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Climate Impact Auctions: Increasing the Effectiveness of Global Climate Finance

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IN BRIEF

The need to meet global climate goals has never been more pressing. Greenhouse-gas emissions from low- and middle-income countries, which contribute approximately 72 per cent of current global emissions, must decline without inhibiting development. High-income countries have committed to mobilize US$100 billion annually to support climate action in developing countries. This paper introduces “Climate Impact Auctions,” a results-based approach. By leveraging competitive bidding for subsidies tied to verified outcomes, this method promises increased cost efficiency, better targeting of high-impact projects, improved access for businesses and measurable results. This mechanism could unlock further climate finance through efficient use of limited resources, presenting a compelling strategy as the world scales up its climate action.

EN BREF

La nécessité d'atteindre les objectifs climatiques mondiaux n'a jamais été aussi pressante. Les émissions de gaz à effet de serre des pays à revenu faible ou moyen, qui représentent environ 72 % des émissions mondiales actuelles, doivent diminuer sans entraver leur développement. Les pays à revenu élevé se sont engagés à mobiliser 100 G$ par an pour soutenir l'action climatique dans les pays en développement. Cette étude présente les « enchères sur l'impact climatique », une approche axée sur les résultats. En tirant parti d'appels d'offres pour des subventions liées à des résultats vérifiés, cette méthode promet une meilleure rentabilité, un meilleur ciblage des projets à fort impact, un meilleur accès pour les entreprises et des résultats mesurables. Ce mécanisme pourrait débloquer de nouveaux financements pour le climat grâce à une utilisation efficace de ressources limitées, ce qui constitue une stratégie convaincante à l'heure où le monde intensifie son action climatique.

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HIGHLIGHTS

Low- and middle-income countries (LMICs) represent around 72 per cent of global greenhouse-gas emissions, and the proportion is growing. Without action to stem the growth of emissions in those countries, the shared goal of keeping global average temperature increases to well below two degrees above pre-industrial levels will not be achieved.

At the same time, high-income countries — including Canada and Germany — are responsible for the largest share of the emissions that have accumulated in the atmosphere, and have greater financial capacity to invest in actions to reduce emissions. Under the United Nations Framework Convention on Climate Change, high-income countries have committed to mobilize at least US$100 billion annually toward climate action in LMICs, and are poised to set a new collective quantified goal on climate finance at the 29th Conference of the Parties meeting in 2024 in Baku, Azerbaijan.

This paper explains the reasons behind climate finance for low- and medium-income countries, and critically examines how current financial flows are allocated. It finds significant room for improvement in existing programs. For example, processes are lengthy and burdensome, and the proposed use of a significant portion of the funding has a tenuous relationship to climate change. Part of the problem is that climate finance has been developed from existing approaches to development assistance, rather than starting anew from lessons learned about the most effective and efficient approaches for emission reductions.

Efforts to reduce emissions in high-income countries rely heavily on financial incentives to achieve their domestic climate goals — such as carbon pricing, reverse auctions for renewable energy or production tax credits. But their financial support to LMICs consists almost entirely of grants and loans, intended to help pay for climate-related projects, for training and conferences, and for other “soft” objectives.

We argue that international climate finance should make more use of results-based payments, specifically through reverse auctions for subsidies based on targeted climate outcomes. Reverse auctions solicit bids from potential providers of the desired outcome and select the lowest-cost bids. When outcomes are measurable — as with renewable energy production and payment per kilowatt hour — such subsidies could help achieve the rapid scale-up of investments needed to reduce greenhouse-gas emissions in LMICs. The mechanism could also apply to carbon removal and adaptation projects.

The approach, which we label “Climate Impact Auctions,” would have many attractive features for donor and recipient countries: greater cost-effectiveness, improved access to climate finance for small and medium-sized enterprises, and measurable outcomes. This would allow funds provided by high-income countries to stretch further, and target projects that yield the greatest local and global benefit.

FAITS SAILLANTS

Les pays à revenu faible et moyen (PRFM) représentent environ 72 % des émissions mondiales de gaz à effet de serre (GES), et cette proportion ne cesse de croître. Si aucune mesure n'est prise pour endiguer la croissance des émissions dans ces pays, l'objectif commun de maintenir l'augmentation de la température moyenne mondiale bien en deçà de deux degrés par rapport aux niveaux préindustriels ne sera pas atteint.

Dans le même temps, les pays à revenu élevé — dont le Canada et l'Allemagne — sont responsables de la plus grande partie des émissions qui se sont accumulées dans l'atmosphère et disposent d'une plus grande capacité financière pour investir dans des actions visant à réduire les GES. Dans le cadre de la Convention-cadre des Nations Unies sur les changements climatiques, les pays à revenu élevé se sont engagés à mobiliser au moins 100 G$ par an en faveur de l'action climatique dans les pays à faible revenu, et sont sur le point de fixer un nouvel objectif collectif quantifié en matière de financement climatique lors de la 29e Conférence des Parties qui se tiendra en 2024 à Bakou, en Azerbaïdjan.

Cette étude explique les raisons qui sous-tendent le financement de la lutte contre les changements climatiques dans les PRFM et examine de manière critique la façon dont les flux financiers actuels sont alloués. Il constate que les programmes existants peuvent être améliorés de manière significative. Par exemple, les processus sont longs et lourds, et l'utilisation proposée d'une grande partie des fonds n'a qu'un rapport ténu avec les changements climatiques. Le problème réside en partie dans le fait que le financement de la lutte climatique a été développé à partir des approches existantes en matière d'aide au développement, au lieu de repartir des enseignements tirés des approches les plus efficaces et les plus efficientes en matière de réduction des émissions.

Les efforts de réduction des émissions dans les pays à revenu élevé s'appuient largement sur des incitations financières pour atteindre leurs objectifs nationaux en matière de climat, comme la tarification du carbone, les enchères inversées pour les énergies renouvelables ou les crédits d'impôt à la production. Mais le soutien financier qu'ils apportent aux PRFM consiste presque exclusivement en subventions et en prêts, destinés à financer des projets liés au climat, des formations et des conférences, ainsi que d'autres objectifs « abstraits ».

Nous soutenons que le financement international de l'action climatique devrait utiliser davantage les paiements basés sur les résultats, en particulier par le biais d'enchères inversées pour les subventions basées sur des résultats climatiques ciblés. Les enchères inversées sollicitent des offres de la part de fournisseurs potentiels du résultat souhaité et sélectionnent les offres les moins chères. Lorsque les résultats sont mesurables — comme dans le cas de la production d'énergie renouvelable et du paiement par kilowattheure — ces subventions pourraient contribuer à l'augmentation rapide des investissements nécessaires pour réduire les émissions de GES dans les PRFM. Le mécanisme pourrait également s'appliquer aux projets d'élimination du carbone et d'adaptation.

Cette approche, que nous appelons « enchères sur l'impact climatique », présenterait de nombreuses caractéristiques attrayantes pour les pays donateurs et bénéficiaires : un meilleur rapport coût-efficacité, un accès amélioré au financement climatique pour les petites et moyennes entreprises, et des résultats mesurables. Cela permettrait aux fonds fournis par les pays à revenu élevé d'être plus étendus et de cibler les projets qui produisent les plus grands bénéfices locaux et mondiaux.

INTRODUCTION

The climate crisis demands urgent and extraordinary action. Unfortunately, many countries have been slow to undertake the necessary and difficult investments required to protect the atmosphere. While technological progress in renewable energy has delivered impressive cost reductions, the amount of investment required to address global energy needs remains daunting; a key priority is to develop a suite of policies to cost-effectively achieve the greatest gains. A particularly challenging issue is designing policies to facilitate the green transition in low- and middle-income countries (LMICs).

LMICs have argued that high-income countries (HICs), those responsible for the lion's share of cumulative emissions, should bear the burden for emissions reductions; LMIC governments have been hesitant to impose substantial additional mitigation costs on their own hard-pressed economies while the emissions per capita in HICs are relatively high. At the same time, many LMICs are highly vulnerable to the impacts of a changing climate, such as drought and flooding. Governments of HICs have recognized the justice of these claims and have committed to "mobilize" financial support for climate change mitigation and adaptation in LMICs. They have established a multibillion-dollar multilateral institution, the Green Climate Fund, to channel climate-related funding to developing countries. In addition, numerous other initiatives, both bilateral and multilateral, have been launched to assist developing countries in transitioning away from carbon-based fuels.

The scale of support to developing countries nevertheless remains inadequate. Most climate-related spending by HICs has been focused on domestic emissions. While this may appear reasonable — on the basis that each country should clean up its own mess — it fails to address the reality that LMICs' share of current global greenhouse-gas (GHG) emissions is about 72 per cent and growing. If emissions from LMICs are not adequately addressed, it will be impossible to attain the Paris Agreement's goal of keeping global average temperature increases to well below two degrees above pre-industrial levels. There is a need for HIC governments to fund emissions reduction investments in LMICs, not as aid, but because people in HICs will benefit from carbon reductions anywhere in the world. At the same time, low-income people have the worst exposure to climate change and need financial assistance to adapt successfully. Providing such assistance is a moral obligation, not just because of our common humanity, but because HICs have contributed more than their fair share to the global stock of atmospheric and oceanic carbon (Sayegh, 2018). Since HICs caused most of the global ecological problems, they have a duty to help those most harmed.

While the obligation — and, indeed, the necessity — to provide financial assistance for mitigation and adaptation is clear, what is not so obvious is the best way to allocate funding. A reasonable starting point is examining what HIC governments have been doing domestically. The leading domestic policies in HICs have been based on creating results-based incentives, most importantly through some form of carbon pricing as well as reverse auctions for renewable energy production or production tax credits. In Europe, the Emissions Trading System (ETS) has driven up the cost of industrial emissions and thus created strong incentives to reduce emissions in the most cost-effective manner possible. In Canada, the price of carbon is on a steep upward trajectory and is set to

achieve efficient emissions reductions. In the U.S., performance-based subsidies, such as renewable energy production tax credits in the *Inflation Reduction Act*, are a critical component of the policy framework.

In contrast, the same countries' climate finance support to LMICs is almost exclusively in the form of grants and loans, insensitive to outcome. A typical grant might fund training "to build capacities of all stakeholders on project development and management," or "training on project implementation modalities and reporting procedures" (Green Climate Fund, 2023a). These types of grants, while useful, have a less direct connection to outcomes than does carbon pricing.

Very few LMICs have put carbon pricing in place, and so industries and households in those countries generally face no results-based incentives to reduce emissions. This is problematic since, in the right circumstances, results-based incentives such as carbon pricing can effectively drive change. It is not clear why results-based payments are so infrequently used to support global climate ambitions. The lack of results-based subsidies in LMICs is not due to inadequate capacity for monitoring, reporting and verification (MRV): there is an active commercial market in the sale of carbon credits, including from LMICs, that demonstrates a high level of capability in MRV. It is instead most likely that the model of grants and loans, typically applied in development finance, has now become the default mechanism applied in climate finance.

This paper thus aims to explore the potential for the inclusion of more results-based subsidies, allocated using a competitive mechanism, in climate finance provided by HICs. Tying subsidies to performance would have many benefits, including accountability, greater efficiency, empowerment of local agents and protection of funders against non-performing projects. Just as important, it would enable the governments of donor countries to clearly show taxpayers how their funds have delivered on measurable climate goals. In contrast, grants tend to be complex and lack clear deliverables that can be shown to directly benefit voters in HICs.

THE RATIONALE AND NEED FOR CLIMATE FINANCE

Climate finance from rich countries to LMICs can target mitigation (i.e., reduction of future emissions) or adaptation to higher temperatures and changing weather patterns caused by past emissions. First, we consider the case for assistance in funding investments to mitigate GHG emissions.

The rationale for mitigation assistance

It is reasonable to ask why HICs should support efforts to reduce emissions in LMICs. There are several reasons, based on the self-interest of donor countries.

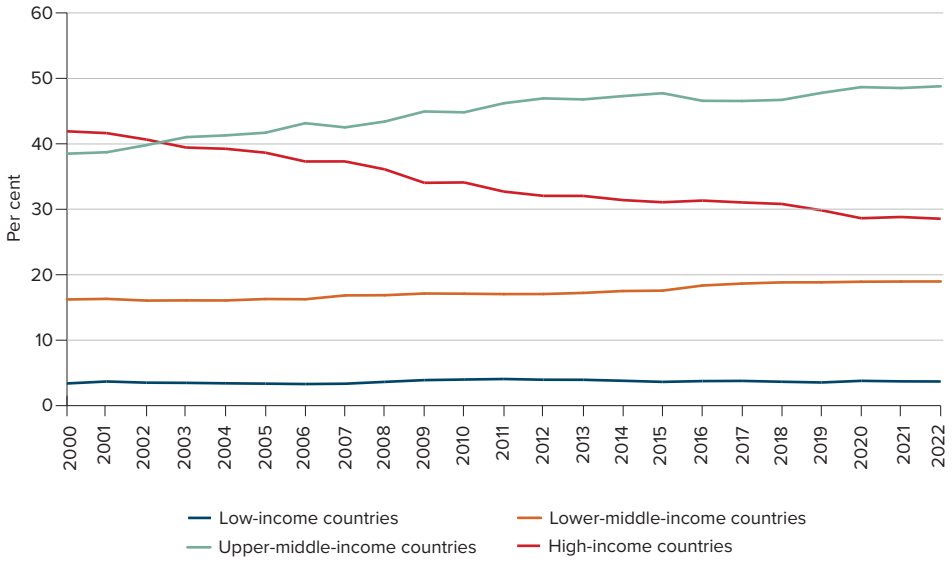
Emissions of carbon dioxide and other GHGs, such as methane, are widely and rapidly distributed throughout the atmosphere: their effect is global. Germans benefit as much from emissions reduction in Indonesia as from reductions at home. Since addressing

climate change requires substantial investment, we should make every effort to minimize the costs of achieving climate goals, and this implies choosing the lowest-cost mitigation projects, wherever they are. Many of the most attractive opportunities are in LMICs, where marginal abatement costs are often less than half as much as in HICs (Aldy et al., 2016). Bolton et al. (2024) show that the the climate-related economic benefits to HICs of subsidizing the replacement of coal-fired electricity generation in LMICs with renewables would greatly exceed the costs of those subsidies.

Second, LMICs lack the resources to mitigate their emissions. This is problematic because, as figure 1 shows, the share of GHGs emitted by HICs has fallen from 42 per cent in 2000 to 29 per cent in 2022. HICs cannot solve the problem of climate change on their own; without reductions in emissions in LMICs, climate goals cannot be met. For most people in LMICs, as well as for their governments, expenditures on mitigation have a very high opportunity cost. For example, India's median income per day in 2017 was US$3.46 (World Bank Poverty and Inequality Platform, 2023).[1] It is unreasonable to expect people at this income level to engage in costly mitigation activities for the world's benefit. Relatedly, governments of LMICs have severely constrained budgets. Therefore, capital-intensive mitigation activities in LMICs will not happen without subsidies from HICs.

Third, governments of LMICs have argued that imposing mitigation costs on them is unfair, given that HICs have grown wealthy by exploiting fossil fuel resources. LMICs are asking for an equitable opportunity to develop their economies without constraints on fossil

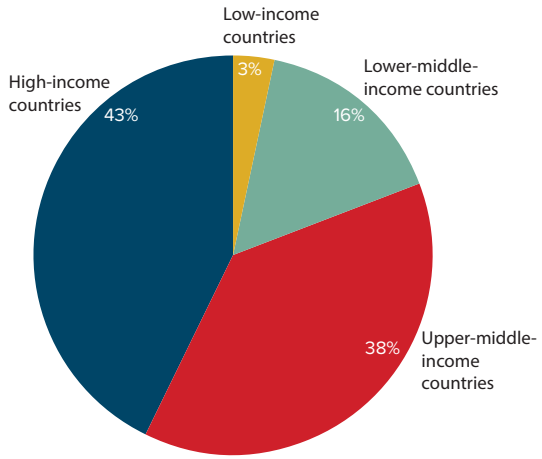
Figure 1. GHG shares by country income group



Notes: Gross national income per capita by category are as follows: high-income countries more than US$13,845; upper-middle-income countries between US$4,466 and US$13,845; lower-middle-income countries between US$1,136 and US$4,466; low-income countries less than US$1,136; World Bank Atlas method (World Bank Group, 2024). Measured in CO_2 equivalents (CO_{2e}).
Source: Jones et al. (2024).

[1] This amount is expressed using Purchasing Power Parity at 2017 prices.

Figure 2. Cumulative GHG emissions by country income classification (since 1850)

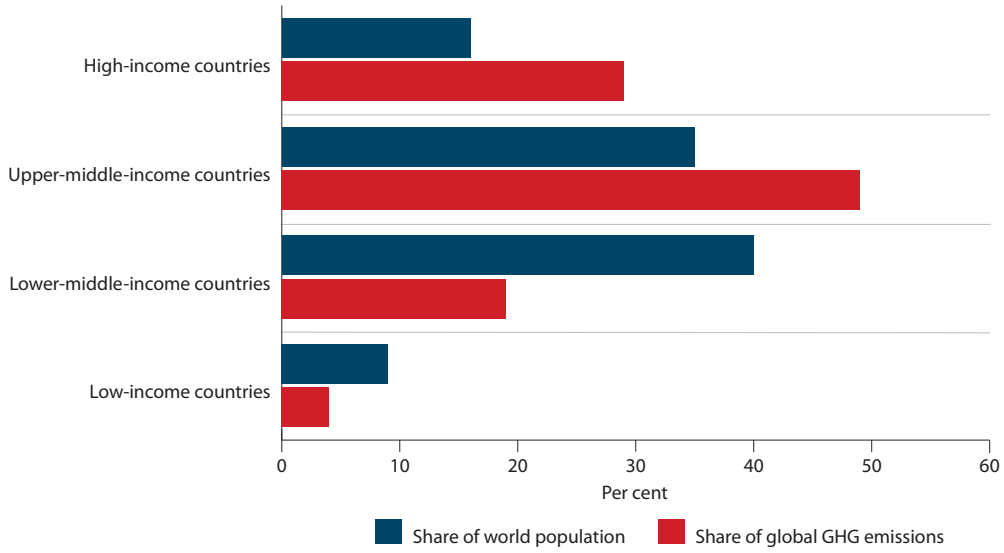


Source: Jones et al. (2024).

fuel usage, recognizing that those constraints are primarily required because HICs have historically contributed so much carbon to the atmosphere. As figure 2 shows, the share of total cumulative emissions of HICs is about 43 per cent, compared to the 57 per cent caused by the much larger population in LMICs. Moreover, as shown in figure 3, people in HICs continue to emit GHGs at a much higher rate than people in LMICs. The obvious solution to this inequity is for HICs to provide financial assistance for the decarbonization of LMIC economies — they caused the problem, and they can fix it.

There is, however, some debate regarding where the line should be drawn between countries expected to pay for climate finance and countries eligible to receive climate finance. Currently, the 24 countries that were OECD members in 1992 — when the United Nations Framework Convention on Climate Change (UNFCCC) was signed — are responsible for paying for climate finance (Alayza et al., 2024). The global economy has shifted significantly since that time, and some developed countries have called for the use of metrics to measure both a country's ability to pay and its historic responsibility for climate change.

Figure 3. Share of global GHG emissions and population, 2022



Source: Jones et al. (2024).

The rationale for adaptation assistance

Adaptation is necessary because of the existing stock of excess GHGs in the atmosphere that, as discussed above, is due principally to the economic activities of HICs. Thus, it is reasonable for LMICs to expect the countries that caused the harm to the global environment to provide compensation for adaptation to the effects of climate change. The fundamental concept underlying this responsibility of HICs is the "Polluter Pays Principle," something that is widely accepted (OECD, 2024a). This principle implies that polluters, rather than those who are harmed, should bear the costs of dealing with their pollution. Rigorous application of the principle thus incentivizes polluters to avoid environmental damage.

Harms from degradation of the climate are likely to disproportionately affect low-income people in the Global South (Edmonds et al., 2020). People and countries with fewer resources for adaptation, that lack the ability to manage climatic disruptions, are much more vulnerable to climate change. They have contributed little historically to climate change but suffer the worst effects. If anything, this increases the obligation of wealthy countries to support adaptation efforts in LMICs. There are also calls to include loss and damage funding in climate finance, which would additionally compensate communities for impacts to which they cannot adapt, such as the loss of homes and buildings from flooding linked to climate change (Alayza et al., 2024).

In summary, support for climate change mitigation and adaptation in LMICs is not some charitable donation. It either benefits the donor (mitigation) or compensates for a harm committed (adaptation, loss and damage). Thus, climate finance should be additional to development aid. This is the essential framework for thinking about HICs' commitment to climate-related investments in LMICs, and for thinking about how to ensure money is well directed.

Existing funding gap

The need for climate finance in LMICs has been met with numerous efforts. Notably, HIC governments pledged at the Copenhagen COP in 2009 to "mobilize" US$100 billion per year in financing to assist developing countries in both mitigation and adaptation by 2020.[2] This pledge is less impressive than it sounds. In 2022, although the US$100 billion number was achieved, much of the financing was in the form of loans at commercial rates. The mixing of loans and grants classified as climate finance makes discernment of the underlying impact complex (Pauw et al., 2022). Oxfam's analysis of the financing concluded that the value of the claimed financial transfer of US$83 billion in 2020 was actually under US$25 billion (Zagema et al., 2023).[3] A detailed review of climate finance submissions by Reuters found that much of the earmarked use of the money appeared

[2] The COP (Conference of the Parties) is the annual meeting of governments that are the parties to the United Nations Framework Convention on Climate Change.

[3] Oxfam's analysis estimated the grant equivalent of loans provided and discounted financing that was only partially linked to climate change.

to have a tenuous relationship to the climate.[4] The current strategy of many countries for meeting their climate finance commitments by "green-tagging" as many items as possible fails to serve the pressing need for resources to address climate change. The discussions at the 2024 COP29 (29th Conference of the Parties to the UNFCCC) in Baku, Azerbaijan are expected to focus on increasing this climate finance through a New Collective Quantified Goal; some countries have proposed annual financing of over US$1 trillion, though there seems to be less interest in directing how the money is to be used (UNFCCC, 2024).

In any case, state-provided climate finance is not large enough on its own to achieve global climate goals. Numerous studies have established that the amount needed to meet climate goals is far more significant than the sum currently available (Buchner et al., 2019; Masson-Delmotte et al., 2018; UNCTAD, 2014). One important way to address this deficit is to leverage state-provided climate finance by using it to subsidize projects, attracting additional private finance that has a much higher potential capacity, under the right conditions.

In the next section, we examine how that funding has been allocated, and we make the argument that results-based payments should be a larger part of the mix. One important reason for optimizing the allocation of payments is that it would be easier to obtain political support for global climate finance commitments if HIC taxpayers believed them to be effective.

THE ALLOCATION OF CLIMATE FINANCE

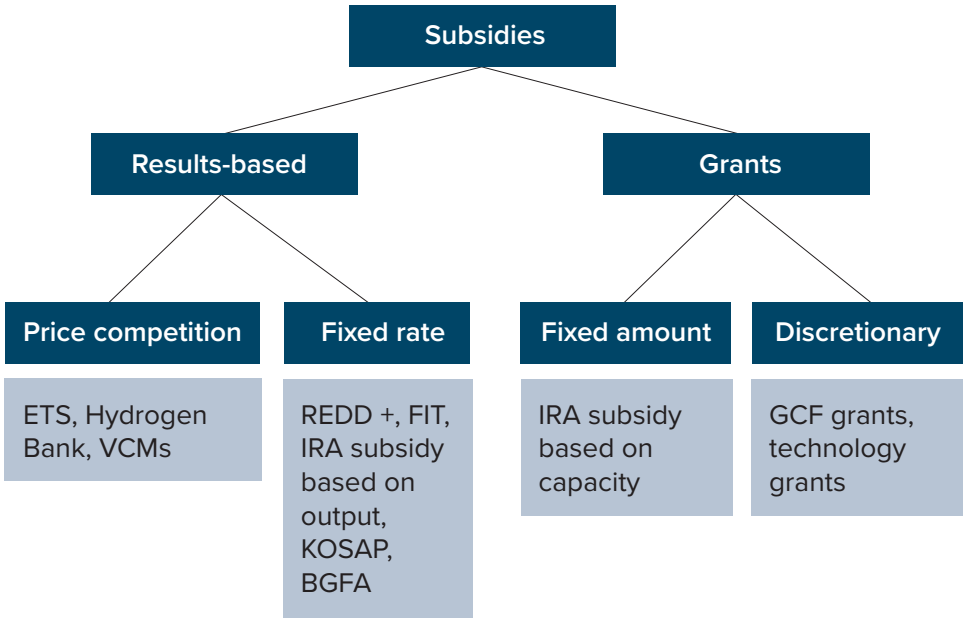
In this section, we examine the allocation of different types of climate finance. Our key finding is that HICs have made extensive use of incentive mechanisms domestically, but have relied on grants and cost-based subsidies to support climate action in LMICs.

The schematic in figure 4 provides a simple framework for our analysis. At a high level, we can distinguish between results-based subsidies, such as an emissions trading system, and grants and loans given to support investment in a project. A results-based subsidy is conditional on the program or project delivering specific outcomes determined by the funder, and is normally paid per unit of output. Such subsidies may be allocated at a rate that is predetermined by the funder, or at a rate endogenously determined through an auction or other form of competition between suppliers. The clean electricity production tax credit, offered under the U.S. *Inflation Reduction Act*, is an example of the former, since the subsidy per kilowatt hour produced is fixed in the legislation. The EU Emissions Trading System is an example of the latter, since the price at which firms sell or buy credits is determined by the market.

A grant or loan pays part of the cost of a program or project, in the expectation that it will be performed or developed. Grants and loans may be provided in a fixed amount based on standardized properties of specific projects (e.g., based on planned size of solar

[4] For example, the U.S. reported as part of its "climate financing" a US$19.5-million loan to a luxury hotel in Haiti. The hotel apparently qualified as "climate-related" based on the included hurricane protection measures. Japan reported loans for coal-fired power plants as part of its climate finance effort (Rumney et al., 2023), though claimed to withdraw from supporting further coal after fierce criticism (Ministry of Foreign Affairs of Japan, 2022).

Figure 4. Climate subsidy types



Note: EU Emission Trading System (EU ETS), Voluntary Carbon Markets (VCMs), Reducing emissions from deforestation and forest degradation in developing countries (REDD+), Feed-in tariff (FIT), *Inflation Reduction Act* (IRA), Kenya Off-Grid Solar Access Project (KOSAP), Beyond the Grid Africa (BGFA), Green Climate Fund (GCF)

facility prior to construction), or more commonly through an evaluation process that allows the grantor discretion to determine the amount. Grants and loans given on concessional terms (i.e., with below-market interest rates or lengthy grace periods for repayment) are "cost-based" subsidies because they are not based on results or output.

As we discuss below, while HICs tend to use results-based subsidies at home, almost all climate finance delivered to LMICs is given through grants and loans on a discretionary basis. How should we evaluate which strategy is best? We begin by examining how HICs support their own climate transition.

Climate policies in high-income countries

The strategy of HICs domestically has been to implement market-based systems of carbon pricing, tradable permits and results-based subsidies. The World Bank maintains a database of carbon pricing models that shows that all the G7 countries, the entire EU, Switzerland, Korea and New Zealand all have market-based systems of carbon pricing, either through a carbon tax or tradable permits (World Bank Group, 2024). The U.S., while lacking a national carbon pricing system, has implemented extensive results-based subsidies through the *Inflation Reduction Act*. In addition, 12 U.S. states have implemented an emissions trading system (C2ES, 2024). In Canada, market-based incentive policies designed around carbon pricing are the most important tool for limiting domestic emissions (Beugin et al., 2024).

Market-based systems of carbon pricing can be properly conceived as a results-based subsidy with price competition. Those that reduce emissions pay less in carbon tax or can sell permits to other emitters in a trading system. This model is the most common and effective strategy for achieving climate goals (Krupnick & Parry, 2012).

Not only are results-based approaches most commonly used in HICs, but they are also, in some cases, mandated. In the EU, cost-based subsidies such as grants and concessional loans are explicitly discouraged by the European Commission. The commission's guidelines on state aid for climate-related projects encourage member states to use competitive, open auctions for results-based subsidies (European Commission, 2022):

> The selection criteria used for ranking bids and, ultimately, for allocating the aid in the competitive bidding process should as a general rule put the contribution to the main objectives of the measure in direct or indirect relation with the aid amount requested by the applicant. This may be expressed, for example, in terms of aid per unit of environmental protection or aid per unit of energy. (paragraph 50)

The commission's guidelines have two key features. First, the "contribution to the main objectives of the measure" (i.e., the results) is to be the basis of state aid, not the investment cost. Second, the aid should be allocated through a competitive bidding process, so that the firms needing the least aid should be the ones to be subsidized. The guidelines explain that the reason for this competitive bidding process is that it minimizes the aid needed, in turn minimizing the risk that subsidies to selected firms will create adverse and unintended effects on competition and trade. Such effects could include distorting the market, undermining efficient firms and creating barriers to entry.

Climate funding in LMICs

Funding by HICs for climate action in LMICs differs radically from the policies the same HICs apply domestically. Almost all climate funding to LMICs is allocated through grants and loans rather than results-based subsidies. European countries and the EU itself provide climate aid that, if provided in Europe, would violate the European Commission guidelines.

The main sources of climate finance are, in order of importance, multilateral development banks such as the World Bank, bilateral financing and climate funds such as the Green Climate Fund. The development banks specialize in loans, with 89 per cent of financing provided in 2022 being loans. Bilateral financing and climate funds offer approximately an even split of loans and grants (OECD, 2024b). The share of results-based payments in all types of institutions is very low.[5]

Climate funds

The Green Climate Fund (GCF) was established through agreement at the 2011 UNFCCC conference in Durban, with the purpose of providing "support to developing countries to limit or reduce their GHG emissions and to adapt to the impacts of climate change"

[5] A World Bank web page claims that "about 95 per cent of international public climate finance is provided up-front before a project is operational" (World Bank Group, 2022).

(UNFCCC, 2011). As of March 2024, the GCF had committed US$13.9 billion to 253 different projects, with US$4.2 billion actually disbursed. It is clear that the scale of funding, though trending in the right direction, cannot deliver the kinds of results that are needed, with an average of about US$0.4 billion disbursed annually over the last 10 years.

The GCF funding model is primarily grant-based, and the protocol for applying is complex and time-consuming. Most funding is provided through national authorities designated by the recipient countries, ensuring that funding proposals are consonant with national climate strategies and plans. There is also a private-sector facility that enables the funding and mobilization of private-sector actors to encourage corporate co-investment (Green Climate Fund, 2024).

According to its Governing Instrument, the GCF "may employ results-based financing approaches, including, in particular for incentivizing mitigation actions, payment for verified results, where appropriate" (UNFCCC, 2011, p. 14). However, this capability has been very little employed. An analysis of GCF project funding during 2015-2020 found that, of the US$7.2 billion committed during that period, 93 per cent was allocated through grants with the remaining 7 per cent allocated through results-based payments (Alldredge et al., 2020). The use of results-based payments was almost exclusively limited to REDD+, a program relating to verified emissions reductions stemming from reduced deforestation and forest degradation.

The GCF has faced many criticisms, as might be expected for a rapidly growing international organization having to balance many competing interests. Its internal evaluations have highlighted the challenges the fund has had in enabling access to funding. Private firms have struggled to obtain financing, especially in the most vulnerable countries. As a related problem, "partners continue to perceive the project appraisal and approval cycle as bureaucratic, lengthy, inconsistent and non-transparent" (Green Climate Fund, 2023c).

It is not surprising that appraisal and approval are challenging. The GCF evaluates projects with considerable diligence to ensure that they deserve the millions of dollars in grants and loans each seeks. A typical example of a proposal is "SAP032: Local Climate Adaptive Living Facility — LoCAL," a proposal by the National Fund for the Environment and Climate of Benin (Green Climate Fund, 2023b). This proposal is 60 pages long with 19 annexes. The resources required to produce such a set of plans and documents, all in English, are substantial and preclude smaller projects. Furthermore, such proposals require extensive and time-consuming reviews. Many proposals, of course, are never funded, meaning project proponents must be prepared to expend substantial resources without the certainty of success. Given the challenges inherent in this model of funding, the GCF faces considerable headwinds in ramping up its activities to the levels that are needed.

Multilateral development banks (MDBs)

MDBs are the most important source of financing, but they specialize in loans that are generally not results-based. Loans are important for accelerating climate action but also lead to increases in LMICs' debt burdens. Consequently, an important challenge for

MDBs is finding good projects that can support loan repayment. This typically excludes adaptation projects, which often do not create an attributable income stream. We highlight three initiatives that demonstrate the MDBs' nascent interest in using results-based mechanisms to drive outcomes.

The Inter-American Development Bank created a pilot program in 2023 to support the achievement of nature and climate objectives. The program offers to borrowing countries a grant equal to 5 per cent of a loan, with the grant dependent on "setting ambitious environmental targets, identifying the proper policies and expenditures to meet these targets, and being able to measure and report on their progress in a timely manner" (IDB, 2023).

The World Bank is currently exploring using results-based climate finance to influence policies. The approach ties payments to defined climate outcomes resulting from specified policies, such as mandatory energy efficiency standards for appliances. The underlying idea is that, when governments have ongoing revenues conditional on the success of climate-friendly policies, they will focus their "attention on effective policy implementation" (World Bank Group, 2023).[6]

The African Development Bank has proposed an "Adaptation Benefit Mechanism" to help fund adaptation projects that are commercially unviable. The idea is that the bank will validate and certify project benefits, so that project proponents may more easily obtain results-based grants (African Development Bank Group, 2024). While this mechanism was proposed several years ago, it appears that no projects have been financed.

Bilateral climate finance

A substantial share of climate financing from rich to low-income countries is allocated through bilateral aid agencies, by which funding flows directly from a rich country's government to a low-income country. As discussed above, this often results in some degree of overlap between aid for development and climate finance, with several attendant risks: support for development may be cannibalized for climate purposes; development aid may be "tagged" as having a green component in order to meet a country's commitments for climate finance while having little impact on climate; or the funder may try to achieve both development and aid objectives with the same dollar. From a donor country's perspective, it is attractive to be able to claim credit for achieving commitments on aid and climate finance.

What we observe is that climate finance tends to be allocated in a fashion that mirrors that of development aid. Given the complexity of development objectives and the long-term nature of benefits, the overwhelming majority of development aid consists of grants, loans and technical assistance. This model, however, is likely unnecessary for mitigation projects that have a simpler and more easily measured objective.

[6] The World Bank has also experimented with other impact bonds wherein the bond's effective interest rate is in part determined by performance of a government in delivering on environmental objectives, such as the Plastic Waste Reduction-Linked Bond and the Indonesia Coral Bond.

Missing incentives in climate finance in LMICs

The continued failure to include results-based incentives will make it harder to achieve climate goals in LMICs. While not every climate policy should be based on creating incentives, at least some of them should be. We first review key literature on results-based financing and then examine some evidence of its effectiveness in achieving climate goals.

The value of results-based financing

Existing analyses of climate finance have demonstrated a benefit from the use of climate policies that rely on incentives and competition where possible. Bhandary et al. (2021) note there is relatively little literature assessing different policies in climate finance; most work has focused on the importance of more financing rather than how it is allocated. They compare nine classes of climate finance, concluding that there is "no policy 'silver bullet,'" given that the "impact of climate finance policies depends on the details of policy design, characteristics of the local market, country conditions…and the technologies that are being deployed" (p. 540). Different projects can be optimally supported using different approaches.

Recent studies have emphasized the value of results-based subsidies in driving meaningful change in outcomes. Stechemesser et al. (2024) find that carbon pricing is the single most impactful policy in developed economies, and is an important policy tool in developing countries.[7] Hahn et al. (2024) empirically show that production tax credits for wind and solar generation generally had the highest "marginal value of public funds" in the U.S. (p. 1). Their analysis fully accounted for the fact that such subsidies are in part captured by non-additional projects; that is, those that would have proceeded even without the subsidy.

Clist (2016, 2019) analyzes the effectiveness of results-based payments in development aid generally, emphasizing the challenge of assessing success when the reporting of outcomes is done by "incentivized" data sources. However, he also notes that payment by results could work well when used in the right circumstances:

(a) a good and verifiable outcome measure that the donor cares about
(b) a recipient that can control the related improvement but "undervalues" it and is willing to accept the payment structure
(c) a donor that can design and enforce the contract in a reasonable time frame

All three of these criteria are met in certain cases in climate finance. With respect to the first, verifiable outcome measures are available for numerous climate projects and, indeed, a whole industry of measurement, reporting and verification has been established to support tradable carbon credits. Indeed, for many types of projects, we have already seen extensive use of results-based subsidies, but not through international climate finance. With respect to the second, "undervaluing" is particularly relevant for mitigation activities since a person, business or country captures only a tiny fraction of the benefit of reductions in emissions. This leaves the third criterion as the relevant challenge: whether donors can design and manage contracts effectively.

[7] Comprehensive carbon pricing is challenging to implement, even in HICs, and its practicality in LMICs is questionable, at least in the near future.

Evidence: Auctions for results-based subsidies in LMICs

In this section, we consider whether there is evidence that results-based subsidies are (a) effective for achieving climate objectives, (b) effective in LMICs and (c) effective when allocated through competitive auctions.

First, as an initial observation, results-based payments allocated competitively are the standard tool for supporting the green transition in HICs, with studies showing that it is a cost-effective approach to reducing emissions (ESMAP, 2015; Liñeiro & Müsgens, 2021; World Bank Group, 2024). This provides supporting evidence for (a) and (c).

Second, renewable energy auctions, where national electricity system operators have solicited bids to supply solar and wind energy, provide a particularly important demonstration of the feasibility and effectiveness of results-based payments in LMICs. Indeed, "auctions are globally becoming the instrument of choice for [renewable energy support]" (Haufe & Ehrhart, 2018, p. 222). Such auctions have been used globally, including in India, South Africa, Morocco, Brazil and Peru (IRENA, 2019). These auctions, to be clear, are typically for the full payment, or offer a contract for difference that results in a guaranteed price. One of the important benefits of using auctions in these projects has been price discovery — learning the price required to support investment in renewable energy by soliciting bids from producers through a competitive process. National electricity companies have, in many cases, been happily surprised by low bids (Haufe & Ehrhart, 2018). These auctions provide supporting evidence for (a), (b) and (c).

Feed-in Tariffs (FITs) are a related instrument in renewable energy incentives. Such tariffs typically offer a fixed price — rather than a price determined by auction — for renewable energy supply (Roberts, 2020). While FITs have been criticized as relatively expensive, given the rapid decreases in the price of solar photovoltaic panels, they have succeeded in supporting investment, including in many LMICs, in turn providing supporting evidence for (a) and (b). Auction-based payments appear superior when feasible, given the ability to take advantage of competition between suppliers to lower costs.

India offers a salient example of how auctions for results-based subsidies can support the rapid expansion of renewable energy. The Indian government has been using reverse auctions to determine the required subsidy for solar and, more recently, offshore wind construction, given a fixed revenue per megawatt hour (Jai, 2016; PIB Delhi, 2024).[8] Auction winners are required to supply the electricity at a fixed rate but receive a subsidy equal to their bid ("viability gap funding") upon completion of the project. A similar auction process is now being used for electricity storage (PMINDIA, 2023). This approach has been highly effective in increasing the supply of renewable energy in India and offers supporting evidence for (a), (b) and (c).

Europe is applying a reverse auction mechanism to support hydrogen production within its borders (European Commission, 2024a). The Hydrogen Bank, financed by Europe's Innovation Fund, recently held an auction with a fund of 800 million euros to provide

[8] In a reverse auction, the lowest bid wins the auction.

subsidies for green hydrogen production in Europe. With 132 bidders, the Hydrogen Bank was able to pick the seven qualifying applicants who required the lowest subsidy per kilogram of green hydrogen. While the bids ranged up to 4.50 euros per kilogram, successful bids were between 0.37 euros and 0.48 euros (European Commission, 2024b). The Hydrogen Bank has demonstrated the effectiveness of using an auction mechanism to maximize the impact of limited public subsidies, providing evidence for (a) and (c). Europe is now planning a second round, while also advancing a global auction for green hydrogen procurement through the "H2 Global" mechanism (H2 Global Stiftung, 2023).

The European-financed program EnDev has successfully used results-based payments in numerous countries to subsidize clean cookstoves, mini-grids, solar panels and energy-efficient appliances, particularly targeting access for very low-income households. Its main approach has been to subsidize suppliers while verifying delivery to consumers. Its own evaluation of the program over many years shows considerable successes, but also many warnings about the circumstances under which outcome-based subsidies work well. It also notes that "external events (such as natural catastrophes and pandemics), changes in the enabling environment and national policies, new donor initiatives, price fluctuations on global markets, and changing consumer priorities (to mention but a few) require a constant re-assessment and — if necessary — a readjustment of initial strategies" (EnDev, 2021, p. 70). The work of EnDev is particularly impressive because it has succeeded with results-based payments for projects that address the needs of very low-income households that are typically challenging to reach. EnDev offers relevant evidence for (a) and (b). However, EnDev's projects have had relatively small budgets: its first 17 projects, operating in 14 countries on three continents, supporting nine different technologies, had an aggregate budget of only 46 million euros (EnDev, 2021).

The World Bank ran several rounds of its Pilot Auction Facility, using a reverse auction to allocate subsidies for projects that earned "credits" for methane abatement in middle-income countries, mainly from landfills. While somewhat complex, the auctions appear to have been successful in achieving their goals at a modest cost per tonne of carbon dioxide equivalent abated (Bodnar et al., 2018; World Bank Group, 2024).

All these examples show that results-based subsidies can be used effectively and that, given the right circumstances, they can be allocated with competitive pricing through an auction mechanism. Moreover, the Indian viability funding gap mechanism shows that such subsidies can be the modality of climate investment support preferred by an LMIC.

The voluntary carbon market (VCM) — which also provides results-based subsidies, including in LMICs — is worthy of note. The VCM operates on the following basis. Firms or households, usually in HICs, that want to be "net zero" but have unabated emissions can "offset" those emissions by purchasing credits from firms that claim to have reduced or removed GHG emissions.[9] The most common source of credits is afforestation, reforestation or protection of forests. Unfortunately, since many buyers are unable to

[9] It is unclear to what extent offsets purchased in the VCM are used to justify additional carbon emissions by buyers, or whether they have no effect on the buyers' emissions and merely serve to provide moral cover, or a positive advertising spin. Certainly, the quality of offsets is in many cases questionable.

assess — or are uninterested in knowing — the quality of credits, the "integrity" of these offsets has been questionable (Greenfield, 2023). Nevertheless, while imperfect, these markets have created subsidies for investments in green technologies at a meaningful scale, including in LMICs. Thus, systems designed to subsidize emissions reductions or carbon removal are well established in LMICs, with a steady evolution in the rigour of monitoring, reporting and verification mechanisms (Schuetz & Poulos, 2021).

However, on their own, VCMs are insufficient: in 2021, for example, the retirement value of offset credits in African countries totalled only US$123 million (African Carbon Market Initiative, 2022). Moreover, investing in the expectation of selling credits into VCMs has also been problematic because of uncertainty about future price levels. In any case, the VCM is only a mechanism for reducing costs rather than reducing emissions since sellers are, at best, "offsetting" the emissions of others. The lesson VCMs provide about the potential effectiveness of results-based payments in achieving climate objectives is that it is essential to have a robust and meaningful system of monitoring, reporting and verification that does not rely too heavily on claims of unverifiable counterfactuals (i.e., what would have happened in the absence of the investment).

Article 6 of the Paris Agreement includes the possibility for countries to participate in something similar to VCMs: countries facing high abatement costs meeting their own carbon emission goals could purchase emissions reductions from other countries, as "Internationally Transferred Mitigation Outcomes." As with VCMs, this Article 6 transfer does not actually reduce emissions, but allows countries with high costs of achieving their climate goals to purchase cheaper emissions reductions elsewhere. An important limitation of this approach is that it requires the construction of a counterfactual estimate of emissions; the purchasing country is buying the difference between the actual emissions and the hypothetical emissions that would have occurred if not for its investment.

Bregazzi et al. (2022) note there is "considerable potential for the broader adoption of [outcome-based contracts] in the environmental sector," with one little-recognized benefit being a reduction in opportunities for greenwashing — making a product or activity appear more environmentally beneficial than it is in reality (p. 43). Their review concludes that there is "emerging evidence" that results-based subsidies can be effective in the right context. However, there are many situations where a results-based approach is not practical, as when the financed project does not have a single measurable output. The variety of situations means that climate finance cannot be uniform; it must fit the situation. Bhandary et al. (2021) note that we can expect some evolution: they argue that "as the economic competitiveness of new technologies increases, finance policy that is used to subsidize and buy down the cost of new technology initially should then intentionally shift to a competition-based approach" (p. 540).

Summary: Competitive, results-based subsidies

The extensive use of incentive-oriented mechanisms to reduce emissions by rich countries makes it surprising that these same countries, when funding climate action in LMICs, do not use results-based subsidies more commonly. The use of grants and loans in international climate finance is most incongruous for Europe, given that it has explicit policies recommending

results-based subsidies domestically. In light of the opportunities for results-based payments to be used for international climate finance, we discuss below a specific model for applying results-based payments using a competitive auction framework.

CLIMATE IMPACT AUCTIONS

As the discussion above shows, there is a need for effective, well-targeted climate funding in LMICs. Most existing funding is allocated as grants or loans intended to subsidize or finance the costs of various climate-related programs. What is missing is funding streams that create direct incentives to deliver measurable reductions in emissions, removal of CO_2 or adaptation benefits. We propose, in this section, a renewed effort to use results-based subsidies where appropriate; that is, where there is a measurable output that is closely tied to the desired outcome, and existing private incentives result in suboptimal investment. These two conditions appear to be particularly relevant for renewable energy.[10]

A key component of this proposal is the application of an auction mechanism to determine the required magnitude of payments, and to guide the allocation of subsidies to the most impactful projects. The justification for using auctions to allocate subsidies is straightforward. Given a limited budget, as seems reasonable within global climate finance, and assuming that subsidies are results-based, an auction targets the producers that need the smallest subsidy. This enables a limited budget to achieve the greatest outcome.[11]

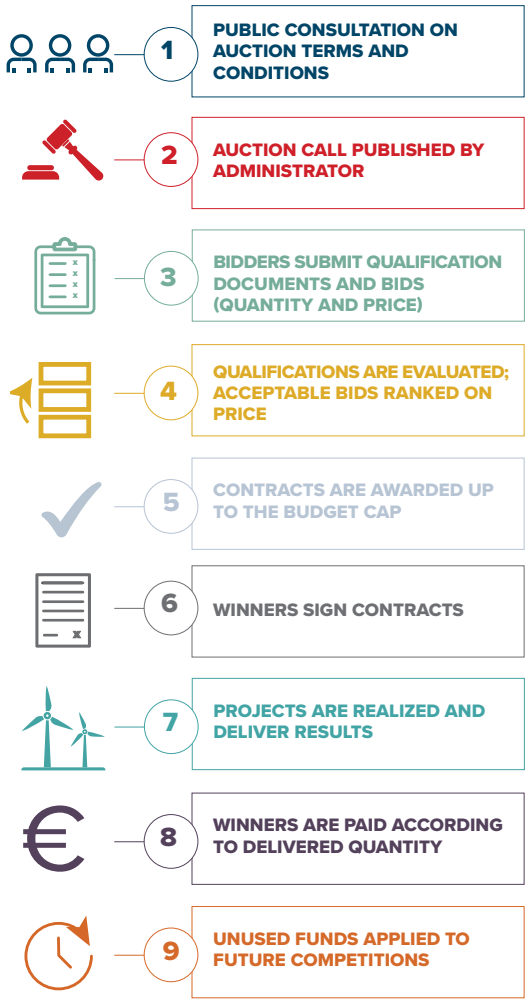
We label this climate finance design "Climate Impact Auctions." The Climate Impact Auctions (CLIMA) model can be implemented as a series of competitive auctions for results-based subsidies of climate mitigation and adaptation projects in LMICs. Financed by one or more states (or potentially by philanthropic organizations), CLIMA auctions would be administered by national or international organizations. They would supplement existing climate finance initiatives, providing an option for organizations in developing countries to earn payments for qualifying projects. Funders could set the terms of auctions to target specific technologies and/or regions.

Each auction would offer a fixed total amount of subsidies and solicit bids from qualified bidders. Winning firms could be paid according to their bid, based on measured results over a specified period. For example, a competition might be aimed at providing new, grid-connected renewable energy in sub-Saharan Africa from 2026 to 2030. Bidders would make a bid consisting of the number of kilowatt hours of power to be produced during each year, and the required subsidy per kilowatt hour. Bids would be ranked by subsidy, with the lowest bids accepted until accepting an additional bid would exceed

[10] Measurement of output is particularly easy for electricity production, even in remote settings; and the willingness to invest in renewable energy and storage is reduced because of existing fossil fuel generation.

[11] Suppose that the donor has a limited budget available, and it can either offer a fixed subsidy per unit or set the subsidy based on an auction. Assume also that the auction has a ceiling price equal to the fixed subsidy rate. If the fixed rate is high enough so that the budget is oversubscribed, then there will be a rationing process, either random or pro rata or based on time of application. All of those are in almost all circumstances inferior to rationing based on the bid price in the auction. If the fixed rate (and the ceiling bid in case of an auction) is so low that the budget is undersubscribed, then both mechanisms should attract the same projects, although the total amount paid may be lower for the auction.

Figure 5. Climate Impact Auctions process flow



the available budget. Bidders — which could be public or private entities — would be paid the subsidies only upon power delivery during the specified years, limited by their bid quantity and subsidy rate. Importantly, there must be a measured output that can be verified, as a condition for success of the results-based payment model. The process is summarized in figure 5.

The first step of this process, public consultation, is designed to ensure that the terms of the competition are well matched to needs and capabilities. Such a consultation might, for example, determine the selection of technologies that could apply to a single competition, the duration of the delivery period, restrictions on location or country of participants, and other conditions for qualification. Auctions could also include other conditions, such as requiring project proponents to meet specific objectives, including social and environmental goals. To encourage diversity, an auction might limit the share of payments payable to a single bidder or within a single region.

Second, the administrator publishes the auction call. The public call notifies potential bidders of the opportunity to earn a stream of income. This is an important aspect of the auction mechanism since it helps to publicize projects that would otherwise be unknown to any potential grant-making organization. Publicizing the auction within the relevant region, and allowing adequate time for potential bidders to develop their bids, would be a critical component of the process. In some cases, technical assistance might be offered to assist potential bidders.

Third, bidders submit qualification documents and bids. Qualification documents would normally include information that would allow the administrator to assess compliance with relevant environmental, social and ethical standards, and evidence of potential ability to execute the contract. Mitigation and adaptation projects in LMICs are intrinsically tied to development goals, so it would be important to specify any relevant development-related qualifications for projects. Standards of qualification would vary across auctions and could include various terms, including local content, ownership, employment and so on. The bid consists of a bid price and a quantity to be delivered within a given time frame. The

auction could allow a bidder to submit multiple bids at the same or different prices so that a bidder can, in principle, submit bids for more than one project, or offer bids reflecting the costs of building to different scales.

Fourth, the administrator evaluates qualifications to ensure compliance with the terms of the auction, and ranks the acceptable bids by price.

Fifth, bids are accepted up to the highest qualifying bid such that the sum of price times the quantity of accepted bids remains below the budget cap. This ranking process ensures that only the most cost-effective projects are funded; those requiring higher subsidies would be excluded. This does not necessarily mean that high-value/high-cost projects cannot be funded through a CLIMA auction, but the terms of the auction would have to be set so that those projects would be competitive.

Sixth, bidders sign contracts to supply the contracted quantities, as detailed in each bid, with subsidies set according to the auction terms. Auctions can be structured as either "pay-as-bid" or "uniform-price" (also referred to as "pay-as-clear").[12]

Seventh, successful bidders realize their projects and begin producing the committed quantities. It is important to emphasize here that there must be a measurable output that can be tracked, and that is desired by the funder. This, as noted by Clist (2016) for results-based payments generally, constrains the types of projects that may be financed through Climate Impact Auctions.

Eighth, the administrator pays out subsidies according to each firm's bid, with payment conditional on meeting the contracted supply. Note, this implies that project proponents would have to arrange financing for their projects, partly based on the anticipated CLIMA revenues. The CLIMA model does not provide ex ante climate finance but instead funds climate-related projects based on results, so it is possible that some financing might be provided by multilateral development banks.

Finally, if firms fail to supply as bid, unused budgets could be applied to future competitions or returned to the sponsors. Thus, sponsors would be fully insured against non-performance. Given the highly structured nature of government budgets, it may be most effective to rely on a third party to manage the auction process, as has been done with the Hydrogen Bank and H2 Global.

Supply risk can be mitigated by requiring bidders to post a performance bond that is returned to the bidder only subject to successful performance of the project. Matthäus et al. (2021) note that performance bonds increase the probability of projects being realized and therefore lead to higher bids. In addition, they observe that performance bonds increase the

[12] In a pay-as-bid auction, each successful bidder receives the price submitted by the bidder, while in a uniform-price auction, each successful bidder receives the highest accepted bid. Theoretical considerations suggest that uniform-price auctions are superior since they can, in principle, elicit honest bids, revealing the minimum subsidy required by bidders. Empirical evidence, however, indicates minimal divergence in the realized pricing outcomes between these two auction designs, with "pay-as-bid" potentially offering greater political appeal, since no bidder receives more than its bid, as observed by Matthäus (2020).

cost of aggressive market entry strategies designed to push competitors out of the market. In the absence of a performance bond, an aggressive bidder may bid a low price for a large quantity that it does not intend to supply, thus preventing other bidders with more realistic prices from succeeding in the auction. An appropriately scaled performance bond makes such strategic bids unprofitable. Unfortunately, performance bonds create an additional financial barrier that may be particularly burdensome in developing countries where the cost of capital is high. This consideration suggests that performance bonds should be set as low as possible, while preserving incentives for bidders to bid honestly concerning their expected volume of output. It may be possible in some situations to redeem performance bonds as physical infrastructure required to perform project obligations — such as progress on construction of a wind turbine — is put in place, prior to payment under the auction. This would help reduce the financial burden created by a performance bond.

Auctions could be administered by existing organizations, such as the Green Climate Fund, the European Bank for Reconstruction and Development or a bilateral aid agency such as Germany's GIZ, or a specialized organization such as EnDev, to minimize costs and prevent institutional duplication. The GCF's Governing Instrument states that a "results-based approach will be an important criterion for allocating resources" (UNFCCC, 2011, p. 13). We are not proposing a new institutional structure so much as proposing that existing institutions could increase the effectiveness of climate finance by adding competitively determined results-based payments to their portfolio. However, we note that the institutional requirements for providing results-based payments can be challenging, with contracting and budgets that are different from the typical aid program (Dissanayake & Camps, 2022).

Features of Climate Impact Auctions

The CLIMA model has two main features: results-based payments and competitive auctions. This combination yields numerous advantages, which we describe below. Before doing so, however, it is important to acknowledge that the CLIMA model can only be applied in specific circumstances: (a) where there is a contractible metric of outcomes desired by the donor, (b) where there is a justification for more investment, and (c) where the contract can be paid out in a reasonable time frame (Clist, 2016, 2019). For auctions to be competitive, this model also requires that (d) there be multiple projects that can compete for the subsidy.

These four criteria limit the types of projects to which the CLIMA model is applicable. As a result, existing modalities of climate finance, such as the GCF's grants and loans, would continue to be necessary for most climate-related projects; within the scope of its applicability, Climate Impact Auctions can offer a cost-effective conduit for supporting needed mitigation and adaptation projects in LMICs.

Improved selection of projects and cost-efficiency

Because of their openness to any projects meeting the auction criteria, Climate Impact Auctions can achieve improved selection of projects relative to a cost-subsidy model; the qualified firms requiring the lowest subsidy will be supported. The auction mechanism automatically identifiifes the most cost-efficient projects. In contrast, the cost-based

subsidy model is vulnerable to the risk of choosing projects based on other criteria, and must depend on ex ante claims about costs that may lack credibility. Moreover, because a bidding process is transparent, the risk of corruption is significantly reduced.

Risk allocation

Because payment is based on actual results, rather than a loan or grant given in advance, the project proponent need not provide comprehensive justification for the subsidy, and the auction administrator need not perform a comprehensive evaluation. Generating such a justification, and then evaluating it, are both time-consuming and very costly. Instead, the risk of performance is imposed on the proponent. Many projects that receive cost-based subsidies fail to achieve the targeted results, resulting in wasted funding. When there is no penalty for failure and no reward for success, the proponent may be chiefly interested in getting the subsidy, rather than delivering the project goals.

Access for smaller projects

One of the challenges with cost-based subsidies is that the application process can be unaffordable for small organizations lacking in resources. Since cost-based subsidies are paid out at the start of a project, it is important for the proponent to be able to demonstrate its capability in advance. This effectively excludes many small organizations that lack a track record of performance. In contrast, the results-based subsidy approach requires less ex ante assessment: if the proponent fails, then there is no payment.

Donor perspective

Because Climate Impact Auctions use results-based payments, they require measurement of results. This offers the opportunity for donor countries to demonstrate value to taxpayers. Grant-funded projects often have many “soft” objectives which, while valuable, may lack concreteness or measurability. With Climate Impact Auctions, since payment is tied to results, it is possible for donors to avoid two types of problems: expenditure on a failed project or expenditure on a project with results that cannot be easily measured or demonstrated to taxpayers. In addition, the use of auctions helps to ensure that the donor gets the most value for its contribution.

Effect on innovation

Climate Impact Auctions could substantially increase the demand for green technologies in LMICs. In turn, this would enhance the incentive for innovators to invest in the development of technologies appropriate to the needs of those countries. Moreover, because auctions would only pay out based on the measured objectives, they would encourage innovators to focus on ensuring the practical effectiveness of their innovations.

Cost control

Climate Impact Auctions would control costs by means of a fixed annual budget and secure cost-effectiveness through competition among a variety of green technologies. The budget size would naturally depend on the willingness of countries to finance auctions. However, a reasonable strategy is to start with one auction and then refine and replicate. With additional experience, and subject to the demonstration of cost-effectiveness, the Climate Impact Auctions approach could be scaled up.

Financial deepening

While payment based on results requires firms to raise capital rather than receiving an upfront subsidy, there is a corresponding benefit. As frequently observed, developing countries' green transition efforts are inhibited by underdeveloped financial institutions (Mulugetta et al., 2022). Climate Impact Auctions would help shallow capital markets deepen, rather than undermining them by relying only on foreign capital. One reason for the high costs of capital is that firms have uncertain revenues. The subsidies offered by Climate Impact Auctions would help to provide some stability in project revenues since the subsidy has the backing of an international institution and will be reliably paid subject to the project delivering the committed output. Thus, such subsidies would help local financial markets become deeper and acquire greater experience in financing climate-relevant projects, by providing attractive local investment/lending opportunities with stable revenues.

Potential fields of application

In this section, we comment on potential fields of application. Renewable energy installations and energy storage projects constitute the most notable opportunity to see benefit from Climate Impact Auctions; indeed, renewable energy is often already procured by national or regional energy companies through auctions. The model proposed could be applied synergistically in conjunction with such auctions, or as a replacement.

Projects that involve carbon removal may also represent attractive opportunities, provided that practical approaches for measuring their climate benefits and avoiding negative environmental effects can be developed. We see both biochar and enhanced rock weathering as deserving of further exploration, given the potential climate benefits and small scale of operations. Bioenergy with carbon capture and storage is already attracting carbon credits in the voluntary carbon market (Möllersten & Zetterberg, 2023; PuroEarth, 2024).

The use of green hydrogen in LMICs, where the H2 Global program is procuring hydrogen, might also be a good fit for Climate Impact Auctions. In principle, the approach could also be applied to adaptation projects with a measurable outcome. There is a wide range of opportunities that vary in their climate effectiveness across countries (Hahn et al., 2024; Stechemesser et al., 2024).

Renewable energy

Renewable energy is the primary target for Climate Impact Auctions, given that it represents the most compelling opportunity to replace fossil fuel power and support electrification of transportation, industry and buildings. At a small scale, EnDev and Beyond the Grid Africa have already been subsidizing mini-grids in villages in many countries (EnDev, 2021; Greencroft Economics, 2024). At a larger scale, grid-connected renewable energy is necessary to replace existing fossil fuel power production. A national or international subsidy auction for producing new grid-connected renewable energy facilities could effectively support the development of additional capacity, just as it has in India's viability gap funding auctions. To be sure, this would be complex and would require an understanding of relevant markets; in most settings it would be conducted in collaboration with the grid operator.

A key point to note is that a CLIMA auction could base payments on kilowatt hours of renewable energy delivered or on kilowatt hours of capacity installed, both of which are easily measured. Some existing projects subsidized by VCMs receive payments based on the estimated scale of emissions averted. However, payment based on emissions requires the use of a counterfactual, which is impossible to estimate accurately given the dynamism of power markets.

Crop-residue biochar

Crop-residue biochar projects are a possible future extension of the CLIMA model. Biochar is produced by heating organic material (biomass such as wood, manure or leaves) under a limited supply of oxygen. At a theoretical estimate, biochar may be able to remove up to 5.7 to 7.7 billion tonnes of carbon dioxide equivalent per year, well over 10 per cent of global emissions (Lehmann et al., 2021). Biochar can be made from crop residues such as rice husks or nutshells, which can be collected at processing facilities and then used as a feedstock in continuous biochar production. Additionally, biochar can sequester carbon in the soil for hundreds of years. There are numerous potential values from such a process, including enhanced agricultural productivity, energy production and improved local air quality (Basso et al., 2013; Hagemann et al., 2017; Yu et al., 2013).

However, more experience is needed with biochar projects to determine the potential to scale the approach, and further work is needed to develop a practical approach to measuring the desired outcomes without overly burdening small-scale agricultural producers.

Enhanced rock weathering

Enhanced rock weathering (ERW) involves spreading finely ground silicate rocks, such as basalt, to accelerate natural weathering processes. This process converts atmospheric CO_2 into stable bicarbonates that are washed into the oceans, effectively reducing atmospheric CO_2 (Lehmann & Possinger, 2020). ERW can sequester significant amounts of CO_2 with potential removal rates ranging from 0.4 to 1.9 tonnes of carbon dioxide equivalent per hectare per year (Vienne et al., 2022) while potentially delivering co-benefits for agriculture (e.g., reduced nitrogen losses, increased yields). ERW can improve soil health and increase crop yields, but is as yet untested at scale and involves considerable risks if misapplied. Once better understood, ERW may be a promising strategy for both carbon removal and sustainable agriculture (Skov et al., 2024). Currently, the costs of ERW projects depend on the source of the rock, rock grinding technology and transportation. With certain approaches, there could be reduced climate benefits or even other environmental damages (Babiker et al., 2022). Additional work would be needed to develop a workable metric for desired outcomes.

Bioenergy with carbon capture and storage

Reverse auctions for subsidies have also been proposed for bioenergy with carbon capture and storage; that is, burning biomass for energy while capturing and storing the resulting CO_2 (IEA, 2024). A survey of experts indicated strong support for auction-based subsidies in this field in particular, because of “the fact that costs are minimized through competitive bidding” (Wähling et al., 2023, p. 8). Carbon credits are already issued for bioenergy with carbon capture and storage, showing that measurement is

practical (Möllersten & Zetterberg, 2023). While carbon capture and storage projects are contentious, the fact that there is broad support for a mechanism like CLIMA in this underdeveloped technology suggests it could be a viable possible application. However, additional work would be needed to develop a metric that maximizes climate benefits and avoids unintended consequences, such as harm to biodiversity or air quality.

GLOBAL CLIMATE FINANCE: PERSPECTIVES FROM CANADA AND GERMANY

Germany and Canada are leaders in calling for donor countries to meet the US$100-billion climate finance goal, as articulated in recent public letters (Auswärtiges Amt, 2022; Government of Canada, 2023a). These two countries, however, have demonstrated different self-conceptions of "contributing their fair share." Oxfam's analysis of reported climate finance by country estimates that Canada's contribution per year in 2019 and 2020 was equivalent to grants totalling US$200 million, while Germany (which has Gross National Income approximately 2.5 times that of Canada) contributed the equivalent of US$3.84 billion, not including indirect contributions through the EU (Zagema et al., 2023).

The two countries have emphasized the importance not only of achieving the US$100-billion annual climate finance goal, but of allocating 40 per cent to 50 per cent of it to adaptation. They have also committed to trying to reduce barriers to climate finance access (Auswärtiges Amt, 2022).

Canada

Canada's current commitment to climate finance in developing countries is C$1.06 billion (US$0.78 billion) per year over the next five years (Government of Canada, 2024). This amount, which is less than 1 per cent of the $100 billion per year goal, is relatively small given that Canada's share of GDP among donor countries was 3.9 per cent in 2022 (World Bank Group, n.d.). Canada's commitment grant financing is 40 per cent of the total, with at least 40 per cent of funding targeting adaptation projects (Government of Canada, 2023b). The increase in grant financing, including adaptation projects, represents an important step toward achieving global climate goals, but the total amount of support seems relatively low when compared with the Canadian government's expressed commitments.

One feature of Canadian climate finance stands out. The Canadian government has established a set of performance indicators for different aspects of both mitigation and adaptation. For example, indicator 1200a is "Area (hectares) of farmland, rangeland, and other managed agricultural landscapes under climate-smart agriculture management as a result of Canada's Climate Finance" (Government of Canada, 2023b). Using measurable goals is appealing, and it implies that there are measurable outcomes, which is one of the requirements for applying the CLIMA model. A biochar or enhanced rock weathering subsidy auction, as described above, could meet the requirements for "climate-smart agriculture management," which is defined as targeting three objectives: "(1) sustainably increase agricultural productivity without harming nature; (2) adapt and build resilience of

agricultural and food security systems to climate change and; (3) reduce greenhouse-gas emissions from agriculture and agricultural practices."

Canada estimates that its C$2.65 billion (US$1.9 billion) of climate finance "has reduced or avoided over 223.7 megatonnes of GHG emissions" (Government of Canada, 2023c). Given that at least some Canadian climate finance has been allocated to adaptation rather than mitigation, this implies a cost of at most US$9 per tonne of emissions averted. Canada's current carbon tax, by comparison, was C$80 per tonne as of April 1, 2024. Canada's investment in climate finance appears to be a exceptionally good deal.

A notable additional feature of Canada's climate finance is its commitment to requiring that all climate projects it finances "must integrate gender equality considerations" and should "achieve a measurable change in skills, awareness, or knowledge that will contribute to gender equality." The CLIMA model has the flexibility to incorporate this kind of social consideration into auctions, as the terms and conditions could be designed to include such requirements (e.g., bidders could be asked to include a target for female employment and training).

Canadian climate finance would benefit from applying the Climate Impact Auction model to at least some of its assistance, since it could not only increase efficiency, but help it to meet some of the goals established in its performance indicators.

Germany

In 2022, Germany's budgeted international climate finance reached 6.4 billion euros (6.9 per cent of the US$100 billion goal) compared to its share of GDP among donor countries of 7.4 per cent (World Bank Group, n.d.). More recently, however, it is facing considerable challenges in maintaining this level of funding. It has been criticized recently for green-tagging non-climate aid, labelling — among others — food aid connected with the war in Ukraine as climate finance (Schwarz, 2023). Shifting some resources to Climate Impact Auctions may enable the German government to maintain public support for climate finance through providing direct evidence of impact.

The German government's international climate policymaking is divided between two ministries: the Ministry for International Cooperation and Development (BMZ) and the Ministry of Economic Affairs and Climate Action (BMWK). In addition, Germany is closely involved with the international climate policies of the European Union. In terms of results-based payment mechanisms, Germany has been active. It has already supported EnDev and Beyond the Grid Africa. In addition, Germany is leading the H2 Global project, which uses auctions to procure and deliver green hydrogen from LMICs to European buyers, with subsidy financing from the BMWK. Thus, Germany already has a sophisticated understanding of the value and operation of auction mechanisms in supporting investments in green projects but, as described in this paper, there is room for an increase in the use of Climate Impact Auctions in other fields.

As a member of the EU, Germany will receive funds from the EU's Carbon Border Adjustment Mechanism, which will impose tariffs on certain high-carbon imports to keep

European industry on a level playing field, given the costs of carbon pricing in Europe. One of the important unresolved issues around this mechanism is the allocation of revenues. Assuming some share is allocated to fostering mitigation in LMICs, as recommended in a Bellona Foundation Report (Stocchetti & Nagell, 2024), it would make sense to allocate it to results-based projects, given that the European carbon mechanisms are results-based.

CONCLUSION

International climate finance is critical to successfully meeting global climate change goals. Without financial support, low- and middle-income countries that are the source of over 70 per cent of greenhouse-gas emissions cannot be expected to deliver the cuts to emissions that are needed for the protection of our climate. High-income countries have committed to providing support to low- and middle-income countries; still, it is critical that (a) countries live up to their commitments and (b) that committed financing deliver the greatest possible impact. Too often, existing climate finance has outcomes that are poorly defined and unmeasurable, and furthermore lacks incentives designed to maximize benefits. The current focal points, for discussion of climate finance through the UNFCCC process, are the New Collective Quantified Goal and Internationally Transferred Mitigation Outcomes. The first focuses on how much finance is to be provided to developing countries, rather than how carbon emissions can be averted. The second focuses on how rich countries can minimize the costs of achieving their domestic climate goals by buying offsets from developing countries. In effect, neither directly addresses the requirement to accelerate overall reductions of greenhouse-gas emissions.

Results-based auctions for climate subsidies — whether for mitigation or adaptation — have the potential to achieve cost-effective, measurable climate-related goals. The Climate Impact Auctions model, employing this tested mechanism, could be applied in a variety of fields, including renewable electricity generation.

Because they apply a pay-for-results model, auctions would be particularly attractive for donors with a preference for competitive, market-type mechanisms. Thus, the incorporation of auctions by existing institutions could help drive additional funding support. It would also allow such institutions to demonstrate quick wins by funding smaller-scale projects. Equally important, it is possible to scale up auctions by offering them in multiple regions with multiple targets.

Climate finance needs are complex and multifaceted, and different approaches should be applied in different circumstances. Where appropriate, Climate Impact Auctions could be an effective tool to achieve significant progress in the transition to a low-carbon and climate-resilient world.

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