Docking into a global carbon market: Clean Investment Budgets to finance low-carbon economic development*

Gernot Wagner**, Nathaniel Keohane, Annie Petsonk, and James Wang
Environmental Defense Fund

17 March 2009

Forthcoming in: *The Economics and Politics of Climate Change* (Oxford University Press, 2009)

Financing the transition to low-carbon economic development must be the focus of any framework to encourage developing countries' participation in the global carbon market. It needs to do so with the aim of eventual full participation in carbon markets while maintaining the core market's integrity and meeting the environmental goal of avoiding long-term warming in excess of 2°C above pre-industrial levels. This paper proposes a mechanism to achieve these goals: Clean Investment Budgets (CIBs).

Under this proposal, emerging economies could adopt binding limits on greenhouse gas emissions, set above current levels but within economic and environmental constraints. Such a step would enable these nations to access carbon finance immediately and far more efficiently than existing and proposed mechanisms. Moreover, the growth increment – the portion of the CIB in excess of a nation's actual emissions – provides a pool of readily available emissions allowances that could be leveraged in carbon markets, financing investments in renewable and low-carbon energy generation, energy efficiency, and technology transfer. CIBs would thus reward early action taken by emerging economies, providing them with a source of capital to enable a rapid transition to a low-carbon economic development path.

1 Introduction

Different actions by countries with different circumstances will need different docking stations of support. So what tools will you create within the climate change regime to deliver on adaptation and mitigation? How will you use those tools to develop a self-financing climate compact?

—Yvo de Boer, Executive Secretary, United Nations Framework Convention on Climate Change[1]

---

* Our deepest appreciation goes to Sabeen Ali, Kevin Gorman, Stanislas de Margerie, Stephanie Mandell and Clare Sierawski for their tireless research and assistance. Many thanks also to Richie Ahuja, Dan Dudek, Jason Funk, Peter Goldmark, Sasha Golub, Steve Hamburg, Jennifer Haverkamp, Kristen Hite, Ruben Lubowski and Kyle Meng as well as other current and former colleagues at Environmental Defense Fund for invaluable comments and suggestions. We are also indebted to Jos Cozijnsen, Leif K. Ervik, Jeff Frankel, Christian Hald-Mortensen, Cameron Hepburn, Michael Oppenheimer, Pedro Piris-Cabezas, José Eduardo Sanhueza, Christian Schumer, and others who have reviewed and commented on previous drafts of this proposal and provided feedback at discussions and presentations in Accra; Beijing; Cambridge, MA; London; New York, NY; Poznan; and Washington, DC. Finally, we thank Stève Gervais and Pawel Olejarnik at IEA for providing emissions data. All remaining errors are our own.

** Corresponding author. Environmental Defense Fund, 257 Park Avenue South, New York, NY 10010. gwagner@edf.org.

1 Statement at the high-level segment at the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol, Poznan, Poland, 11 December 2008. Full remarks available at: http://unfccc.int/files/press/news_room/statements/application/pdf/cop_14_hls_statement_de_boer.pdf

A central challenge of any new international climate agreement is financing the transition to low-carbon economic growth in developing countries. Avoiding dangerous climate change will require concerted global action to reduce greenhouse gas (GHG) emissions. Limiting the long-term increase in global mean temperature to two degrees Celsius (2°C) above pre-industrial levels – which many scientists identify as a key threshold to avoid catastrophic climate change – will not be possible without emissions reductions in all major emitting countries. Nor can that goal be achieved absent a framework that makes economic development an integral part of addressing climate change.

These twin challenges of emissions reductions and economic growth can both be addressed by channeling capital flows towards investments in emissions reductions in developing countries, resolving the usual tension between equity and efficiency. Developing countries offer a cornucopia of low-cost abatement opportunities, largely by decoupling economic development and carbon emissions. At the same time, the immediate and sizeable investments in low-carbon economic growth that are crucial to curbing emissions in the narrow time window available for averting massive climate shifts can only happen with the engagement of capital markets in the world's advanced economies.

A framework that delivers substantial financing for low-carbon economic growth in emerging economies should satisfy four goals.

First, it should provide emerging economies sufficient access to capital to drive low-carbon economic growth. This capital cannot simply be delivered: it must be deployed in a way that decisively breaks the link between economic growth and carbon – driving economic growth up and GHG emissions down.

Second, the framework should prepare emerging economies for eventual participation as full partners in a global climate regime. A particular need is rapid development of the technical, institutional and human capacity to effectively limit and ultimately reduce GHG emissions, starting with credible and comprehensive measurement, reporting and verification (MRV) of current emissions.

Third, the framework must be commensurate with the capacity of nations and markets both to generate and to absorb this new set of resources. In particular, it needs to be consistent with maintaining the integrity of the core compliance market, which initially will largely consist of industrialized country markets.

Fourth, the framework must be consistent with environmental integrity defined by a goal of avoiding long-term warming in excess of 2°C above pre-industrial levels, which requires a reduction of global GHG emissions on the order of 50% below current levels by 2050.[2] In taking this as our goal, we are explicitly adopting a science-based approach that treats climate change fundamentally as a problem of risk management rather than consumption smoothing.[3]

Many proposals have been put forward to meet these and similar goals. Some argue for massive increases in official development assistance (ODA). A second set of proposals revolves around shares of proceeds of auctions of the emissions allowances of industrialized nations and their firms. Third are levies on a range of activities ranging from emissions trading transactions or financial transactions in general to ones on aviation and shipping, among others. Fourth is compensation for reductions in emissions from deforestation and degradation in developing countries (REDD). A fifth proposal focuses on maintaining the Kyoto Protocol's Clean Development Mechanism (CDM) but applying a discount to its certified emission reductions.[4]

All of these proposals are important. None on its own, or even in the aggregate, is likely to be sufficient either in terms of revenue generation or in terms of incentive delivery.[5] Moreover, it is not at all clear that taxpayers and politicians in industrialized nations will be willing to direct

---

2 See appendix for more details on the science.

3 See Weitzman (2009) and Yohe *et al.* (2004) on the point of risk management versus consumption smoothing. Keller *et al.* (2005) similarly employ economic analysis in the service of a science-based target.

4 For CDM reform see Hepburn (2009) and Petsonk (2007), among others, and our own more detailed discussion in section 1.2 below.

5 See section 3.1 on the need of funds and the inadequacy of the size of current financing proposals.

governmental instrumentalities to provide the necessary funds – a concern of particular relevance for the first three proposals. This paper outlines a new mechanism meant to build upon and complement the proposals above.

1.1 A proposal: Clean Investment Budgets

Under our proposal, emerging economies could voluntarily adopt domestically enforceable limits on the GHG emissions from a substantial fraction of their economies – with the limit set initially *above* current levels, consistent with a global 2°C goal. We call this approach adopting a "Clean Investment Budget" (CIB). In particular the growth increment, the portion of the CIB in excess of a nation's actual emissions, provides a pool of emissions allowances that could be leveraged in existing and future carbon markets in industrialized countries – financing investments in renewable and low-carbon energy generation, energy efficiency, and technology transfer. CIBs would thus reward early action by emerging economies, providing them with a source of capital to enable a rapid transition to a low-carbon economic development path.

Countries could use their CIB allowances in a variety of ways: for example, as collateral to secure private financing; to repay equity or debt finance in clean energy projects, with the payment tied to the emissions reductions achieved; or to provide grants for institutional capacity such as emissions registries and MRV capability. The flow of capital would increase as a country progressed through a series of performance benchmarks. Over time, as low-carbon investments matured, reductions in emissions would enable those nations to grow their clean investment capital accounts, making more surplus allowances available for leveraging even larger investments in new technologies and infrastructure.[6]

CIBs represent a particular application of a broader idea that has gained momentum in the international arena: "docking stations," or flexible mechanisms to bring a wide range of countries into a global climate regime.[7] In the short time between Poznan and the 2009 Copenhagen Conference of the Parties, it is vital that nations elaborate the concept of docking stations

[6] See section 3 on more detail on financing and leveraging mechanisms.
[7] See Petsonk (2009) on the legal aspects of docking stations.

further, and develop the notion into concrete tools that will enable a self-financing climate compact, as UNFCCC's Yvo de Boer proposes. To meet this challenge, docking stations could take on several forms. A new compact could enable tropical forest nations to dock into the carbon market if they reduce emissions from deforestation and forest degradation (REDD). Another version could use innovative tools to generate adaptation funding and enable small island developing nations to dock into that funding. CIBs represent a third docking station, aimed at emerging economies.

1.2 Relationship to the existing literature

We are not the first to propose granting developing countries emissions targets that exceed current emissions. "Premium budgets" were first proposed over a decade ago (EDF 1997), and subsequently developed by Oppenheimer and Petsonk (2004), among others. Stewart and Wiener (2003) have also proposed allocating "major developing countries allowances above their existing emissions. That would provide headroom – not hot air – for future growth and profitable allowance sales that attract investment while also reducing costs to industrialized countries."[8] The contribution of this paper is to present a detailed proposal for implementing the approach, show how it can be consistent with maintaining the core market integrity as well as a goal of limiting warming to 2°C, discuss the design of financing mechanisms that can provide "carbon leverage," and explore practical issues of implementation.

By affording emerging economies clean investment budgets set initially above current emission levels, the CIB concept follows the principles of "common but differentiated responsibility" and equity, as elaborated by Su Wei (2008), who noted the need to assure development space and carbon space for developing countries while promoting the transfer of environmentally friendly technologies from industrialized to developing countries. Zou Ji (2008) has developed one possible institutional design in the form of a body, parallel to the subsidiary bodies of the UNFCCC, that would develop public-private partnerships by linking public finance with carbon

[8] See Frankel (2008), who proposes "growth budgets" with initial allowance allocations based on business-as-usual (BAU) paths for major emitting developing countries. Also see Wiener (2008) and Olmstead and Stavins (2006).

markets, capital markets, and technology markets, leveraging larger amounts of private finance by smaller initial amounts of public finance.

Hall, Levi, Pizer and Ueno (2008) have laid out other ways for developing countries to engage in the international process and group these efforts into three broad areas: domestic policy improvement, international financial mechanisms, and private and public diplomacy. CIBs fall chiefly into the second category but combine elements of all three.

CIBs stand in clear opposition to other proposals that focus on more incremental measures to engage developing nations without generating large-scale capital flows for low-carbon development. Sectoral standards or technology requirements may have a place in domestic policy-making to achieve emissions reductions, especially in sectors (like energy efficiency in commercial and residential buildings) where market imperfections appear to persist. But such command-and-control approaches are inadequate to meet the scale of the challenge: they fail to provide an economic incentive for cost-effective abatement, and tend to stifle rather than stimulate technological innovation. A second approach, intensity targets, may limit emissions per unit of economic output. But even if emissions intensity falls, emissions may continue to rise – especially in a context of robust economic growth. Moreover, a reduction in emissions intensity on its own does not yield a readily measured reduction in emissions, undermining trading and limiting the role for carbon markets, which would ultimately lead to more emissions.[9]

Approaches that rely on project-based offsets, like the existing Clean Development Mechanism (CDM), suffer similar drawbacks. The CDM is insufficient to provide a supply of financing at scale, due to systemic bottlenecks in the approval process and the difficulty in proving "additionality" (that is, whether credited activities provide real emissions reductions in addition to what would have occurred in the absence of a project).[10] At the same time, the CDM fails to provide any incentive or preparation for developing countries to eventually reduce their own

[9] See Hall et al. (2008) for a more detailed discussion of emissions standards and intensity targets.

[10] Wara and Victor (2008) lay out some of the inadequacies of existing CDM and offset tools in more detail. Axel Michaelowa (2005) as well as Cameron Hepburn (2009) in this volume provide perspectives for CDM reform that would address some of the current shortcomings.

emissions; indeed, it creates a perverse incentive for countries to refrain from accepting emissions targets in order to keep receiving funding from CDM.

By contrast, CIBs have the potential to bring developing countries into a global carbon market framework in a way that achieves early emissions reductions while respecting the principle of common but differentiated responsibilities. Limits on absolute emissions, initially set slightly above current levels and covering a substantial fraction of a nation's economy, can help ensure environmental integrity while simultaneously leveraging carbon markets in the industrialized world as a source of funds to drive low-carbon economic development.

1.3 Overview of the paper

The rest of the paper proceeds as follows. Section 2 describes how CIBs might be determined and uses a simple numerical example for illustration. Section 3 discusses the design of mechanisms to deliver finance necessary to achieve maximum emissions reductions. Section 4 lays out clear and measurable performance standards and discusses compliance and enforcement. Section 5 concludes.

2 Determining Clean Investment Budgets

2.1 Allocation of emission allowances above current levels

It is useful to think of a CIB as imposing a limit on emissions from a substantial fraction of a country's economy – with that limit initially set above current levels. In an international climate agreement that allows emission trading among countries (as the current Kyoto Protocol does, and as its successor likely will), however, no country truly accepts a *fixed* limit on its emissions: rather, each country commits itself to holding emission allowances at the end of each compliance period equal to the country's GHG emissions over that period.[11] A country accepting a CIB

[11] We are indebted to Leif K. Ervik for succinctly expressing the nature of country obligations in an international climate regime. To state the matter precisely, Article 3, Paragraph 1 of the Kyoto Protocol commits each Party to emit no more than its allowable level. While Annex B of the Protocol set out specific emissions targets relative to 1990 levels, these did not represent fixed limits: rather, those allowed amounts can be changed by a country's

would take on the same fundamental commitment to cover its emissions with allowances in each compliance period. Note that this commitment is necessarily denominated in absolute terms – that is, in tons of emissions, rather than as an intensity standard or other rate-based measure.

The Kyoto Protocol itself provides a precedent for CIBs. Australia ratified the Protocol with an emissions budget set at 8% above its 1990 baseline. Similarly, the European Union's Kyoto Protocol burden-sharing agreement set some countries' emissions above 1990 levels.[12] As in the Kyoto Protocol, the initial CIB allocation would be expressed as a quantity of Assigned Amount Units (AAUs). Unlike the Protocol, however, a CIB country's obligation could either cover its emissions economy-wide, or cover emissions from its major emitting sectors only. Such a multi-sectoral approach would accommodate the difficulty of establishing a credible MRV system, and allow emerging economies to participate sooner. Of course, the sectors covered by a CIB would have to be chosen to represent a substantial fraction of the country's economy and to minimize the possibility of within-country leakage.

The actual CIB – the assigned allowance allocation – should be determined in advance for at least two successive commitment periods, to strengthen the incentive countries have to comply with their commitments in the first period.[13] The second period's budget could be set at or below the level of the first, to put CIB countries on a path toward a high-technology, low-carbon economy.

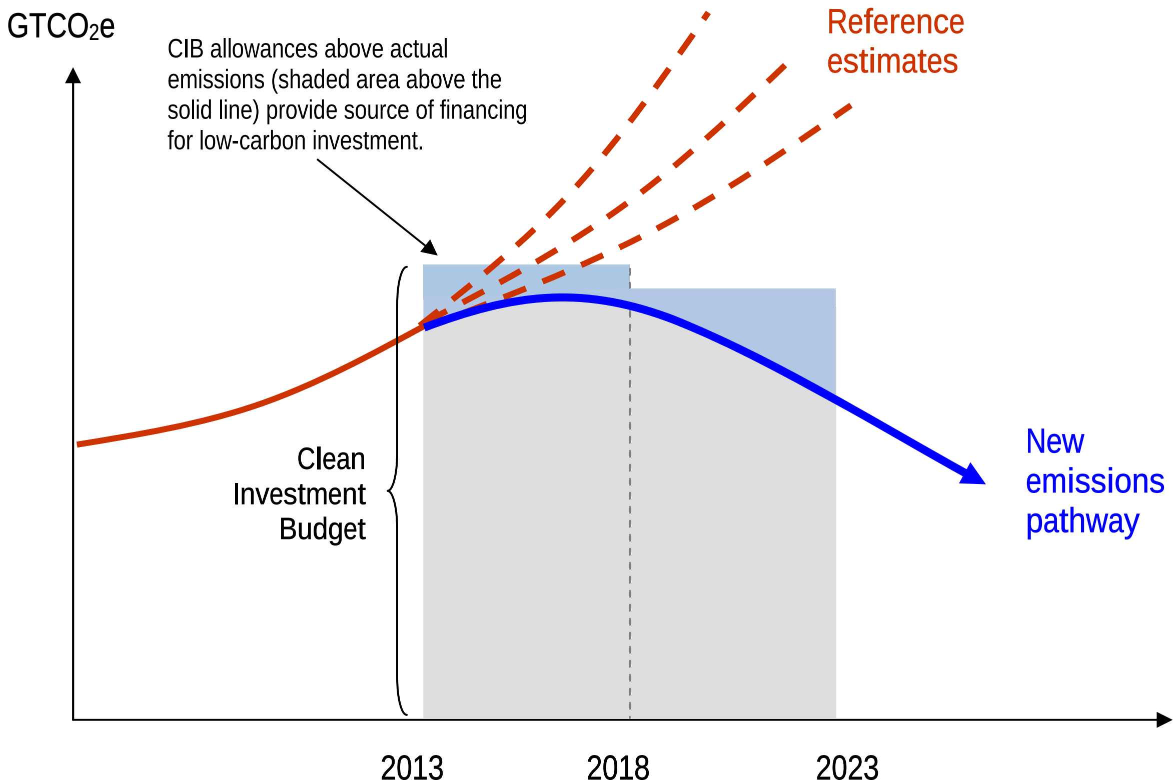
Figure 1 illustrates a hypothetical CIB over two five-year commitment periods starting in 2013. The rising dashed lines labeled "Reference estimates" represents projected emissions under "business-as-usual.". The lower solid line represents the emissions path after investments in low-carbon energy sources and energy efficiency, among others made possible by the CIB.

participation in one of the Kyoto flexibility mechanisms – e.g., CDM, Joint Implementation (JI), or emissions trading in AAUs.

[12] Note, however, that these targets with positive percentages were not "growth budgets" per se but only a function of the base year used. In the case of Spain, for example, emissions had already grown above +15% of 1990 levels – it's target under the burden-sharing agreement – by the time the agreement was reached in 1998.

[13] Helm, Hepburn and Mash (2003) note the trade-off between commitment and flexibility: ex ante commitment to reduction targets spanning two commitment periods removes some options for readjusting policies within the two time periods.

Figure 1: Clean investment budgets reward early action



A CIB for an individual country would be set as a percentage above a historical base year, and would be above a reasonable expectation of "business as usual" emissions during the early years of the program.

Taken as a whole, meanwhile, the *sum* of CIBs must satisfy two constraints. The first is market integrity: compliance markets in industrialized countries must be able to absorb the number of surplus CIB allowances available for sale without significantly depressing the allowance price. The second constraint is environmental integrity: the sum of all nations' CIBs, in conjunction with commitments by industrialized nations, must be consistent with limiting global warming to 2°C above pre-industrial levels – what we refer to as a "2°C global emissions reductions pathway." Before discussing those constraints in detail, however, we illustrate the concept with a simple quantitative example.

2.2 A numerical example

The concept of CIBs might be best illustrated via a numerical example. Suppose Mexico, for example, were to adopt a CIB beginning in 2013, and it negotiated a CIB set at 750 $MtCO_2e$ per year, for ten years.[14] In this illustration, by joining the global carbon market on this "early action" basis, Mexico would obtain immediate access to an amount of surplus allowances roughly equal to 80 $MtCO_2e$, the area above annual mid-range BAU projections and below the annual allocation of 750 $MtCO_2e$. At a price of \$20/tCO_2e, the surplus would be immediately worth roughly \$1.6 billion; at \$30/tCO_2e, it would be worth roughly \$2.4 billion. Leveraged at only 2-to-1, Mexico could secure a loan of anywhere between \$3 to 5 billion, depending on the allowance price.

This system could provide a significant amount of up-front capital to invest first in harvesting the low-end of the marginal abatement cost curve (MACC), where there are likely to be many no-regrets (i.e. low, no, and even negative cost) emission reduction opportunities. If this source of financing could enable nations to access otherwise inaccessible rate-of-return abatement projects, whose success could in turn free up more surplus allowances to be added to the escrow amount to secure even more financing, it would begin to address the financing needs identified by Mexico to pay for its recently proposed emissions reduction commitments.

2.3 Ensuring market and environmental integrity

CIBs have a demand and supply component. The demand for CIBs is given by the required upfront capital expenditures and a discounted stream of expected costs (net of potential gains) from emissions reductions. The supply side focuses on how many CIB allowances would be available in the first place. We focus on this second aspect of CIBs, and distinguish two constraints: the *economic* constraint represented by the ability of compliance carbon markets to absorb an influx of new allowances, and the *atmospheric* constraint implied by a global 2°C

[14] 750 $MtCO_2e$ roughly corresponds to Mexico's BAU projections for 2016, allowing it a surplus component for the first three years of the program. For simplicity, we are keeping the budget constant across two commitment periods.

pathway. Because CIBs offer a "premium" above actual emissions in the initial years of the program, it is crucial that they be designed with these constraints in mind.

Several safeguards can help to ensure market integrity. First, the number of CIB allowances available for sale by developing countries could be tied to their progress in meeting performance benchmarks. In particular, nations that lack well-developed emissions measuring and monitoring systems could be required to hold significant portions of their CIBs in reserve to reduce the risk of over-selling; these reserve requirements could be loosened as the nations' abilities to measure and report actual emissions improve. This "metering" of allowances would prevent a sudden influx of allowances into carbon markets, while at the same time providing continuing incentives for developing countries to improve their institutional capacities.

Second, as a practical matter, nations with CIBs might not wish to sell all of their surplus allowances at the outset. Three reasons account for this quasi self-regulation of the supply of allowances that flow into the market. For one, and most significantly, CIB allowances are most valuable when leveraged to generate a multiple of investment potential from the actual value of allowances.[15] Second, countries may wish to bank or save some allowances to cover potential emissions increases in the future, or to sell at a later date when they have reduced emissions even further and allowance prices have risen. The potential for banking to moderate and stabilize allowance markets has been explored in a variety of similar contexts, e.g., REDD markets and the EU ETS.[16] Lastly, the market for credits from CDM projects has typically been a sellers' market; i.e. demand for credits exceeds supply (Wara and Victor 2008). Such excess demand suggests that the market could absorb a further increase in supply without threatening market integrity or flooding compliance markets.

A full check of market integrity would require a complete model of the carbon market, ideally in a general-equilibrium framework. For present purposes we rely on a back-of-the-envelope calculation to derive an order-of-magnitude estimate of the total value of surplus CIB allowances

---

[15] See section 3 on leverage for a more detailed discussion of this concept.
[16] See, e.g., Piris-Cabezas and Keohane (2008) or Ellerman and Montero (2007).

consistent with market integrity. The global mandatory carbon market now largely consists of the EU Emissions Trading Scheme (ETS), which accounts for about 2 of 45 $GtCO_2e$ emitted globally in 2008. The United States would add another 6 $GtCO_2e$. A price of \$20-30/tCO_2e would imply a value of \$40-60 billion for EU ETS, compared to \$160-240 billion for the EU plus U.S. carbon markets.[17] If 10 percent of a combined EU-U.S. carbon market consisted of allowances from CIB countries, CIBs could deliver a total of \$16-24 billion in a given year or, roughly speaking, emissions of 800 Mt CO_2e per year at a price of \$20-30/tCO_2e.[18]

With an estimate in hand of how many allowances carbon markets could absorb, we can move on to an assessment of environmental integrity. Given the uncertainties associated with climate physics and the amount of past and future emissions, it is difficult to determine with precision the surplus allowances available for a given temperature goal. However, the number of tons derived through the back-of-the-envelope market calculation – 8 GTCO2e over ten years – is small enough not to tip the physical balance one way or another. In the appendix, we demonstrate that CIBs of this magnitude could indeed be consistent with the 2°C target, using a standard climate model. Moreover, because CIBs are premised on a future of at least a decade or more of constraints on emissions – including mandatory, progressively more stringent caps on emissions in industrialized nations – the advent of CIBs would give rise to a powerful incentive to harvest emissions reductions in developing countries as soon as possible, and bank or save the resulting surplus allowances for the future, when the supply of emissions allowances will become more scarce. Bankability of CIB allowances, coupled with limits on the amount of CIBs

[17] Given the lack of a global carbon market and the lack of any compliance market beyond 2012, it is difficult to pinpoint an appropriate CIB carbon price. EU ETS allowances with a settlement date of December 2012 have traded between €15and €30/tCO_2e, or roughly \$20 to \$40/ tCO_2e, between 2005 through 2008. January and February 2009 have seen prices decrease to €10 (or \$13) due to the global economic slowdown, but prices are very likely to increase once longer-term economic projections turn more optimistic. We take \$20 to \$30/ tCO_2e, the lower range of the long-term price band as a rough estimate of allowance prices beyond 2013.

[18] This is clearly a rough estimate. Several factors would influence the actual size, including if and when a domestic cap-and-trade system comes into force in the United States and how much room the system opens for international allowances. The back-of-the-envelope calculation also misses an important point a more comprehensive – possibly general equilibrium – analysis would consider: any country joining the carbon market through this program necessarily expands the market itself. This is particularly true since not all allowances would be traded north-south but also within each region and country.

allocated consistent with the 2°C constraint, can thus help ensure that CIBs satisfy and, in fact, advance the crucial criterion of environmental integrity.

3 Delivering financing to achieve maximum emissions reductions

The primary goal of CIBs is to enable emerging economies to finance the transition to a low-carbon economy. Nations would be able to use CIB allowances to finance investments in a wide range of areas such as energy efficient buildings (or retrofits) and renewable electricity generation, among others.[19] CIB funds could also be used to fulfill the need for quick development of capacity for monitoring and independent verification of emissions. Initially, countries receiving CIBs may not be equipped to monitor, report and verify emission reductions in line with best-practice or even minimum standards to ensure the integrity of allowances and, thus, the core carbon market. A portion of CIB funds can and should be used to build these fundamental reporting tools and help the country move along the path towards full accession into the global carbon market.

Realizing the goals of the CIB proposal, however, requires more than simply granting these countries a generous allotment of allowances: a framework must be erected to ensure that CIB funding is well spent. This section discusses how CIB countries could access compliance markets, suggests how CIB allowances could be used to finance development, and discusses the range of financing mechanisms that could be employed.

A key goal in designing financing mechanisms is employing two types of leverage mechanisms: carbon and financial leverage. "Carbon leverage" – essentially, price discrimination – allows getting more than one ton of emissions reductions (on average) for every CIB allowance sold into global carbon markets. Such leverage is made possible by the gap in abatement costs between industrialized countries and the developing world. Developing countries have abundant low-cost

[19] Some of these programs could be modeled after existing mechanisms for Green Investment Schemes (GIS) of sales of AAUs mostly from Eastern Europe and Russia, possibly with additional safeguards.

(or perhaps even negative-cost) opportunities for emissions reduction, but many of these opportunities require initial financing that simply is not available, particularly in credit-constrained economies. "Financial leverage" refers to perhaps a more traditional interpretation of leverage: using CIB allowances as collateral to gain access to more financing in form of "carbon loans" or other financing partnerships.

3.1 Access to compliance markets as a source of carbon finance

The cornerstone of the CIB approach is to provide emerging economies with a source of up-front capital, created by the value of their CIB allowances in excess of current emissions. Ultimately, once a credible and reliable system of emissions monitoring had been established, and a country had managed to bend its emissions trajectory downward, a country accepting a CIB would be able to sell surplus allowances – those above their actual emissions but below their allowance allocation (recall the blue-shaded area in Figure 1).

In the initial years of the program, however, a country's use of CIB allowances would be subject to additional oversight to help ensure that they financed reductions in long-run emissions. Rather than being issued directly to participating countries, CIB allowances could be held by an independent intermediary acting as trustee. This approach would balance the need to give developing countries access to capital with the imperative that the money be used to help countries transform their economies.[20]

One practical detail concerns the use of AAUs, since the AAU market (which involves country-to-country trades) has seen only a handful of trades to date. To boost liquidity, a nation might wish to hold its CIBs in escrow and borrow against them, or it might wish to devolve them to national firms and emitters, so that they could be freely traded. Liquidity could be increased further by allowing CIB allowances to be sold directly into compliance markets such as the EU-ETS and a future U.S. emissions market. In any case, transfers of CIB allowances, and security

[20] Developing countries may well argue that industrialized countries have "borrowed" such tons all along, no strings attached. This is certainly true. However, it this argument would miss the binding environmental imperative and the opportunities additional CIB funds can provide in the required global transition to a low-carbon economy.

interests in them arising from pledging them as security for loans, would need to be recorded in electronic registries, as is already done to a great extent under the registries of the Kyoto Protocol and other cap and trade systems.

Even with substantial safeguards in place, CIBs offer a potential solution to the current dramatic shortfall in carbon finance. Current sources of funding are roughly an order of magnitude smaller than what is required. UNFCCC (2007) provides a comprehensive review of financing needs and derives a global figure in the order of $200 billion per year by 2030, a third of which is needed in developing countries.[21] By comparison, existing multilateral funding is on the order of a few billion dollars per year (Table 1). CDM stands out as the largest such source with funds of $6 billion in 2006 and $13 billion in 2007 (Capoor and Ambrosi 2008). UNFCCC (2008) summarizes alternative policy proposals, which come closer to filling the gap, but are still not adequate by themselves (bottom half of Table 1).

[21] This $200 billion figure assumes a mitigation scenario that achieves global GHG emissions reductions by 25 percent below 2000 levels by 2030. Similarly, IEA (2008) estimated the cumulative need of financing in non-OECD countries in the order of $27 trillion by 2050 to decrease global emissions by at least 50% below current levels by 2050.

Table 1 Current and proposed funding towards mitigation

Existing	*per year, in billion $*
Official Development Assistance (ODA)	*‹ 2*
Global Environment Facility (GEF)	*0.25*
World Bank's Climate Investment Fund	*6 (total pledged over 3 years)*
CDM	*6-13*
Proposals	*per year, in billion $*
CDM levy (EU, others)	*0.2-1.7*
JI, market levy (Colombia, LDCs)	*‹ 2.25*
AAU auctions (Norway)	*15-25*
CO2 tax (Switzerland)	*18.4*
Air travel levy (LDCs)	*4-10*
Bunker fuels levy (LDCs)	*4-15*

Sources: UNFCCC (2008), Table 3; Capoor and Ambrosi (2008)

CDM is the largest current source of funds for mitigation in developing countries. CDM reform is sorely needed, especially given current inefficiencies in the system. While the criticisms leveled at CDM often focus on operational considerations such as high transactions costs and concerns about additionality, two other concerns are more fundamental (Hepburn 2007). First, even in the best of circumstances CDM is a very expensive way to reduce emissions in the developing world: the price paid, which is currently driven by demand in the European Union compliance market, is far above marginal cost. As a result, CDM cannot achieve the "carbon leverage" crucial to reducing emissions at the required scale. Second, CDM currently not only fails to reduce net emissions but actively undermines the incentives for participating countries to commit to limiting their own emissions (Hepburn 2007 and 2009).

A number of proposals have been advanced for addressing CDM's environmental shortcomings. The most important of these, CDM discounting, would be environmentally essential if, in the context of attempting to keep options open for limiting warming to 2°C, the Parties opted to reform the CDM primarily by broadening it to sectoral or programmatic CDM.[22] Expanding the CDM to programmatic and sectoral levels could increase the scope for financial transfers to developing countries. But the steep discount on Certified Emission Reductions (CERs) that would have to accompany such expansion in order to keep the 2°C option open would necessarily diminish the extent to which expanded CDM could help fill the funding gap. CIBs seek to capitalize on the broadening aspects of these CDM reform proposals, while narrowing the funding gap, all in the context of remaining fully consistent with a 2°C path. CIBs, therefore, have the potential to build on CDM reform proposals while enabling developing countries to tap the power of carbon markets further, faster, and more efficiently.

CIBs could help fill the funding gap while remaining consistent with a 2°C path. Recall our preliminary calculations above, estimating flows in the order of at least $20 billion per year for ten years. This is larger than any CDM flows, at least one order of magnitude larger than other existing multilateral flows and ranks among the highest proposed new funding mechanisms. Moreover, the $20 billion estimate represents a lower bound, since the pool of CIB allowances could be leveraged to achieve a multiple of the initial figure.

3.2 "Carbon leverage"

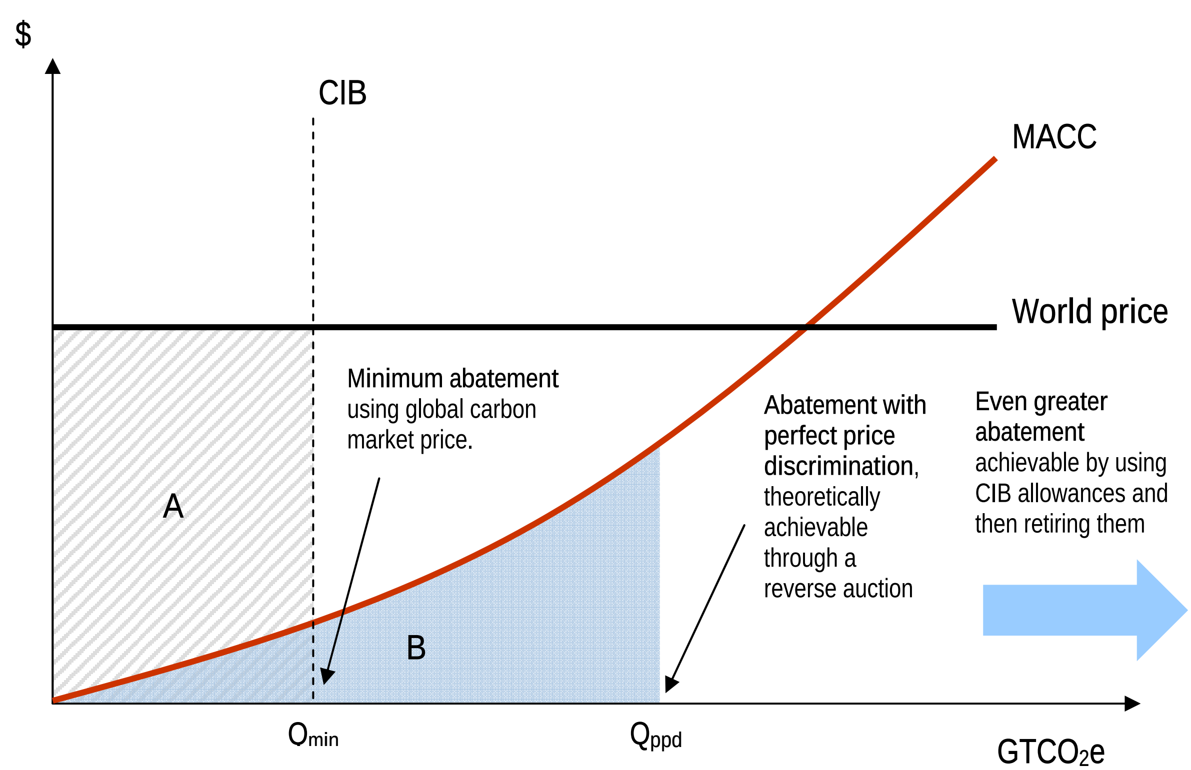
"Carbon leverage" means achieving more than a ton of emissions reduction for each CIB allowance. To make this concept more concrete, consider Figure 2. The *minimum* abatement that a CIB could finance (setting aside uncertainty for the sake of exposition) would be that achieved on a ton-for-ton basis – i.e., if CIB allowances were simply sold and used to purchase emissions reductions in the CIB country at the world market price. Given the "low-hanging fruit" available in emerging economies, however, the marginal cost of emissions reductions (depicted in the figure by the marginal abatement cost curve [MACC]) is likely to lie well below

[22] By CDM discounting, we refer to the proposition that industrialized nations would apply a discount to Certified Emission Reductions (CERs) from the CDM, so that emitters in industrialized nations would need to tender more than one CER for every ton of compliance crediting in their home countries. See Petsonk (2007) and Hepburn (2009) in this volume, among others.

the world GHG price. As a result, a ton-for-ton approach would transfer a sizeable rent to the CIB country, while failing to maximize emissions reductions.[23]

With greater information about the MACC, of course, more emissions reductions could be purchased with the same amount of money. In the limit, perfect price discrimination would equate the area under the MACC with the value of the CIB at world prices. Such an outcome might be approximated in practice with a reverse auction, or through a form of third-degree price discrimination in which projects were differentiated by sector or other observable characteristics. Finally, even greater abatement could be achieved through financing mechanisms – such as using CIBs as collateral to secure traditional financing that would otherwise not be available (or would otherwise be too costly).

Figure 2: "Carbon leverage" to increase abatement



[23] See Hepburn (2009) in this volume for a discussion of "carbon leverage," there referred to as "price discrimination."

3.3 Financing mechanisms to enable "financial leverage"

The second kind of "leverage" corresponds to the more traditional definition of "financial leverage." One could imagine three broad channels for disbursing CIB funds. First, CIB allowances could be used as collateral or as guaranteed debt service for commercial loans to secure traditional financing through private banks or perhaps export credit agencies. Used in this way, CIBs would facilitate financing by alleviating the need for alternative loan guarantees and expanding access to credit. Because the financiers would retain their incentive to assess the viability of projects and monitor performance, this approach would require relatively little oversight by the CIB trustee (the authority holding the CIB allowances) other than to perform due diligence on the banks providing the financing, and to ensure that the contract terms were not too generous. Since CIBs would be used only as collateral, a substantial fraction of them would be returned to the "carbon capital account" after the completion of the underlying loan. Moreover, allowances could be (partially) retired after loan repayment to further strengthen the environmental integrity of the program.

A second option – perhaps less leveraged but also more tightly overseen – could be a system of carbon loan payments or carbon dividends. In this case, the CIB allowances serve as a guaranteed stream of "carbon cash flow." Banks would provide incremental debt or equity financing for emissions reductions projects (in conjunction with other base financing).[24] The host country or project sponsor would repay its debt (or pay out dividends) with CIB allowances. In the meantime, allowances would be held in escrow by the CIB trustee, who would disburse the funds and monitor compliance. The trustee (or another authority) would also be responsible for approving the projects and determining their expected yield of emissions reductions. Payments could still be structured to yield "carbon leverage" of greater than ton-for-ton reductions. The International Finance Corporation (IFC), the private-sector lending arm of the World Bank, provides examples of systems following the first and second approach.

[24] While incremental cost is an elusive concept in practice, given information asymmetries, it offers in principle a means of leveraging direct funding to supplement traditional sources of finance. For example, traditional project finance might be available to fund a conventional coal-fired power plant; a CIB grant could provide the additional funding needed to drastically improve the plant's operating efficiency or to replace it with a renewable energy source.

Finally, direct grants, funded by the proceeds from the sale of CIB allowances, would be the most tightly overseen and probably least leveraged alternative. A grant mechanism could be modeled after the Multilateral Fund established by the Montreal Protocol to assist developing countries in reducing ozone-depleting substances, which is commonly seen as a success. As in that case, the responsibility of overseeing national action plans could be assigned to one central, international body, while other entities worked on a local level (the "Implementing Agencies" in the Multilateral Fund) to approve funding and monitor projects. Grants could be directed at the incremental cost of emissions reductions.

While carbon leverage would be harder to achieve with grants than with alternative financing mechanisms, it could still be achieved by suitable selection of projects. An ideal mechanism would be a reverse auction. Given the desire of host countries to exercise significant control over investments, however, some sort of negotiated payment scheme might be more practical. For example, the size of a grant could be scaled to the expected emissions reductions, but with an initial payment per ton that was set well below the market allowance price. Or a portfolio of grants could be approved (perhaps at a programmatic or even sectoral level), with total payment tied to an estimate of the average cost per ton of avoided emissions. While there are obvious informational asymmetries, and hence a strong likelihood of significant information rents accruing to host countries, a greater than ton-for-ton reduction would probably be feasible.

None of these financing mechanisms is sufficient on its own; they are complements rather than substitutes. Using CIB allowances as collateral could appeal to countries with well-developed capital markets, and would be suited to projects where an incremental investment is easily identified and yields reliable and significant operating cost savings – for example, energy efficiency in commercial buildings. Carbon loan payments or dividends would be more appropriate to finance projects where (i) the incremental cost was fairly well-defined, (ii) the resulting emissions reductions could be accurately estimated and monitored, but (iii) those emissions reductions fail to translate into financial gains. Finally, grants could be used to finance policies or broader projects (e.g., transmission networks to support renewables) that contribute to long-term reductions in emissions but are less suited to conventional private-sector project finance.

4 Designing institutions to promote performance

CIBs must be designed carefully to ensure that maximum financing flows toward low-carbon development projects and be able to achieve the twin goals of emissions reductions and economic growth. In particular, we need to define minimum criteria for participation, so that countries adopting CIBs are prepared to take full advantage of the financing provided; clear benchmarks for performance should be established, both to measure progress and to build confidence; and sharp incentives for compliance should be created.

4.1 Minimum criteria for participation

To be allocated a CIB, a country would be required to meet a set of minimum criteria along the following lines:

1. *Monitoring, reporting, and tracking requirements*. Ideally, nations taking CIBs will already have in place robust monitoring, tracking and accounting systems for GHGs. However, the urgency of early action suggests that CIBs should be available to countries that are in the process of developing their GHG monitoring systems, even if those systems are not yet fully operational. The minimum criteria, therefore, might be (i) that a country have completed a current GHG inventory covering at least the sectors represented in the CIB,[25] and (ii) that it be actively developing a GHG registry with associated emissions monitoring and reporting systems at the facility level.

[25] Under the UNFCCC, non-Annex I countries submit GHG inventories as part of their "national communications." As of December 2008, however, only four countries have submitted more than one such communication – meaning that most countries lack updated, internationally vetted inventories. Hence the criterion suggested here would indeed be a binding one. Nonetheless, it could be met by gathering credible data on imports, production, and consumption of fossil fuels.

2. *Institutional capacity*. At a minimum, countries taking CIBs should have demonstrated ability to manage international donor funds or loans from international financial institutions such as the IBRD or the IMF, and must express a willingness to accept international oversight of CIB financial flows.

3. *National Action Plans.* A prerequisite for participating countries to obtain financing under the CIB mechanism could be that they prepare national action plans defining a domestic strategy that will enable rapid shifts toward low-carbon pathways. These plans could include, among others, new or revised climate policies and regulations, plans to put in place operational GHG monitoring systems, projections of investments and financing needs, and timetables for emissions reductions. The plans would also set out performance benchmarks. This approach could enable oversight bodies to assess a country's progress towards its commitments, while ensuring that all activities for which CIB financing will be requested remain consistent with a defined strategic framework.

4.2 Clear and measurable performance benchmarks

The cornerstone of the CIB approach, and the key to maintaining its integrity, is to tie the availability of CIB allowances to measurable performance. A set of performance indicators or benchmarks should be established in advance on MRV and tracking of GHG emissions. Initially, a country's use of CIB allowances would be subject to a "reserve requirement," with a substantial fraction of allowances withheld – similar to the "commitment period reserve" allowances required under the Marrakech Accords (2001). In the CIB framework, these withheld allowances serve both as an incentive for the country to improve its MRV capabilities, and as a bond against the possibility of nonperformance. As a country achieves each successive benchmark, the reserve requirement would be relaxed, giving the country access to a greater portion of its CIB allowances (and thus greater funding for low-carbon investment).

To build confidence in a country's ability to comply with its commitments, and to ensure an early start in reducing emissions, the criteria for progressing through the CIB mechanism could include requirements – or at least strong (financial) incentives – for complementary policies and measures to reduce emissions. CIB countries could, for example, be provided with funding and technical expertise to be able to demonstrate measurable progress in implementing building codes to promote energy efficiency, or minimum efficiency standards for certain consumer durables.

Over time, it is essential that comprehensive GHG inventories be available if compliance is to be assessed, and that the process does not go forward without accurate inventory data. Consequently, nations taking CIBs need to report their annual GHG emissions within a relatively short time period, for example three years. The international community could usefully help these countries improve their emissions reporting and GHG inventories. Moreover, CIBs give participating nations incentives to improve the accuracy and transparency of their inventories, since it will enable them to attract more foreign investment.

4.3 Compliance and enforcement

Compliance and enforcement are central issues in the design of *any* international regime; climate policy generally, and CIBs specifically, are no exception. In the context of CIBs, two distinct compliance problems can be identified. First, is the country using its CIB allotment to finance clean investment? Second, is the CIB country meeting its obligation to hold allowances sufficient to cover its emissions?

Each of these problems is individually familiar from international environmental policy. Multilateral development banks as well as private financiers face similar challenges in overseeing how grants and loans are spent in the context of economic development. As in that context, robust oversight of financial flows will be necessary to ensure that countries use their "growth" budgets to fund long-term projects that will reduce GHG emissions in the long run. The stringency of such oversight would presumably vary depending on the financing mechanism used. In particular, when CIB allowances are effectively given to the recipient country as grants, the case for stringent oversight (on both normative and practical grounds) is strongest. When CIB allowances are used as collateral, with the prospect of eventually retiring them rather than releasing them into the market, the potential impact on the atmosphere is much reduced, and thus the need for oversight is as well. Moreover, in the case of private sector involvement, some of the onus of compliance can be placed on the private sector actor, who might be better equipped to monitor financial compliance.

With respect to compliance with emissions obligations, a CIB country could be treated much as Annex B parties are under the current system, once it had put in place an operational GHG monitoring system. (Recall that a country's incentive to put such a system in place is the prospect of accessing its CIB allowances.) In particular, a CIB country whose emissions exceeded allowable levels would be subject to the sanctions applicable to non-complying Annex B parties under the Marrakech Accords; i.e., the amount of its excess emissions would be subtracted from its emissions budget for the next commitment period, at a penalty rate of 1:1.3. When this provision was originally developed for inclusion in Kyoto context, it was intended to apply in the context of an agreement that comprised multiple commitment periods. The Kyoto Parties' failure to agree multiple commitment periods blunted the force of this "seller liability" provision. This problem could be partially addressed by negotiating at least two consecutive compliance periods simultaneously, as we propose for CIBs.

While each compliance problem may be familiar from other settings, it is their combination that distinguishes CIBs from other compliance problems. Paradoxically this may be an advantage – in the same way that "issue linkage" can enhance the potential for enforcement and compliance in other international regimes.[26]

For example, we have proposed that CIB allowances would be held in an "escrow account" in order to allow for oversight. This, in turn, can serve as key incentive for compliance, which ought to be especially effective in the early years of the program: if a country has voluntarily taken on a CIB, presumably it will find it valuable in the first few years to comply with the requirements in order to continue to receive the withheld (escrowed) tons. This logic argues for giving large CIBs, but holding most allowances in reserve and releasing them only slowly over time. In this way the CIB can help solve not only the initial participation problem but also the ongoing

[26] See Abrego *et al.* (2001) and Conconi and Perroni (2002), but see Barrett (2008) for another view.

dynamic participation (continuation) problem. It is also crucial that the escrow account be held as long as possible.

In theory, the escrow account can grow over time – to the extent that early investments "bend the curve" downward, they will help free up more allowances under the CIB that can be invested in further projects. However, if the escrow account gets smaller as the date of "full participation" (with a tighter cap) approaches, the incentive for compliance diminishes.

Ultimately, as in any agreement among sovereign nations, enforcement cannot be imposed entirely from without. The long-run solution to compliance, therefore, has to rest on changing the effective "payoff" for those who withdraw. CIBs need to finance investments that make it *more* attractive *ex post* to continue along the low-carbon path than to abandon the path and the commitments to it.

Again, the two compliance problems can work toward a mutual advantage. If financial oversight can be constructed in a way as to assure proper investment incentives, then the investments made under CIBs will help increase the value from remaining in the international climate regime – akin to a "low-carbon path dependency."

Two analogies may be useful here. The first is the mobile phone network in the developing world. A stylized fact is that many developing countries have "leapfrogged" development of a landline network with a mobile network. Once that happens there is little incentive to go back and develop the landline network. CIBs could help fund investments that leapfrog a high-carbon infrastructure in the same way. The case of distributed solar versus a reliable, national electric power grid comes to mind.

The politics and policy of international trade provide a second analogy. While the overall benefits of free trade to a country generally outweigh the costs, the political success or failure of a trade agreement depends on how it affects core domestic constituencies rather than aggregate net benefit. Initial participation in international trade agreements must overcome built-in domestic political resistance, because the losers from free trade (industries that have benefited from protectionist policies) will be more easily identified and better organized than the winners. However, once established, trade pacts can create an endogenous source of political support, by promoting the growth of export industries with new incentives and resources to engage in lobbying. The abstract aggregate benefits from freer trade are translated into concrete benefits for particular sectors and industries. Those domestic constituencies can then help to sustain the political will to comply with trade regimes going forward, even when such compliance comes at a cost to other interest groups. In effect, the act of participating in the regime helps to reshape incentives in favor of compliance.[27]

As the trade example makes particularly clear, the key to long-run compliance is to create the conditions within a country to sustain participation and involvement in a global carbon regime. That means creating domestic political constituencies that benefit from clean energy and from engagement with carbon markets in other countries.

5 Conclusion

Financing the transition to a low-carbon, high-efficiency economy is the key question of any international framework to address climate change and attempt to limit warming to 2°C above pre-industrial temperatures. Docking stations, in general, and Clean Investment Budgets, in particular, provide emerging economies with a voluntary mechanism to participate in global carbon markets on an early action basis.

CIBs achieve these twin challenges of emissions reductions and economic growth by giving countries allowances *above* current emissions in exchange for proper oversight and additional compliance mechanisms to enable the required rapid transition to cleaner development. The funds freed by CIBs could be quite significant – on the order of $20 billion per year over ten

[27] See Gilligan (1997) and McGinnis and Movsesian (2000) for discussions of this effect in the context of U.S. trade policy. Haggard (1988) presents a related institutional view (recounting how the passage of the Reciprocal Trade Act of 1934 favored pro-free-trade domestic interests) while Frieden and Rogowski (1996) provide a succinct summary of how trade policy can affect the preferences of domestic interest groups by altering relative prices.

years, without accounting for potential financial leveraging – and could provide an important element in the toolkit of available financing mechanisms for technological transfers and other mitigation options. CIBs reward early action, and do so in an environmentally sound and economically – and, thus, politically – viable fashion.

Appendix: Details on the science

The analysis laid out here shows that CIBs can be undertaken consistent with the goal of limiting global warming to 2°C above pre-industrial levels. Using peaking pathways, we generate sufficient atmospheric space under a global emissions reduction pathway that meets the 2°C goal with a probability of 60% and annual reductions after the peak of no more than 2.5%.

Our analysis of global emissions reduction pathways builds on Wang *et al*. (2007) and Meng *et al* (2007). We determined emission reduction pathways using the MAGICC model of greenhouse gases and climate (Wigley and Raper, 2002; Wigley et al., 2002; Wigley, 1993), assuming the range of climate sensitivities recommended in the IPCC Fourth Assessment Report. The emissions in this paper include the six Kyoto gases (CO_2, methane, nitrous oxide, HFCs, PFCs, and SF_6). We aggregate them into units of CO_2 equivalent (CO_2e) using global warming potential values from the IPCC Second Assessment Report. We assume that emissions of other climatically important gases, including SO_2 and tropospheric ozone precursors, follow the median of the IPCC SRES scenarios. Through additional simulations, we found that concurrent abatement of these other gases under a global emission reduction pathway would have only a small effect on temperature, as reductions in tropospheric ozone, a greenhouse gas, offset reductions in SO_2, a climate cooler.

The global emission reduction pathway considered in this paper avoids 2°C of warming with a probability of 60% and a maximum annual emissions reduction rate of 2.5% after the peak

(Figure 3).[28] Various authors, including O'Neill and Oppenheimer (2002) and Oppenheimer and Petsonk (2005), have identified a warming of approximately 2°C above pre-industrial as a threshold beyond which the risk of dangerous climate change increases significantly. The pathway transitions from a peak to the maximum rate of reduction over a period of five years and corresponds to a total budget of 2550 $GtCO_2e$ between 1990 and 2050, with approximately 1770 $GtCO_2e$ remaining from 2009 onwards.

Note that we focus on concentration peaking pathways, rather than concentration stabilization pathways, in this analysis, similar to Wang *et al*. (2007) and Meng *et al.* (2007). Although stabilization pathways have been more commonly discussed in the scientific and policy arenas, there are other plausible pathways for avoiding dangerous levels of warming.[29] Peaking pathways have the additional benefit of allowing the possibility to bring concentrations, and eventually temperature, back down to or below today's level. However, a general guideline that should be followed is to choose as tight an overall emissions budget as possible to avoid a high *rate* of warming in the near-term from a peaking pathway that may be acceptable in terms of the long-term *total* warming. Note that the main pathway we consider in this paper, which gives a 60% likelihood of avoiding 2°C of warming, entails a level of emissions reduction by 2050 equal to about 30% below 1990 levels globally. This is comparable to a concentration stabilization pathway that gives a roughly 50% likelihood of avoiding 2°C of warming (M. Meinshausen's 450 ppm CO_2e pathway that overshoots to 500 ppm[30]).

We also test sensitivity around the maximum annual reduction rates after the peak (changes in the slope), which corresponds to different levels of banking of emissions allowances (Figure 3).

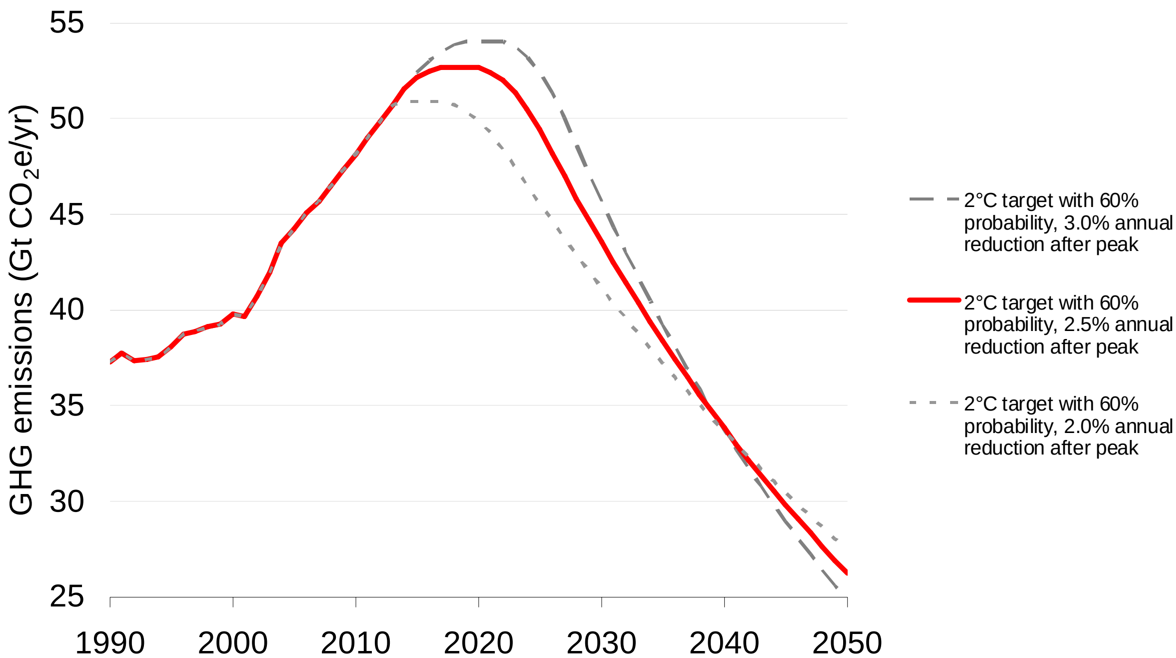
---

[28] We assumed that the probability of avoiding a particular temperature threshold is influenced mainly by the probability distribution function (PDF) for climate sensitivity, which we derived from the IPCC recommendation, with smaller effects from uncertainties in the carbon cycle, ocean heat diffusivity and the magnitude of sulfate aerosol radiative forcing (Meinshausen, 2006).

[29] See also Frame *et al.* (2006) for a critique of concentration stabilization pathways. Den Elzen and van Vuuren (2007) have also suggested peaking pathways as a more cost-effective alternative to stabilization pathways.

[30] Various citations to M. Meinshausen *et al*'s work available at www.simcap.org.

Figure 3: Global emissions reduction pathways with different annual reductions after the peak

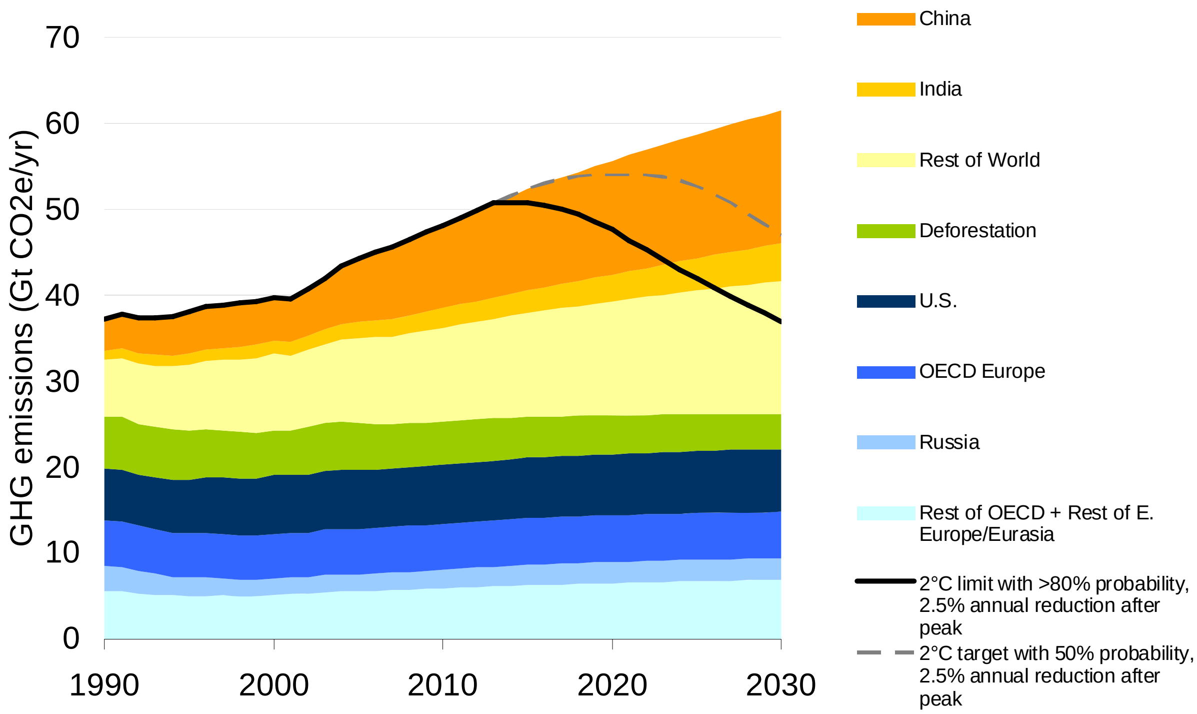


Source: IEA and other emissions data, EDF analysis

We estimated historical emissions with data from various data sources: the International Energy Agency (IEA) for CO_2 from fossil fuel combustion from 1990-2006 (OECD/IEA, 2008a); the EDGAR 4 database developed by the Netherlands Environmental Assessment Agency, the Joint Research Centre and the Netherlands Organisation for Applied Scientific Research for other fossil CO_2 emissions from industrial processes such as cement production and from oil and natural gas wells from 1990-2005 (Olivier and Berdowski, 2001); Houghton (2008) for CO_2 emissions from land-use change and forestry (LUCF) from 1990-2005; and U.S. Environmental Protection Agency (EPA) for non-CO_2 gases from 1990-2005 (U.S. EPA, 2006). For projected BAU fuel combustion CO_2 emissions from 2007 through 2030, we used the IEA *World Energy Outlook* (OECD/IEA, 2008b), interpolating between the years for which data are provided. For other fossil CO_2 emissions, we simply assumed that they contribute the same fraction of total fossil CO_2 emissions going forward as they did during 1990-2005. For LUCF, we simply extrapolated the Houghton data using the average regional linear trends during 1990-2005. As the EPA estimates for non-CO_2 gases included projections through 2020, we used those projections, extrapolating to extend them beyond 2020.

Figure 4 displays the resulting historical and BAU greenhouse gas emissions for large emitting countries, regions, and LUCF.

Figure 4: Global emissions at BAU through 2030



Source: IEA and other emissions data, EDF analysis

Note that following BAU through 2030 would exceed a 2°C pathway with >80% probability as well as one that assures warming below 2°C with only 50% probability.

We have also conducted sensitivity analysis using projected fossil CO_2 emissions from POLES (via the World Resources Institute's Climate Analysis Indicators Tool (CAIT)), which resulted in a larger amount of atmospheric space, due to the lower projections given by POLES relative to IEA.

Table 2 lays out our assumptions for the future emissions from industrialized countries and deforestation under climate policy. Using these assumptions we find sufficient space under the 2°C pathway to support CIBs with a total global volume of 12 $GtCO_2e$ in 2013, commensurate with the 8 $GtCO_2e$ budget needed over ten years to generate annual CIB flows of $20 billion.

Table 2: Emissions targets assumed in analysis (% difference from 1990 base year)

Country/ Group	*U.S.*	*OECD Europe*	*Russia*	*Canada, Japan, Rest of OECD Pacific*	*Rest of E. Europe / Eurasia*	*Tropical Deforestation*
2020	0%	-20%	-20%	0%	-20%	-30%
2050	-80%	-60%	-60%	-80%	-60%	-80%

The targets for the United States are based on the proposal by President Barack Obama stated at the Governors' Global Climate Summit on November 18, 2008. Those for OECD Europe are based on the EU's announced targets (with the weaker option for 2020). For Russia, we interpreted optimistically that their proposal to establish a post-Kyoto target along the lines of other Annex I countries, announced at the U.N. climate negotiations in Poznan in 2008, will amount to targets identical to those of the EU. For the rest of the industrialized countries, we assumed that they would adopt either the U.S. or the EU targets. For tropical deforestation, the targets we assumed correspond roughly to Brazil following through with its targets announced in Poznan and the rest of the tropical forest countries not acting until after 2020, when they, in turn, begin reducing deforestation. For all the aforementioned targets, we assumed that the new climate policies begin in 2013 and interpolated linearly between the emissions in 2012, 2020 and 2050.

Note that these targets necessarily assume that any emissions trading proceeds within the hypothesized caps set forth in the table. That is, this particular example assumes that neither the United States nor the EU authorizes the use of CERs, derived from reducing emissions in uncapped developing countries below BAU, to be used to offset increases in emissions in industrialized countries; and it necessarily assumes that no reductions in emissions from deforestation in Brazil are used to offset emissions increases above capped levels in industrialized countries. Of course, different scenarios entailing the use of CDM or REDD tons as offsets could be developed; however, they would entail more ambitious targets in other nations if the overall emissions constraints specified are to be met.

References

Abrego, Lisandro; Perroni, Carlo; Whalley, John; and Wigle, Randall M. 2001. Trade and Environment: Bargaining Outcomes from Linked Negotiations. *Review of International Economics*.

Barrett, Scott. 2008. "Climate treaties and the imperative of enforcement." *Oxford Review of Economic Policy*.

Capoor, Karan and Ambrosi, Philippe. 2008. *State and Trends of the Carbon Market 2008*. Washington, DC: World Bank.

Conconi, Paola and Perroni, Carlo. 2002. Issue Linkage and Issue Tie-in in Multilateral Negotiations. *Journal of International Economics* 57(2): 423-447.

Ellerman, A. Denny and J-P Montero. 2007. "The Efficiency and Robustness of Allowance Banking in the U.S. Acid Rain Program." Massachusetts Institute of Technology Center for Energy and Environmental Policy Research.

den Elzen, M.G.J. and D.P. van Vuuren. 2007. Peaking profiles for achieving long-term temperature targets with more likelihood at lower costs. *Proc. of the National Academy of Sciences, 104*, 17931-17936.

Environmental Defense Fund (EDF). 1997. Building a Durable Climate Change Protocol: Participation of Developing Nations. New York, NY.

Frankel, Jeffrey. 2008. "An elaborated proposal for global climate policy architecture: specific formulas and emission targets for all countries in all decades." Harvard Project on International Climate Agreements. Working paper, October 20.

Frame, D.J., D.A. Stone, P.A. Stott, and M.R. Allen, 2006. Alternatives to stabilization scenarios, *Geophysical Research Letters, 33*, L14707, doi:10.1029/2006GL025801.

Frieden, Jeffrey A., and Ronald Rogowski. 1996. The impact of the international economy on national policies: An analytical overview. In Robert O. Keohane and Helen V. Milner, eds., *Internationalization and Domestic Politics* (New York: Cambridge University Press, 1996), pp. 25-47.

Gilligan, Michael J. 1997. *Empowering Exporters: Reciprocity, Delegation, and Collective Action in American Trade Policy*. Ann Arbor: University of Michigan Press.

Haggard, Stephan. 1988. The Institutional Foundations of Hegemony: Explaining the Reciprocal Trade Agreements Act of 1934. *International Organization* 42 (1):91–119.

Hall, Daniel S.; Levi, Michael; Pizer, William A.; Ueno, Takahiro. 2008. "Policies for developing country engagement." Harvard Project on International Climate Agreements. Working paper, October.

Helm, Dieter; Hepburn, Cameron; and Mash, Richard. 2003. "Credible Carbon Policy." *Oxford Review of Economic Policy* 19(3).

Hepburn, Cameron. 2007. Carbon trading: a review of the Kyoto mechanisms, *Annual Review of Environment and Resources*.

Hepburn, Cameron. 2009. "Reforming the Clean Development Mechanisms." In: Helm, Dieter and Hepburn, Cameron. 2009. *The Economics and Politics of Climate Change*, Oxford University Press (this volume).

Houghton, Richard A. 2008. Carbon Flux to the Atmosphere from Land-Use Changes: 1850-2005. In *TRENDS: A Compendium of Data on Global Change*. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.

IEA. 2008. *Energy Technology Perspectives 2008: scenarios and strategies to 2050*. IEA, Paris.

Keller, Klaus; Hall, Matt; Kim, Seung-Rae; Bradford, David F.; and Michael Oppenheimer. 2005. "Avoiding dangerous anthropogenic interference with the climate system." *Climatic Change* 73: 227–38.

Neohane, Nathanial; Revesz, Richard; and Robert Stavins. 1998. "The Choice of Regulatory Instruments in Environmental Policy," *Harvard Environmental Law Review* 22

Kyoto Protocol to the United Nations Framework Convention on Climate Change. 1997.

The Marrakech Accords Implementing the Kyoto Protocol on Climate Change. 2001.

McGinnis, John O., and Mark L. Movsesian. 2000. The World Trade Constitution. *Harvard Law Review* 114 (2):511– 605.

Meinshausen, M. 2006. "What does a 2°C target mean for greenhouse gas concentrations? A brief analysis based on multi-gas emission pathways and several climate sensitivity uncertainty estimates." In: H.J. Schellnhuber et al. (eds.), *Avoiding Dangerous Climate Change*, pp. 265-280. Cambridge: Cambridge University Press.

Meng, Kyle; Dudek, Daniel J.; Golub, Alexander; Lugovoy, Oleg; Petsonk, Annie; Strukova, Elena; Wang, James. 2007. "Constructing a Post-2012 Pathway: Being on track to avoid dangerous climate change." Environmental Defense Fund, New York.

Michaelowa, Axel. 2005. "CDM: current status and possibilities for reform." Hamburg Institute of International Economics (HWWI) Research Programme on International Climate Policy, Paper No. 3.

Morris, Jennifer; Paltsev, Sergey; Reilly, John. 2008. "Marginal abatement costs and marginal welfare costs for greenhouse gas emissions reductions: results from the EPPA model." MIT Joint Program on the Science and Policy of Global Change, report 164.

OECD/IEA. 2008. *CO2 Emissions from Fuel Combustion (2008 Edition)*.

OECD/IEA. 2008. *World Energy Outlook 2008*.

Olivier, J.G.J. and J.J.M. Berdowski. 2001. Global emissions sources and sinks. In: Berdowski, J., Guicherit, R. and B.J. Heij (eds.) "The Climate System", pp. 33-78. A.A. Balkema Publishers/Swets & Zeitlinger Publishers, Lisse, The Netherlands. ISBN 90 5809 255 0.

Olmstead, Sheila M. and Stavins, Robert N. 2006. An International Policy Architecture for the Post-Kyoto Era, *American Economic Review Papers and Proceedings* 96(2), 2006: 35-38.

O'Neill, B. C., and M. Oppenheimer. 2002. Dangerous climate impacts and the Kyoto Protocol. *Science* 296: 1971-1972.

Oppenheimer, M. and Petsonk, A. 2004. "Reinvigorating the Kyoto System and Beyond: Maintaining the Fundamental Architecture, Meeting Long-Term Goals." Post-Kyoto Architecture: Toward an L20? Council on Foreign Relations, New York City, September 20-21.

Oppenheimer, M. and Petsonk, A. 2005. "Article 2 of the UNFCCC: Historical origins and recent interpretations," *Climatic Change* 73, 195-226.

Petsonk, Annie. 2007. "Climate Change – International Issues, Engaging Developing Countries," Testimony before the Subcommittee on Energy and Air Quality, Committee on Energy and Commerce, U.S. House of Representatives, March 27.

Petsonk, Annie. 2009 "'Docking Stations': designing a more welcoming architecture for a post-2012 framework to combat climate change", *Duke Journal of Comparative and International Law*, May (in press).

Piris-Cabezas, P. and Keohane, N. 2008. "Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD): Implications for the Carbon Market," Environmental Defense Fund, New York.

Stewart, Richard B. and Wiener, Jonathan B. 2003. Practical Climate Change Policy, *Issues in Science and Technology* 20: 71-78; available at http://www.issues.org/20.2/stewart.html.

Su Wei. 2008. "The UN-China Climate Change Partnership," side event presentation at the UN Climate Change Conference, Poznan, Poland, 9 December.

UNFCCC, 1992, 31 I.L.M. at 851-56.

UNFCCC, 2007. Investment and Financial Flows to address climate change.

UNFCCC, 2008. Investment and financial flows to address climate change: an update. Technical paper FCCC/TP/2008/7.

United States Environmental Protection Agency (EPA). 2006. Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990-2020. Office of Atmospheric Programs, Climate Change Division.

Wang, James S., O'Neill, Brian C., and William L. Chameides. 2007. Linking mid-century concentration targets to long-term climate change outcomes. Interim Report IR-07-022. Laxenburg, Austria: IIASA.

Wara, Michael W.; Victor, David G. 2008. "A realistic policy on international carbon offsets." Program on Energy and Sustainable Development Working Paper #74, Stanford University.

Weitzman, Martin L. 2009. "On modeling and interpreting the economics of catastrophic climate change." *Review of Economics and Statistics* February.

Wiener, Jonathan B. 2008. "Climate Change Policy and Policy Change In China", *UCLA Law Review* 55: 1805-26.

Wigley, T. M. L. 1993. Balancing the carbon budget. Implications for projections of future carbon dioxide concentration changes. *Tellus* 45B: 409–425.

Wigley, T. M. L., and S. C. B. Raper. 2002. Reasons for larger warming projections in the IPCC Third Assessment Report. *Journal of Climate* 15: 2945–2952.

Wigley, T. M. L., Smith, S. J., and M. J. Prather. 2002. Radiative forcing due to reactive gas Emissions. *Journal of Climate* 15: 2690–2696.

Yohe, Gary; Andronova, Natasha; and Michael Schlesinger. 2004. "To hedge or not against an uncertain climate future?" *Science* 306: 416–7.

Zou Ji. 2008. "The UN-China Climate Change Partnership," side event presentation at the UN Climate Change Conference, Poznan, Poland, 9 December.