permit allocation, they should be rewarded, while if they achieve a smaller reduction in emissions, they should incur a penalty.

The specific contractual structures that can incorporate such ex-post assessment will vary depending on the project category. To clarify ideas, we describe how the contract structure might work in the instance of land-use projects. We

follow Hardstad (2025) who shows that structuring contracts as loans with repayment terms tied to project performance can incentivize developers' to maintain investments in project success over time, thereby mitigating misbehavior by project developers. Initially, an upfront loan is advanced in the form of free permit allocations. The loan value is established based on estimated permit price and a conservative baseline assessment of the emission reductions anticipated from the project. In subsequent periods, permit allocation is adjusted based on the carbon abatement the project delivers, measured using pre-specified methodologies. If the carbon abatement is identical to ex ante predictions then permits would not be adjusted (this is equivalent to the loan repayment being set to zero). If it is lower, the developer has to buy permits that equal the value of loan repayment that is due. If it is higher, the project will receive a financial reward in the form of additional free permits, the value of which will be added to the project's loan.

2 **Derisking through diversification**: By bundling multiple projects together, the idiosyncratic risks associated with each can be diversified. This includes idiosyncratic exogenous risk (e.g., tree disease) and endogenous risk reflecting developer behavior. Bundling projects and issuing permits against the group of projects allows expected emissions to be assessed collectively rather than separately, reducing risk.

3 **Pricing the residual risk:** The final risk adjustment is via direct "risk-pricing" of projects. In this step we price the aggregate, uninsurable and any residual idiosyncratic risk. The ex-ante number of permits allocated to a project will be based on a conservative estimate of the "expected" emission reductions associated with the project. The expectation will be established by incorporating the probability of adverse exogenous outcomes (realization of aggregate and idiosyncratic exogenous risk) and their impact on the project's emission reduction capacity. The expectation can be further refined by also incorporating ex-ante estimates of the probability that the given project is not additional.

Determining initial permit allocation in this manner will, in effect, result in a lower allocation than if risks were not accounted for. This will translate into a lower supply of permits within the market and, by consequence, an increase in the permit price. It is because of this mechanism—lower permitting causing higher market prices—that we use the term "risk-pricing". Note that the market will continue to have a single market clearing price.

Precise estimation of the "expected" emission reductions is essential for the market to align as close as possible to the target annual emission reductions, despite the subsequent realization of various risks.

> "The lack of upfront financing is likely to act as an entry barrier to projects in many emerging market and developing economies."

The novel combination of ex-ante baselining with ex-post verification has only recently become possible because of an increasing availability of data that allows for estimation of accurate counterfactual emissions.

One consequence of linking ex-ante baselines with ex-post audits to manage risk is that final payment to a project developer will be uncertain at the outset of a project. As a result, projects with highly uncertain results, and therefore prospects for profitability and ability to obtain financing, may fail to enter the market. Such selection is desirable from the perspective of meeting market net zero targets, as long as it is due to true underlying differences in project uncertainty rather than, for example, differences in market participants' understanding of the market structure.

Conversely, if jurisdictions (and project developers) have deep financial pockets then it may be desirable to entirely base permit allocations on ex-post metrics (Aldy and Halem, 2024). The lack of upfront financing, however, is likely to act as an entry barrier to projects in many emerging market and developing economies. To ensure that high-value projects from emerging market and developing economies can enter the market, we favor contracts that include a portion of up-front financing.

V.1.b. Managing durability risk using collateral

Another risk to the long-term durability of the market is the risk of attrition on the part of buyers or developers.We propose managing attrition risk, by mechanisms such as requiring participating jurisdictions and companies to post collateral as a condition of market participation. The requirement of the collateral would be that it should be easily seizable in an international setting. Viable options include sovereign bonds and cash. If a participant subsequently exits the market, they would forfeit their collateral. Other internationally enforceable means, such as fines enforced through jurisdictions and collectible by MARVIN, could be used as well, for example on buyers who do not pay. The proceeds from forfeited assets or fines would provide a source of finance that could be used to undertake emissions reduction activities equivalent to those the previously participating entity had committed to. If a project developer decides to exit the market and increase emissions, any permits sold by the developer in the past no longer represent a durable emissions reduction. This is similar to, but distinct from, how we manage ex-post risk in that it is a condition of market participation rather than how the payment structure for a nature based project is designed.

To manage country attrition, we would rely on CBAM-like cross-border taxes. In particular, countries that drop out of the market will be subject to import and export restrictions from other participating countries (GCPP Working Group on Climate Coalitions, 2025).

V.1.c. Fostering market credibility via transparency

Markets can only function well with transparent governance, including both institutions and contracts, making MARVIN's transparency critical to market credibility. MARVIN will centralize project crediting, rather than dispersing it across a series of registries, ensuring that reductions are correctly accounted for in countries' nationally determined contributions, and eliminating double-counting concerns (as discussed in greater detail below). It will adopt a set of robust carbon accounting methodologies that cover different project types. Each methodology will include:

i) Complete Physical Accounting: Measures physical carbon emissions, input-by-input, through credible measurement methodologies and tracks the transmission of carbon content through the supply chain so that the carbon content of all final goods are precisely calculated and recorded as a function of the composition of intermediated inputs. It will account correctly both for removals projects, that reduce the stock of carbon in the atmosphere, and emission reduction and avoidance projects, that reduce the flow of carbon into the atmosphere.

ii) Financial Book Accounting: Translates physical liability (the tonnes of CO_2e emissions assigned to an entity) to abatement liability (the abatement cost per carbon tonne)

iii) Determination of Incidence: Assigns emissions liabilities to individual market participants in a consistent way, avoiding double counting across value chains. This will determine the total abatement cost that each entity along the supply chain is responsible for, per unit of final good.

iv) Implementation: The most effective way to achieve the incidence, for instance through carbon taxation.

MARVIN will have overall responsibility for the governance structures used for project monitoring and verification. Verifying additionality calculations and ensuring market participants' permit purchases cover their emissions requires monitoring. To eliminate conflicts of interest in monitoring, MARVIN would contract directly with third-party auditors and standardize payments to measure project performance over time. Research has shown that transferring auditor hiring decisions away from market participants, here project developers, aligns incentives for truthful reporting (see Giles and Coglianese, 2025). Importantly, the case of Gujarat, which changed how environmental auditors are paid and assigned to avoid conflicts of interest, demonstrates how collaborative research with policymakers can provide the evidence needed to successfully argue for policy reform (Duflo, Greenstone, Pande, and Ryan, 2013).

V.1.d Financing

We anticipate that MARVIN would be set up as a utility that in the long-run will be funded by market proceeds, ensuring its independence. In early phases, MARVIN financing could potentially come from market proceeds of the domestic compliance markets that are interested in implementing standardized protocols as a precursor to market link. It may also be feasible to charge fees from firms that opt-in to partially cover MARVIN costs.

This funding would cover several broad sets of costs, including the costs of long-term monitoring for the carbon impacts of emissions avoidance, reduction, and removal projects, the costs of monitoring project governance and investments in communities' clean growth paths, and the costs of maintaining insurance pools in the event of project reversals. Monitoring costs, for example, would entail hiring a pool of third-party auditors to monitor projects' long-term performance, backcheck auditor performance, and maintain data and AI tools for digital measurement, reporting, and verification.

V.2. How an Opt-in Global Compliance Market Ensures Scalability

International participation is crucial for building the scale required in the unified carbon market to achieve global net zero. The first step towards this is standardization of market protocols, including measurement, auditing, risk management and verification which MARVIN will ensure. This will enable the market to achieve the required scale by covering a wide range of project types and political jurisdictions. More diverse and comprehensive investment opportunities in a global market mean greater efficiency gains from connecting them to potential buyers via the unified carbon market. It is also crucial that the market include high income countries and emerging market and developing economies. The introduction of political jurisdictions as market participants is critical to the market's ability to scale. However, linking ETSs across jurisdictions is not straightforward, and emissions may 'leak' beyond the market unless it has comprehensive global scope (Clausing et al., 2024). Below, we outline how a unified international compliance market can overcome existing challenges to foster international participation.

V.2.a. Specifying eligible participants

First, countries with their own compliance markets will be able to link their market into the unified carbon market, once their measurement and accounting practices are standardized. While such interlinking is challenging, EU ETS has demonstrated its feasibility by successfully linking with the Swiss ETS and is now initiating linkage with the UK ETS (see Box 10). Second, in countries without a domestic compliance market, such as the United States, sufficiently large firms that are net emitters (as defined by sector share), will be able to apply for market entry.

Third, emissions avoidance, reduction, and removal project developers will participate. We anticipate requiring, or at the minimum strongly encouraging, project developers to enter via jurisdictions at the country or province level. We anticipate minimum project size restrictions to mitigate against leakage (discussed further below), and to ensure emissions reduction projects are backed by adequate resources to achieve credible emissions reductions. Political jurisdictions have the advantage of having the power to enforce contracts and also offer the best route to scale in the market.

BOX 10

Linking ETSs

On 23 November 2017, the EU and Switzerland signed an agreement to link their emissions trading systems. After it came to force on 1 January 2020, allowances issued in either ETS became usable for compliance in the other, demonstrating an example of an operational linkage between two carbon markets.

Recently, a prospective EU-UK linkage has entered the policy agenda. At the 19 May 2025 EU–UK summit, both sides signalled intent to work towards linking their emissions trading systems. The legal pathway advanced on 16 July 2025, when the European Commission recommended that the Council authorize negotiations (COM(2025) 408). Once authorized under TFEU Art. 218(3)–(4), DG CLIMA would open talks, with Parliament consent required to conclude. Both ETSs already cover power, energy-intensive industry and aviation; the EU added maritime-sector emissions in 2024, while the UK plans to include maritime emissions beginning in 2026. Linkage will require clear alignment on scope, ambition, and relevant financial-market rules, mutual recognition of EU and UK allowances, and registry interoperability (EUTL–UK registry), overseen by a joint committee with agreed dispute settlement and suspension/termination provisions. Once these markets are fully linked and the conditions in the EU CBAM Regulation 2023/956 are met, EU–UK goods would be exempt from CBAM obligations. Merging the EU and UK ETS markets would create a larger, more liquid market, reducing costs and driving investment into abatement-inducing technologies.

Another example of a successful linkage (on a subnational level) is the California–Québec ETS linkage, which commenced on 1 January 2014, creating the largest carbon market in the Americas. Since then, the programs have held regular joint auctions, supported by the Western Climate Initiative (WCI). Currently, Washington is pursuing linkage with California and Québec, with all three jurisdictions expressing mutual interest in the possibility. Linkage can also occur across jurisdictions at the sectoral level.

Finally, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) provides an example of a sectoral market spanning multiple countries. CORSIA is a global initiative that applies to the aviation sector, set to cover all international flights starting 2027.

V.2.b. Using permit allocation to ensure the market upholds common but differentiated responsibilities

The unified carbon market establishes the financial infrastructure for large-scale global decarbonization by bringing together high-income, emerging market, and developing economies. This market benefits high income countries by lowering overall mitigation costs compared to a compliance market that is restricted to high income countries. Emerging market and developing economies gain access to resources that would have otherwise been unavailable to invest in forest preservation and renewables. Similar to the EU ETS, where there is economic imbalance between countries within the market, the principle of common but differentiated responsibilities will be implemented by allocating a portion of permits as free allocations. These free allowances will generate revenue as they are sold within the unified carbon market, creating an incentive for emerging market and developing economy countries to join.

In addition, some high income countries participants may be allocated negative initial permit balances. These participants are effectively required to purchase permits in excess of their own emissions, which may be desirable in order to ensure the cost of investing in global decarbonization opportunities is shared among participants in accordance with the notion of common but differentiated responsibility.

Using initial permit allocations in this manner means that the unified carbon market has a great deal of flexibility in allocating abatement costs among participants. At one extreme, each participant is responsible for financing mitigation of their individual emissions (achieved via no free initial permits), while at the other, one participant is required to finance everything. An example of how this latter extreme could be achieved is given in Appendix 4. The exact distribution of initial allowances and, by implication, abatement costs cannot be determined up-front and will instead be negotiated among prospective participants at the outset.

V.2.c. Double counting

Where countries join this market, the system will work similarly to the EU ETS to prevent double-counting. Countries will establish their joint nationally determined contribution, as EU countries do, and the market mechanism will ensure that countries move together towards the joint target. This eliminates the necessity for Article 6.2 trades among nations within the market, similar to the EU ETS. The market cap will reduce over time to ensure that market participants reduce emissions in line with global net zero.

We propose that the entity that joins the market, whether it is a jurisdiction, a firm or a project developer, be removed from a country's nationally determined contribution accounting entirely (this does not mean the removal can be shown as a reduction—it is removed from both baseline and commitments). Instead, it follows the same trajectory and shared nationally determined contribution as a unified carbon market.

V.2.d. Leakage and minimum scale requirements

Because participation in the unified carbon market is voluntary, it is likely that only some jurisdictions and firms will opt-in. Partial market coverage raises the risk of emissions 'leakage' beyond market participants. For example, at the industry level, if only a portion of firms opted into the market and passed on the cost of compliance to customers through higher prices, non-

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participating firms' market share would increase as customers favor their relatively low prices. Thus, while the emissions of participating firms would fall due to the market's functioning, the emissions of the sector as a whole would not fall as much and could even remain unchanged in extreme cases. Similarly, at the jurisdictional level, if economic activity shifts away from participating jurisdictions, it undermines the market's ability to contribute to global net zero.

Scale is an excellent approach to reducing leakage. The wider the geographical and sectoral scope of the carbon market, the less likely it is that a jurisdiction outside of the market may replace activities previously undertaken by market participants. This is why we are promoting linkage between the growing number of ETSs run by political jurisdictions at the primary and most essential step toward the development of a unified carbon market. As a result, it is always preferable for jurisdictions to enter the market rather than individual projects or firms, and for countries to enter the market instead of sub-national jurisdictions.

Inter-jurisdictional leakage is also mitigated by the increased use of carbon border adjustment pricing. This offsets differences in carbon prices across countries and thereby acts to reduce international relocation of economic production due to some, but not all, countries participating in the unified carbon market. To reduce leakage among firm participants, we anticipate that the market regulator will place minimum size requirements at the sector level, reducing the likelihood that reduced emissions by participating firms are offset by higher emissions by non-participants.

Finally, leakage over time is possible where an emissions activity resumes with increased intensity after being prevented for a period by an emissions reduction project. This is particularly an issue where, for example, projects to prevent deforestation target very well for additionality; our analysis shows that, if economic conditions remain exactly the same post-project, rates of deforestation increase post-project compared to pre-project, and over the same length of time as the project lasted, overall emissions trend back up to the previous baseline. We propose to avoid this phenomenon both by creating financial incentives to extend protection beyond the length of the market, and by ensuring that investment of project income creates cleaner economic pathways to replace deforestation or other ecosystem destruction.

We anticipate that creating a unified carbon market at scale will be a multi-year effort involving several phases, and below we propose one potential pathway to scale.

VI. Conclusion: The Path Ahead

VI.1. Phase in-implementation

We propose a phase-in design to build towards a full-fledged unified carbon market that operates at scale, generates robust demand for credible emissions avoidance, reduction, and removal projects, and enables significant financial flows towards emerging and developing economies.

Phase 1: Jurisdictional sandbox for market compatibility & MARVIN establishment

The first phase would build on political momentum created by the wide range of countries and regions who have implemented or are developing carbon compliance markets (GCPP Working Group on Climate Coalitions, 2025). We hope to work with at least two compliance markets that will be Oused as sandbox with three goals. First, develop protocols on how to include industrial, renewable and nature-based emission avoidance and removal projects on equal terms in the domestic market. This is to identify the mechanics of how the market can sustain trade in a single product (permits/allowances) with a single market clearing price. Second, identify the protocols that will be needed to link markets, especially across high-income and emerging market and developing economies. Finally, the roles of the overall market regulator will also be identified.

The aim of the sandbox phase is to demonstrate the viability of a unified carbon market and identify regulatory apparatus needed at the jurisdiction level. In order to scale the market, MARVIN must be established with an international legal framework. This includes determining its governance structure and physical location (e.g., as a new UN body or an independent non-governmental organization), defining its exact interaction, if any, with existing bodies like the Article 6.4 supervisory body, and incorporating expertise from VCM reform groups (ICVCM, SBTI, VCMI, ISO) to ensure the adoption of best practices. Alongside, we will identify how the market regulator position will be structured and relation to MARVIN.

Phase 2: Linking existing compliance markets and participants

The next step will be to work with administrations in both high income and emerging market and developing economies who have implemented, or who are considering implementing, compliance markets to identify the full set of conditions under which linking may be feasible. This will build on our learnings from phase 1. Here we will also examine how to construct mechanisms for transfers, based on the EU ETS' success in redistributing free permits to economically weaker countries. We will also initiate discussions with large net emitter firms who are "good buyers" to understand how to structure their joining the carbon market as a long-term commitment. This research will inform the structures we test in the sandbox market.

Phase 3: Scaling

Scaling the market will require incorporating existing compliance markets that are ready to participate. The global market regulator will collaborate with domestic market regulators to allocate permits, establish an overall cap, and determine noncompliance penalties.

Voluntary participation in the market will be driven by the credibility of emissions avoidance, reduction, and removal projects and market transparency and this will be key to scaling a unified carbon market. Underlying forces driving such participation include jurisdictional need to comply with international arrangements like CBAM and reputational benefits for large net emitter firms in jurisdictions that lack compliance markets.

VI.2. Final thoughts

With the plethora of low-cost investment opportunities in emerging markets and developing nations that are stalled by a lack of financing, a single carbon market supported by MARVIN can unlock the capital needed to enable decarbonization investments on a significantly wider scale than is currently conceivable.. These include projects that deploy cleaner industrial processes, expand renewable energy and restore or conserve natural ecosystems that store carbon.

For emerging markets and developing economies, the unified market means new sources of funding for the emission avoidance, reduction, and removal projects, regardless of type, backed by the assurance of strong measurement. The unified carbon market will accelerate investment in industrial emissions reductions projects, clean energy infrastructure and nature-based solutions therefore helping to power the sustainable growth needed to raise living standards and to provide resilience to climate change. It implies decarbonization on a scale that is simply unachievable at the moment which is essential as these are the economies where emissions are growing most quickly.

> "This report along with the others that have been commissioned by the Economics Advisory Group to the COP30 President Andre Correa do Lago represent steps in this direction. There is still much road to travel but, as a team, we are committed to work with a host of collaborators from across the world to make a unified carbon market a reality. Few endeavours can be more important."

For high-income countries the proposed unified carbon market, which guarantees emissions reductions via a combination of standardized measurement, incentives for truth-telling, and the incorporation of measures to remove risk, will allow them to access lower-cost abatement opportunities than are available in their domestic markets. This is important as though many high-income countries have already begun industrial decarbonization the costs of further domestic reductions are rising as the lowest-cost opportunities are exhausted. The unified carbon market would enable them to fund decarbonization in emerging market and developing economies, at lower cost and at a greater scale than is feasible without the market, giving time for technological progress to reduce costs of further abatement at home. This, combined with declines in the unified carbon market's cap, would drive down global emissions and thus contribute to reaching net zero.

The central policy challenge of this century is reducing global emissions to safe levels. So far, emissions remain stubbornly high, and a growing body of evidence confirms rising damages to people and the natural environment. Status quo domestic and international policy simply will not offer a glide path to global net zero. We therefore require fundamental change in global action. This report along with the others that have been commissioned by the Economics Advisory Group to the COP30 President Andre Correa do Lago represent steps in this direction. There is still much road to travel but, as a team, we are committed to work with a host of collaborators from across the world to make a unified carbon market a reality. Few endeavours can be more important.

VII. Appendix

VII.1. Appendix 1: Global Offset Credit Eligibility in ETS and Sectoral Programs (September 2025)

MARKET	TYPES OF OFFSETS ALLOWED	ELIGIBLE OFFSET METHODOLOGIES/ QUALITATIVE CRITERIA	QUANTITATIVE LIMIT (% OF COMPLIANCE)
Jurisdictional (national)			
Australian Safeguard Mechanism (post 2023 reforms)	Australian Carbon Credit Units (ACCUs) issued under the domestic offset scheme.	Projects credited by the Clean Energy Regulator, include those associated with vegetation management, agriculture, forestry, energy consumption, waste, transport, industrial processes.	None.
Brazilian ETS (under development) (approved 2024)	Domestic credits which obtained the Verified Emissions Reduction or Removal Certificates (CRVE); verification performed by an independent entity.	Methodologies accredited by the Brazilian Greenhouse Gas Emissions Trading System (SBCE) management body (to be determined).	The use of CRVEs against compliance obligations will be determined as part of each National Allocation Plan.
Canada Federal Output-Based Pricing System (OBPS) (2019)	Two types of credits: recognized units (issued by a province or territory under a recognized offset program and offset protocol and meet the requirements under section 78 of the OBPS) and federal GHG offset credits (issued under Canada's GHG offset credit system).	Recognized programs: Alberta Emission Offset System (protocols: aerobic composting, aerobic landfill bioreactor projects, GHG reductions from pneumatic devices, reducing GHG emissions from fed cattle, selection for low residual feed intake in beef cattle), British Columbia Greenhouse Gas Emission Offset System (protocol: B.C. Forest Carbon Offset).	At least 25% of the compensation for an entity's excess emissions must be in the form of an excess emissions charge (EEC) payment.
Canada National Cap-and-Trade System for Oil and Gas Emissions (under development) (planned to be phased in starting 2024)	Domestic offset credits.	The Department of the Environment would establish a list of carbon pricing systems where cross-recognition of Canadian offset credits is authorized. The use of offsets under these systems must meet the following conditions: offset credits must be used for compliance within the designated year of the three-year period; offset credits must be applied to emissions from activities in the same province or territory as the operator's facilities; offset credits must be used for standard compliance requirements, not extraordinary situations like canceled credits or penalties.	Up to 20% of the operator's remittance obligation (includes both decarbonization units and offset credits).
China National ETS (2021)	CCER (China Certified Emission Reduction), relaunched in 2024.	Forestation, mangrove cultivation, solar thermal power, grid-connected offshore wind power, coal mine gas utilization, energy saving in highway tunnel lighting projects. Four more methodologies are planned to be added.	Covered entities may use CCERs from projects not covered by the national ETS to meet up to 5% of their annual compliance obligation.
Indonesian Economic Value of Carbon Trading Scheme (2023)	Domestic SPE-GRK (Sertifikat Pengurangan Emisi Gas Rumah Kaca) or equivalent, issued on the national registry.	Mitigation activities: new and renewable energy power plants, new and renewable energy power plants, or other activities in the energy sector.	None.

K-ETS (South Korea) (2015)	Korean Offset Credits (KOCs) and international credits (subject to qualitative criteria).	292 registered methodologies: 211 for Clean Development Mechanism (CDM) and 81 for domestic offset credits. Qualitative criteria for international credits: at least 20% of the ownership rights, operating rights, or the voting stocks were owned by a Korean company or a Korean company supplied low-carbon technology worth at least 20% of the total project cost.	Up to 10% of each entity's compliance obligation, of which up to 5% can be international offset credits.
Kazakhstan ETS (2013)	Domestic offset credits approved by the Ministry of Ecology and Natural Resources.	All sectors (GHG reduction or absorption activities) outside the scope of the ETS are allowed; Intergovernmental Panel on Climate Change (IPCC) methodologies and rules developed by the ministry.	None.
Mexico Pilot ETS (2020)	Two domestic mechanisms allowed: current offset credits and early action (offset credits before the pilot).	Under development. Domestic projects that have been validated and verified under internationally or domestically recognized protocols will be eligible. The Secretariat of Environment and Natural Resources (SEMARNAT) will establish a domestic program for the generation of credits.	Up to 10% of each entity's compliance obligation.
Turkish ETS (under development) (pilot launch planned for 2026)	Domestic offset credits.	The Climate Change Directorate will establish a national carbon crediting and offsetting system.	Up to 10% of the total surrender obligation.
Vietnam Pilot ETS (2025)	Both domestic and international credits.	Projects under the CDM transitioning to Article 6.4 of the Paris Agreement, bilateral mechanisms such as the Joint Crediting Mechanism (JCM) with Japan, other programs aligned with Article 6 of the Paris Agreement.	Up to 30% of each entity's compliance obligation. Entities may also borrow up to 15% of allowances from future allocation periods to meet current compliance obligations.
Jurisdictional (subnational)			
Alberta Technology Innovation and Emissions Reduction Regulation (2020)	Alberta-based emissions offset credits.	Credits must meet criteria set in the TIER Regulation.	Set up to 60% of each entity's compliance obligation in 2023, increasing by 10 percentage points annually until it reaches 90% in 2026.
Beijing pilot ETS (2013)	Domestic CCERs and Beijing Certified Emission Reduction (BCER) credits.	CCERs. Eligible BCERs projects: green architecture, low-carbon transportation, landscaping, renewable energy and energy saving. CCERs issued under the old CCER scheme are no longer valid from 2024. No qualitative limits on new CCERs issued after January 2024 under the new scheme.	Up to 5% of the annual emissions, of which at least 50% must come from projects within Beijing.
British Columbia Output-Based Pricing System (2024)	Offsets from B.C. projects approved through an eligible protocol under Greenhouse Gas Industrial Reporting and Control Act (GGIRCA), then validated and verified through the B.C. Carbon Registry.	Approved protocols: carbon capture and sequestration, forest carbon offset, methane from organic waste. Offset units must be generated within three years of the beginning of the compliance year.	Up to 40% of the compensation, reducing to 30% from 2026 to 2030.

California Cap-and-Trade (2012)	California Air Resources Board (CARB) offset credits (domestic) and international credits from Québec by Western Climate Initiative (WCI) linkage.	Protocoles: livestock (2011, 2014), mine methane capture (2014), ODS (2011, 2014), rice cultivation (2015), U.S. forest projects (2011, 2014, 2015), urban forest (2011).	The share of offsets that can be used by an entity to fulfill its compliance obligation is 4% per year for 2021 to 2025 emissions, and 6% for 2026 to 2030 emissions. No more than 50% of any entity's offset usage limit can come from offset projects that do not provide direct environmental benefits to the state (DEBS).
Chongqing pilot ETS (2014)	Domestic CCERs and Chongqing Certified Emission Reduction (CQCER) credits.	CCERs; credits from hydro projects are not allowed.	Up to 5% of an entity's compliance obligation.
Fujian pilot ETS (2016)	Domestic CCERs and Fujian Forestry Certified Emission Reduction credits (FFCERs).	Credits generated in Fujian province from non-regulated entities and from CO2 or CH4 reduction projects. Credits from hydro projects are not allowed. FFCER project types: afforestation, forest management, and bamboo management, if implementation took place after mid-February 2005 and if the project developers have independent legal status.	Up to 5% of the annual compliance obligation; the limit is increased to 10% for companies that use both FFCER and CCER offset credits.
Guangdong pilot ETS (2013)	Domestic CCERs and Tan Pu Hui Certified Emission Reductions (PHCER).	Pre-CDM credits, offset credits from hydropower and from most fossil fuel projects, as well as credits generated in other Chinese ETS pilot regions are not eligible. To be eligible, projects must relate primarily (more than 50%) to the reduction of CO2 or CH4 emissions.	Up to 10% of covered entities' annual emissions, of which at least 70% must come from within Guangdong province.
Hubei pilot ETS (2014)	CCERs.	CCERs must come from rural biogas or forestry projects in the key counties under the national or provincial poverty alleviation plan in areas of the middle reaches of the Yangtze River (within Hubei).	The use of CCERs/Wuhan city credits is limited to 10% of the annual initial allocation for each entity.
Oregon - Climate Protection Program (CPP) (2025)	Community Climate Investment (CCI) credits.	Community projects that reduce anthropogenic GHG emissions in Oregon.	First compliance period (2025 to 2027): 15%. Second compliance period (2028 to 2029): 20%.
Québec Cap-and-Trade (2013)	Domestic and international offset credits from California (WCI linkage).	Project types: reclamation and destruction of methane from landfill sites, destruction of halocarbons, carbon sequestration through afforestation or reforestation on private lands, and anaerobic digestion of manure. For a transitionary period, projects in other categories (destruction of methane) remain eligible. Other types are under consideration.	Up to 8% of each entity's compliance obligation.
Regional Greenhouse Gas Initiative (RGGI) (2009)	RGGI states offsets. Phasing out: from 2027 onwards, new offset allowances will not be issued.	Categories: landfill methane capture, sulfur hexafluoride, forestry or afforestation, end-use efficiency, avoided agricultural methane.	Up to 3.3 % of a power plant's compliance obligation.

Saitama Target Setting ETS (2011)	Five types of credits: small and mid-size facility credits, outside Saitama credits, renewable energy credits, Tokyo credits (via link), forest absorption credits.	Verified emission reductions from non-covered small and medium facilities within Saitama Prefecture, reductions from large facilities outside Saitama Prefecture with base-year emissions of 150,000 tCO_2 or less and energy use of at least 1,500 kL of crude oil; renewable energy projects (Environmental Value Equivalent, Renewable Energy Certificates, and New Energy Electricity, generated under the Renewable Portfolio Standard Law), projects that generate solar (electricity or heat), wind, geothermal, hydro (under 1 MW) electricity production or credits from biomass (biomass rate of 95% or more, excluding black liquor) are converted on a one-to-one basis; Tokyo credits via link; forest absorption credits (within and outside of Saitama Prefecture with factors 1.5 and 1 respectively).	Only for Outside Saitama credits: they can be used for compliance for up to one-third of offices' reduction obligations; factories can use up to 50%.
Shanghai pilot ETS (2013)	Domestic CCERs and provincial offset Shanghai Carbon Emission Reduction (SHCER) credits.	CCERs. Offset credits for reductions before January 2013 could not be used for compliance; credits from hydro projects are not allowed.	Up to 5% of each entity's compliance obligation.
Shenzhen pilot ETS (2013)	Domestic CCERs, Tan Pu Hui local offset credits, and other offset credits authorized by the local government.	CCERs. Credits from hydro projects are not allowed; geographical restrictions to the use of certain CCERs and local offset programs.	Up to 20% of the shortfall in compliance obligation.
Tianjin pilot ETS (2013)	Domestic CCERs and Tianjin regional forestry offset credits.	CCERs. Credits from CO2 reduction projects, excluding hydroelectric power plants. The emissions reductions must have occurred after 2013.	Up to 10% of the annual compliance obligation.
Tokyo Cap-and-Trade (2010)	Four types of offset credits: small and mid-size facility credits from non-covered facilities in Tokyo, outside-Tokyo credits from large facilities meeting the specified emissions thresholds, renewable energy credits, and Saitama credits (via link).	Verified emission reductions from non-covered small and medium facilities within Tokyo; reductions from large facilities outside Tokyo with base-year emissions of 150,000 tCO_2 or less and energy use of at least 1,500 kL of crude oil; renewable energy projects (Environmental Value Equivalent, Renewable Energy Certificates, and New Energy Electricity, generated under the Renewable Portfolio Standard Law), projects that generate solar (electricity or heat), wind, geothermal, hydro (under 1 MW) electricity production or credits from biomass (biomass rate of 95% or more, excluding black liquor) are converted on a one-to-one basis; Saitama credits are accepted from excess reductions at qualifying Saitama facilities.	Only for Outside Tokyo credits: these are issued only for the reduction amount that exceeds the compliance factor; can be used for up to one-third of facilities' reduction obligations.

Washington Cap-and-invest Program (2023)	Domestic offset credits.	Projects: livestock, ozone depleting substance, US forest, urban forestry.	First compliance period (2023 to 2026): up to 5% of an entity's compliance obligation from projects not located on federally recognized tribal land, additional 3% from projects located on federally recognized tribal land. Second compliance period (2027 to 2030): up to 4% from projects not located on tribal land, additional 2% from projects located on tribal land.Third compliance period and beyond (2031 -): up to 4% from projects including those located on tribal land, additional 2% from projects located on tribal land.
Sectoral			
CORSIA (2021)	International offsets; International Civil Aviation Organization (ICAO)-approved eligible emissions units.	Programs that meet ICAO's eligibility: American Carbon Registry (ACR), Architecture for REDD+ Transactions (ART), Climate Action Reserve (CAR), Global Carbon Council (GCC), The Gold Standard (GS), Verified Carbon Standard (VCS).	None.

VII.2. Appendix 2: EU ETS Additionality Evaluations using Counterfactuals

PAPER	COUNTRY	SECTOR	PERIOD	METHOD	DATA	MAIN RESULT
Bayer and Aklin (2020)	25 EU member states	All	1990-2016, with 2005 and 2008 as two alternative regulation starting dates	Generalized synthetic control method, with counterfactuals for ETS-covered sectors estimated from non-ETS sector emissions.	Sector-level	Reduction between 8.1 and 11.5% against the counterfactual (1.2 billion tonnes between 2008 and 2016).
Colmer et al. (2025)	France	Manufacturing	1996-2012, including pre-policy years (1996-2000), the announcement period (2001-2004), and ETS trading phases I (2005-2007) and II (2008-2012)	Matched difference-in-differences (DiD) comparing regulated with unregulated control firms matched within sector along multiple dimensions using nearest neighbour.	Firm-level	The EU ETS led to a 14-16% reduction in CO2 emissions among regulated firms during Phases I and II, with no detectable decline in output, employment, or value added. No evidence of outsourcing to unregulated markets; instead, firms made targeted investments, reducing the emissions intensity of production.
Dechezleprêtre,	France, Netherlands, Norway, and the United Kingdom	Energy and Manufacturing	2005-2012	Matched difference-in-differences (DiD), comparing ETS and non-ETS entities before and after the EU ETS started.	Firm-level	The EU ETS was associated with a statistically significant reduction in carbon emissions of approximately 10% between 2005 and 2012. Results suggest that more stringent allocation of free allowances creates stronger incentives for emissions reduction.

VII.3. Appendix 3: Ex-post Evaluations of Voluntary Trading Mechanisms

METHOD	PAPER	SCOPE
Synthetic control	West, et al. (2023)	26 REDD+ projects in 6 tropical countries (Peru, Colombia, Democratic Republic of Congo (DRC), Tanzania, Zambia, and Cambodia)
	West et al.	12 REDD+ projects in the Brazilian Amazon
Difference-in-difference	Stapp et al. (2023)	90 improved forest management (IFM) projects across the U.S.
Matching	Guizar-Coutiño et al. (2022)	40 REDD+ projects in 9 countries certified under the Verified Carbon Standard (VCS)

VII.4. Appendix 4: How 'Free and negative initial Allowances' Might Function in Practice

Assume, for simplicity, no auction of permits (the regulator only distributes permits, and penalizes emission beyond permitted), and only two types of participant: high income country firms who emit nX tonnes CO_2e from fossil fuels each period, and emerging market and developing economy firms who emit X tonnes of CO_2e from deforestation per period. Both types of market participant can emit up to the permits they are given, or buy—and are penalized if they emit more.

For a simple example, we start with one high income country emitter, emitting 2X tonnes CO_2e and 3 emerging market and developing economy emitters each emitting X tonnes CO_2e, in each period. (The actual proportion can vary, and is negotiable but should reflect historical emissions, existing emissions, and development pathways.)

Suppose market participants agree that the high income country should finance all emission reduction activities undertaken by emerging market and developing economy emitters and imagine the regulator, to hit global targets, needs to ensure total emissions are reduced to hit zero over 5 time periods. Current emissions are 5X.

In period 1, to hit 4X overall emissions, the regulator distributes 4 permits—1 to high income country emitter, and 3 to emerging market and developing economy emitters. High income country emitter buys one permit from 1 emerging market and developing economy emitter.

In period 2, to hit 3X overall emissions, the regulator distributes 3 permits to emerging market and developing economy emitters. The high income countries emitter buys 2 permits, from two emerging market and developing economy emitters

In period 3, the regulator wants to hit 2X overall emissions. They have to distribute 3 permits to emerging market and developing economy emitters. So they are giving out permits over the cap. To ensure permits add up to the cap, they need to allocate a negative permit 'free allowance' to the high income country emitter, forcing them to buy three permits from emerging market and developing economy emitters to comply with the 'permits cover emissions' rule.

In period 4, the regulator needs to hit 1X emissions cap: they give 3 permits to emerging market and developing economy emitters, and 2 negative permits 'free allowances' to high income country emitters. high income country emitter buys 3 permits from emerging market and developing economy emitters, and reduces own emissions by 1X.

In period 5, the regulator needs to hit zero emissions cap. so they give 3 permits to emerging market and developing economy emitters, and 3 negative permits 'free allowances' to high income country emitters. High income country emitter buys 3 permits from emerging market and developing economy emitters, and reduces its own emissions by 2X—total emissions over the market are now zero.

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