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GLOBAL WARMING POLICY AFTER KYOTO: RETHINKING ENGAGEMENT WITH DEVELOPING COUNTRIES

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About the Climate Change Research Platform

In November 2005 diplomats from around the world met in Montreal to begin negotiations on a successor agreement to the Kyoto Protocol. While the Kyoto agreement runs through 2012, governments are already focused on the period after 2012 because effective limits on the emissions that cause global warming require a long-term approach. Most of these gases are emitted from the energy sector, where capital investments last for decades. Private firms are unlikely to invest adequately in advanced technologies to cut their emissions unless they believe that limits will become sufficiently strict as governments get serious about slowing global warming.

There is no clear plan for Kyoto's successor. The Kyoto agreement, itself, does not offer an effective framework. The U.S. has pulled out and has yet to offer an alternative strategy for slowing global warming. Canada and Japan have formally joined the Kyoto treaty, but neither nation has yet offered a workable plan for meeting its Kyoto commitments. Only the European Union is implementing a scheme that will yield compliance with its Kyoto obligations. But a system that attracts only Europe is unlikely to exert much leverage on global emissions, as the EU accounts for only 15% of the world's total emissions. Moreover, the limits on emissions enshrined in the Kyoto agreement exclude developing countries, which account for nearly half of the world's GHG emissions. (China alone is responsible for 12%.) Because they are more populous, these countries' per-capita emissions remain much lower than that of the industrialized world. Nonetheless, any viable strategy for taming global warming must include a vision the eventual engagement of developing countries.

About the Author

David Victor is Professor of Law at Stanford Law School and Director of the Program on Energy and Sustainable Development at Stanford University's Freeman Spogli Institute for International Studies. The Program, launched in September 2001, focuses on power sector reform, the emerging global market for natural gas, energy services for the world's poor, the practical challenges in managing climate change, and the role of state-controlled oil and gas companies in the world's hydrocarbon markets. Much of the Program's research concentrates in Brazil, China, India, Mexico and South Africa. He teaches energy law, regulation and political economy at Stanford Law School.

Previously, Dr. Victor directed the Science and Technology program at the Council on Foreign Relations in New York, where he remains Adjunct Senior Fellow. He directed the Council's task force on energy co-chaired by Jim Schlesinger and John Deutch and is senior adviser to the task force on climate change chaired by governors George Pataki and Tom Vilsack. He also leads a study group that is examining ways to improve management of the nation's $50b strategic oil reserve. In the past, his research at the Council his research focused on the sources of technological innovation and the impact of innovation on economic growth. His research also examined global forest policy, global warming, and genetic engineering of food crops. His Ph.D. is from the Massachusetts Institute of Technology (Political Science and International Relations), his B.A. from Harvard University (History and Science).

His publications include: Natural Gas and Geopolitics (Cambridge University Press, July 2006), The Collapse of the Kyoto Protocol and the Struggle to Slow Global Warming (Princeton University Press, April 2001; second edition July 2004); Climate Change: Debating America's Policy Options (New York: Council on Foreign Relations); Technological Innovation and Economic Performance (Princeton University Press, January 2002, co-edited with Benn Steil and Richard Nelson); and an edited book of case studies on the implementation of international environmental agreements (MIT Press, 1998). He is author of more than 100 essays and articles in scholarly journals, magazines and newspapers, such as Climatic Change, The Financial Times, Foreign Affairs, International Journal of Hydrogen Energy, Nature, The New York Times, Science, and Scientific American, and The Washington Post.

Global Warming Policy After Kyoto: Rethinking Engagement with Developing Countries

David G. Victor[1]

Effective strategies for managing the dangers of global climate change are proving very difficult to design and implement. They require governments to undertake a portfolio of costly efforts that yield uncertain benefits far in the future. That portfolio includes tasks such as putting a price on carbon and devising complementary regulations to encourage firms and individuals to reduce their carbon footprint. It includes correcting for the tendency for firms to under-invest in the public good of new technologies and knowledge that will be needed for achieving cost-effective and deep cuts in emissions. And it also includes investments to help societies prepare for a changing climate by adapting to new climates and also readying "geoengineering" systems in case they are needed. Many of those efforts require international coordination that has proven especially difficult to mobilize and sustain because international institutions are usually weak and thus unable to force collective action. All these dimensions of climate diplomacy are the subject of my larger book project and a host of complementary research here at the Program on Energy & Sustainable Development.[2]

By far, the most important yet challenging aspect of international climate policy has been to encourage developing countries to contribute to this portfolio of efforts. Those nations, so far, have been nearly universal in their refusal to make credible commitments to reduce growth in their emissions of greenhouse gases for two reasons. First, most put a higher priority on economic growth—even at the expense of distant, global environmental goods. That's why the developing country governments that have signaled their intention to slow the rise in their emissions have offered policies that differ little from what they would have done anyway to promote economic growth. Second, the governments of the largest and most rapidly developing countries—such as China and India—actually have little administrative ability to control emissions in many sectors of their economy. Even if they adopted policies to control emissions it is not clear that firms and local governments would actually follow.

A serious strategy for engaging developing countries must contend with these two truths. It must create stronger incentives for these countries to adjust their development patterns. And it must fix (or navigate around) the administrative barriers that make so many governments unable to honor international commitments. Failure to address these problems

[1] This chapter is part of a larger book project on more effective "post Kyoto" strategies for managing climate change that the author has under way. Thanks to Joe Aldy and Rob Stavins for the invitation to contribute this part of the research to the Harvard Project on International Climate Agreements; they, Robert Keohane and an anonymous reviewer provided particularly helpful critical comments on a draft. A special thanks to Xander Slaski for terrific research assistance and Michael Wara for joint research on the troubles with the Clean Development Mechanism (CDM).

[2] The sketches that lead to this book are reported in Victor (2007); Wara & Victor (2008); Victor (2008) and the present essay.

will doom any larger portfolio of efforts to control world emissions. Developing countries already account for roughly half of current world emissions of greenhouse gases and their share is rising rapidly. Achieving widely discussed goals for protecting the climate—such as limiting global climate change to a 2 degree average of warming globally or stabilizing global concentrations of greenhouse gases at the equivalent of 550 parts per million of carbon dioxide (CO_2)—will be mathematically impossible without a swift change in policy within the developing countries. Moreover, costly policies to control emissions within the industrialized countries will be impossible to sustain political unless potent economic competitors in the developing world are seen as making an effort as well. Failure to engage the developing countries will force even governments that are deeply devoted to managing the dangers of global climate change to rethink their optimal strategy—away from an emphasis on controlling emissions and toward adaptation and climate engineering.

Such problems are hardly new in international affairs. Diplomats have considerable experience designing instruments to address situations where countries have little interest in cooperation or are unable to implement their commitments. Those instruments have included sticks (e.g. trade sanctions) and carrots (e.g. subsidies for projects that reduce emissions and for administrative capacity-building). In this essay I will argue that those standard remedies have not been designed and applied effectively in the case of climate change. All the sticks that have been considered are costly to deploy in the real world. Trade sanctions, for example, would be an administrative nightmare to apply and would create destructive tensions in an already politically fragile WTO system for promoting world trade. Carrots have thus attractive the most attention. But useful carrots have been too expensive. And the carrot that has occupied most diplomatic effort—the Kyoto Protocol's Clean Development Mechanism (CDM) and various proposals for reform—is unlikely ever to have much impact. An additional imagined carrot has been integration of developing country emission trading markets with the lucrative markets in the west. While CDM was supposed to pave the way for such an outcome, actual integration is difficult to fathom right now since it must content with the politically and administratively difficult tasks of setting acceptable emission targets in developing countries and devising the mechanisms for monitoring compliance with trading systems, levying penalties, and managing the possibly high volatility that would be introduced by the highly varied emissions levels in developing countries.

This essay will offer a new strategy for engaging the developing countries—one that looks beyond the sticks and carrots that are the mainstay of today's debate. Throughout, I will call these nations the "reluctant countries" because what matters most is their wariness about spending their own resources to cut emissions. Reluctance certainly correlates with their status as emerging developing nations, but what explains their behavior and the challenge for policy is their underlying interests and administrative capabilities, not the fact that they are relatively less well off or that their economic output is expanding at a particularly quick rate. Reluctance and wariness are what really determine outcomes, not the status as "developing" countries.

By contrast, the advanced industrialized nations are, to different degrees, "enthusiastic countries" because they care enough about the climate problem that they are willing to devote a wide array of their own resources to the task of controlling emissions. Even the United States, which has notoriously lagged on climate regulation, is adopting regional greenhouse gas

controls and will likely pass federal rules within the next several years. With that shift, nearly all the large industrialized countries will be governed by leaders that are guided by the conviction (and political pressure) that action must be taken.[3] Almost the exact opposite is true of developing countries.

My argument will follow in three parts. First, I'll show that the conventional sticks and carrots strategies for engaging developing countries are unlikely to have much impact. Those strategies can be improved, such as with careful and strategic threats of trade sanctions and a more effective system of CDM carrots.[4] The current toolbox of sticks and carrots can be fine-tuned, but I will argue that, fundamentally, it will never have much impact. A different approach will be needed. The rest of the essay then outlines such a different approach—one that relies on a new system of carrots that are much better tailored to the reluctant countries' underlying interests and capabilities.

Second, I examine in detail the reluctant countries' underlying interests in pursuing policies that contribute to the global goal of cutting emissions of greenhouse gases. My argument is that there are many large policy shifts that are in these countries' interests and which also, fortuitously, reduce warming gases. The task for the enthusiastic nations is to craft deals—what I call "Climate Accession Deals (CADs)" because of their similarity to the accession arrangements that are made when countries join the World Trade Organization (WTO)—that allow those policies to proceed. The second section outlines a large number of opportunities for such deals by examining the underlying forces that determine emissions levels in key sectors of the most reluctant countries with the greatest contribution to climate change.

Such deals, in most cases, will require external resources—such as technology, money, administrative training, security guarantees, or other actions that the enthusiastic nations and international institutions can provide. Each CAD that I outline here thus begins with the host (developing) country's interests and capabilities and is tailored to gain maximum leverage on emissions while minimizing the need for external resources. (By contrast, external compensation in the CDM is largely not determined by the size of resources needed because

[3] Russia is the singular exception for its leaders are little worried about a warmer climate and under little public pressure to be cooperative in addressing global environmental goals. In fact, Russia would perhaps stand to gain from warming both for reasons of a more temperate climate and because melting ice would open up oil and gas fields that Russia has claimed as its own. In this essay I treat Russia as one of the reluctant nations.

[4] Such fine-tuning is worth the effort—notably on the CDM—because the creation of emission permit systems with integrity will allow for the global spread of emission trading systems from the "bottom up." For more on bottom-up trading see, e. g., David G. Victor, 2007, "Fragmented Carbon Markets and Reluctant Nations: Implications for the Design of Effective Architectures," in Joe Aldy and Rob Stavins, eds., Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World, chapter 4 (Cambridge: Cambridge University Press). For a particular focus on trading linkages and the CDM, which points to the need to boost credibility and functionality of the CDM system, see Judson Jaffe and Robert Stavins, 2008, "Linkage of Tradable Permit Systems in International Climate Policy Architecture," Harvard Project on International Climate Agreements Discussion Paper 08-07. For an argument that suggests a different strategy, which would probably lower the integrity of the CDM but increase the flow of emission credits and thus integration with the emerging markets, see: Andrew Keeler and Alexander Thompson, 2008, "Industrialized-Country Mitigation Policy and Resource Transfers to Developing Countries: Improving and Expanding Greenhouse Gas Offsets," Harvard Project on International Climate Agreements Discussion Paper 08-05.

the value of CDM emission credits is priced in markets—mainly Europe's emission trading system—that bear little relationship to the actual need for compensation.) Because CADs will be complex to design and implement they must be small in number and therefore focused in areas with extremely high potential for leverage. This approach is nearly opposite to the CDM, which prizes a large numbers of broadly distributed projects based on a few cookie-cutter methodologies. Unlike the CDM—which requires that project sponsors demonstrate, for purposes of asserting "additionality," that their investments are NOT otherwise in the interest of the host country—CADs are based on aligning external compensation with host country interests. Such an approach, I argue, will create a scheme that is much more closely aligned to host country interests and thus more stable, scalable and self-enforcing. Alignment with host country interests will also make it politically easier to extinguish external compensation as the reluctant countries become more enmeshed in the global institutions for addressing climate change.

Third, I offer a design for the institutions that could facilitate this deal-oriented approach to engaging the reluctant nations. Those institutions include a bidding scheme so that the suppliers of deals are forced to compete and thus minimize the cost of external subsidy. They also include a much stronger international mechanism for scrutinizing potential deals to ensure that they represent genuine additional effort external resources exactly to the levels and purposes needed. The international institutions that I outline here will seem complex and intrusive in the eyes of scholars of international environmental diplomacy, but they are not much different from the institutions that govern the most important areas of international economic coordination, such as trade and macroeconomic policy. The model I offer is based heavily on accession to the WTO. All WTO members subscribe to common norms and principles and new members negotiate a transition—often extending over a long period of time—to that common core. Accession talks are complex, intrusive and especially time-consuming when the stakes are large; applied to the problem of climate change, accession deals would prescribe the norms that would apply when new members were full members of the institutions that govern climate change while also tailoring the compensation—which could extend over many decades—that as part of the membership process. While I focus on the closest analogs in the WTO, other international economic institutions offer similar models—such as the policy review process in the Marshall Plan and the OECD; the macroeconomic reviews of countries under Article IV of the IMF Agreement; and accession to the EU. In all, incentives—initially and fundamentally carrots but eventually also sticks—are tailored to encourage a transition into full regime membership. None of these models is perfect, but they are reminders that the problems of climate change—especially those related to mismatched interests and administrative capabilities—are matters of economic coordination and wholly new playbooks for managing such problems need not be invented. Yet most diplomacy on this issue has been guided by lessons from environmental cooperation where the toolbox is stuffed with instruments and experiences that are not adequate to the magnitude of the tasks in building an effective global warming regime.

I. STICKS AND CARROTS: WHAT'S GONE WRONG

The problem of engaging reluctant countries is one of underlying interests. Over the longer term this problem will abate, to some degree, as these countries will presumably become aware of their interest in controlling emissions. For example, already China and Brazil (two of the most important emerging countries to engage in an effective global regime to regulate climate warming), have softened their opposition to limiting growth in their own emissions as they have become more aware of their own exposure to climate dangers. [5] At the same time, those countries have also developed more sophisticated systems for [6]policy administration as part of the normal process of economic development; those better administrative systems are also, fortuitously, improving their ability to implement limits on emissions.[7]

A full change in attitude among countries that are now reluctant will be a long time coming—long enough that waiting for this turnaround appears to put the planet on a dangerous trajectory of emissions.[8] As those countries delay in imposing tough controls on emissions they not only warm the planet directly but they also encourage "leaking" of emissions-intensive investments (e.g., steel mills and cement plants) away from regulated countries into the less regulated spheres of the world economy.[9] On top of those economic effects, simply waiting for developing countries to realize their own interest in emissions controls is making it hard to sustain the political support for costly emission controls within the more enthusiastic nations where political interests groups fear economic competition across an uneven regulatory field. Those forces—the slow pace at which developing countries will realize a strong interest

[5]Larry Rohter, 2007, "Brazil, Alarmed, Reconsiders Policy on Climate Change," *New York Times*, 31 July; National Development and Reform Commission (Government of China), 2007, "China's National Climate Change Programme," June.

[7] Indeed, much more effective will be to help these countries see that an effective system of regulation for greenhouse gases is in their interest. This is at the center of the arguments that Keohane and Raustiala make about the "economy of esteem." See Robert Keohane and Kal Raustiala, 2008, "Toward a Post-Kyoto Climate Change Architecture: A Political Analysis," HPICA Discussion Paper 08-01, Kennedy School of Government. For policy makers, this approach implies the need to jawbone governments in these countries about the need to participate in collective efforts to control emissions as part of global citizenship (see also Abram Chayes and Antonia Chayes, 1995, *On Sovereignty*, Harvard University Press). It also means soliciting the support of NGOs (in countries where they are influential) to press for change and to redouble investment in studies that show the adverse impacts of climate impacts in the emerging markets themselves as well as practical studies that reveal (presumably) that emissions can be controlled at reasonable cost so that these countries make a different assessment of the costs and benefits of action. Some such efforts are already under way, e.g.: Xinhua News Agency, 2008, "Foreign governments help China map out plans for climate change" 1 July.

[8] Nobody has modeled this shift in attitude and how it might lead reluctant countries to control emissions, but the scenarios of the IEA's World Energy Outlook (2007) suggest that on current trajectories emissions will grow by 2030 to be so high that scenarios such as stabilization at 550ppmv would be beyond reach. For additional research confirming that China's growth, in particular, makes it impractical to meet climate goals without engagement of that country (and other rapidly emerging economies) see Geoffrey Blandford, Richard Richels, and Thomas Rutherford, 2008, "Revised Emissions Growth Projections for China: Why Post-Kyoto Climate Policy Must Look East," Harvard Project on International Climate Agreements Discussion Paper 08-06. Some downward adjustment of such projections, perhaps considerable, may be needed if the current financial crisis permanently lowers the outlook for economic growth in China and the rest of the coupled emerging markets.

[9] E.g., Mustafa Babiker, 2005, "Climate change policy, market structure, and carbon leakage," *Journal of International Economics* 65, 421-445.

in controlling emissions, the "leakage" of investment, and the political fallout from uneven competition in a globalized world economy—has animated efforts to devise sticks and carrots to encourage the developing countries to do more.

Sticks brandished have included trade sanctions and harm to reputation. Reputational harm has been the standard threat that a country's standing as good citizen is eroded when it fails to take global challenges seriously. That argument probably has some impact especially among rising stars who worry about reputation, but it is hard to measure and probably isn't that important when the general goals of global citizenship conflict with interests.[10]

So far, trade sanctions have been threatened (but not applied) mainly in two ways. First, the EU—initially led by France but soon echoed by left-leaning parties across the European nations that are most enthusiastic to control emissions—has threatened to use trade sanctions against countries that did not adopt binding limits on emissions. That effort originated with the goal of forcing the US to adopt emission limits at a time when there was broad European hostility to an American "hyperpower" that was prone to act unilaterally with little respect for international institutions. The impact of this saber-rattling on the US behavior appears to have been nil, and absent much effort by the US it has been even harder to mobilize similar threats of trade sanctions against the reluctant developing countries.

The second attempt to apply sanctions has its origins in the US where proposals to include a form a trade sanctions have been part of some efforts to create a politically viable legislation.[11] These problems are not new in American political discourse. In July 1997, on the eve of negations leading to the Kyoto Protocol, the U.S. Senate passed a resolution unanimously that claimed that it would reject any treaty that did not impose comparable regulation on all countries—notably China and other rapidly developing countries.[12]

So far, the U.S. threats of trade sanctions—as with those in Europe—have been more swagger than substance. None of these proposals has been adopted yet, and so far the prospect of trade sanctions does not seem to have had much impact on the rhetoric or reality of their targets—notably China. The effectiveness of these measures is also blunted by their possibly high cost of administration and questionable legal basis.[13] Further, while many countries may express a desire to implement trade sanctions in national rhetoric, few countries would want to be the one to bear the economic and political costs—a decline in trade, perhaps spiraling beyond control as other nations retaliate—of actually carrying out the threat of sanction. It might yet prove practical to focus trade sanctions on a limited number of sectors that account

[10] For an argument that moral considerations (which yield legitimacy) apply to governments in the conduct of their foreign policy see, e.g.: Charles Beitz, 1999, *Political Theory and International Relations* (Princeton: Princeton University Press). For a contrary view that emphasizes national interest see Jack Goldsmith and Eric Posner, 2006, *The Limits of International Law* (Oxford: Oxford University Press).

[11] Notably see: Michael Morris and Edwin Hill, 2007, "Trade is the Key to Climate Change," *Energy Daily* (February 20).

[12] Byrd, Robert. Hagel, Check. "Byrd-Hagel Resolution" 105th Congress, 1st Session, Senate Resolution 98. (1997), Report Number 105-54

[13] For a full review of the (highly uncertain) legality of such border tariff measures see Joost Pauwelyn, 2007, "U.S. Federal Climate Policy and Competitiveness Concerns: The Limits and Options of International Trade Law" Nicholas Institute for Environmental Policy Solutions, Working Paper 07-02.

for a large share of emissions embodied in traded goods, although nobody has yet worked out the administrative systems needed to make these ideas practical. Concern that these measures will run afoul of the WTO and undermine fragile trade talks probably means that, at best, such trade sanctions can be used as a threat but not actually applied in practice.[14] This lesson is similar to the experience in other areas of international environmental cooperation. Trade sanctions have been applied in only highly limited circumstances, such as where trade in specimens of endangered species is directly linked to the population decline of those species or where importing governments have explicitly sought assistance in improving their systems for administering imports of hazardous waste and chemicals.[15] In only one major area of international environmental law—the Montreal Protocol on the Ozone Layer—have trade sanctions been a central part of the enforcement mechanism. Even there, the utility of trade sanctions has been low because the Montreal Protocol pays all developing countries the "agreed incremental cost" of complying with the treaty. Thus countries that remain outside the regime face hypothetical (but possibly costly) trade sanction that they can avoid fully by joining the regime at essentially no net cost. The few exceptions include Russia and other countries that are not treated as "developing" and thus are not eligible for full compliance funding. Not surprisingly, those exceptions have been the hardest to manage and are a perennial dark spot in the Montreal Protocol's otherwise good record of compliance.[16]

The other method for changing the incentives of the developing countries, carrots, has attracted the most attention. At the time that the Kyoto Protocol was negotiated the standard model for delivering carrots was through an international fund—a model that became the norm after the highly successful funds that were part of the Montreal Protocol on the Ozone Layer. That treaty faced a similar problem of misaligned incentives as bedevils the climate treaty today. The solution, as noted, was for the enthusiastic nations to pump money into a fund that paid all of the "agreed incremental cost" for developing countries. As more demanding commitments were imposed on the developing countries the size of the fund was increased in lockstep. Not surprisingly, essentially every developing country on the planet joined the treaty and complied with essentially all of its substantive requirements. These countries faced trade sanctions if they stayed outside (or failed to comply) and they were paid the full cost of

[14] Exactly that policy advice is outlined, for example, in the Council on Foreign Relations bipartisan consensus task force report: George Pataki and Tom Vilsack (co-chairs), *Confronting Climate Change: A Strategy for U.S. Foreign Policy* (New York: Council on Foreign Relations Independent Task Force #61. The targets of such sanctions know that these are costly to apply and it is often difficult for the "senders" of sanctions to coordinate their actions and administer a program efficiently. For example, see Lisa Martin, 1993, *Coercive Cooperation: Explaining Multilateral Sanctions* (Princeton: Princeton University Press). For a careful full look at sanctions and when they work see Gary C. Hufbauer , Jeffrey J. Schott, Kimberly A. Elliott and Barbara Oegg, 2007, *Economic Sanctions Reconsidered*, 3rd edition (Washington: Peterson Institute for International Economics).

[15] Rosalind Reeve, 2006, "Wildlife trade, sanctions and compliance: lessons from the CITES regime" *International Affairs*, vol 82, pp. 881-897; Jonathan Krueger and Duncan Brack, 1998, *International Trade and the Basel Convention* (London: Royal Institute of International Affairs); David G. Victor, 1998, "Regulation of Trade in Hazardous Chemicals and Pesticides," in Victor et al., eds, *Implementation and Effectiveness of International Environmental Commitments* (Cambridge: MIT Press), chapter 6.

[16] David G. Victor, 1998, "The Operation and Effectiveness of the Montreal Protocol's Non-Compliance Procedure," in Victor et al., eds, *Implementation and Effectiveness of International Environmental Commitments* (Cambridge: MIT Press), chapter 6; Edward A. Parson, 2003, Protecting the Ozone Layer: Science and Strategy (Oxford: Oxford University Press); Richard Benedick, 1998, *Ozone Diplomacy: New Directions in Safeguarding the Planet* (Cambridge: Harvard University Press)

compliance if they joined.[17] To be sure, the fund was well-administered and the treaty included important safety clauses that would prevent impractical regulations from being imposed until effective substitutes were in place. [18]

While the Montreal Protocol offered the most advanced experience with financial transfers for international environmental goals, the canon of international environmental law includes many other experiences as well. Those included payments from countries affected by pollution to polluters in an effort to get the latter to curb their effluent.[19] And they include many examples of payments to countries to improve weak administrative systems, which would make them more capable participants in collective efforts to address environmental problems.[20] These experiences suggested two lessons. One is that it was administratively difficult to target and administer international funds. The other is that funds were usually very small. The Montreal Protocol fund, which has totaled about 3 billion dollars over the lifetime of the agreement, is by far the largest international environmental fund to date. [21] By contrast, academic writing during the leadup to the Kyoto Protocol suggested that a fund on the scale of tens or perhaps hundreds of billions of dollars would be needed. Explicit transfer of resources on that scale were thought to be too large for what governments were willing to spend, and wariness about large UN managed funds was a shadow over the negotiations.[22]

The solution to the incompatible need for financial transfers with the seeming political impossibility of actually mobilizing Montreal-style transfers was to hide and shift the cost. Rather than creating an explicit fund with government-supplied money, the Kyoto process created a system of emission "offsets" under the Clean Development Mechanism (CDM). Offsets allowed governments and firms in the enthusiastic countries (where meaningful limits on emissions were being applied) to earn credit for projects that reduced emissions in the reluctant developing countries. This scheme would thus, in theory, engage developing countries by encouraging investments that lowered their emission trajectories. And it would also make the political challenge of mobilizing funds much easier because the financial transfers were not on official government budgets (and thus not visible) and they were optional (and thus could be selected by the governments and firms that were most keen to invest money

[17] Scott Barrett, 2006, Environment and Statecraft: The Strategy of Environmental Treaty-Making (Oxford: Oxford University Press); Elizabeth DeSombre and Joanne Kaufman, 1996, "The Montreal Protocol Multilateral Fund: Partial Success Story," in Robert O. Keohane and Marc Levy, eds., Institutions for Environmental Aid: Pitfalls and Promise (Cambridge: MIT Press).

[18] Edward A. Parson, 2003, Protecting the Ozone Layer: Science and Strategy (Oxford: Oxford University Press)

[19] Thomas Bernauer, 1996, "Protecting the Rhine River Against Chloride Pollution," in Robert O. Keohane and Marc Levy, eds., *Institutions for Environmental Aid: Pitfalls and Promise* (Cambridge: MIT Press).

[20] Sergio Margulis and Tonje Vetleseter, 1999, "Environmental capacity building: a review of the World Bank's portfolio," Environment Department Paper #68, World Bank.

[21] The size of the fund is calculated from the original "interim" fund plus all replenishments (less carryover funds and plus interest), including administrative costs. Those numbers are from: Multilateral Fund Secretariat, 2008, "Multilateral Fund for the Implementation of the Montreal Protocol: policies, procedures, guidelines and criteria (as at April 2008)." For a careful look at implementation (through the eyes of the World Bank, which is one of the implementing agencies) see: Lauren Kelly, 2004, *The Multilateral Fund for the Implementation of the Montreal Protocol: Addressing Challenges of Globalization: An Independent Evaluation of the World Bank's Approach to Global Programs*, World Bank Operations Evaluation Department.

[22] Daniel Bodansky, 2001, "The History of the Global Climate Regime," in Urs Luterbacher and Detlef Sprinz, eds., *International Relations and Global Climate Change*, pp. 23-42 (Cambridge: MIT Press).

in such ventures). Economically, the CDM scheme would allow some of the lowest cost sources of emission reductions—those in the reluctant, developing countries—to be tapped for credit. Politically, the CDM scheme would allow governments in the enthusiastic nations to show that something was being done in the developing world and would allow the most challenging aspect of that task—namely the mobilization of funds—to be tailored to the particular politics of each enthusiastic country.

There is no question that the CDM (and a related offsets scheme known as "joint implementation") has played a major role in the emerging carbon markets. The architects of the European Union ETS have embraced allow extensive use of offsets.[23] Indeed, without the CDM it is hard to see how the EU would actually meet its Kyoto targets. Japan is relying heavily on the CDM to meet its Kyoto goals.[24] And economic modeling of proposed cap-and-trade bills in the United States has shown that, theoretically, offsets have the potential to allow sharp reductions in costs.[25] Depending on the accounting metric, the CDM has already mobilized about 12-15 billion dollars of emission credits. Not surprisingly, in both countries that depend heavily on the CDM for compliance and in the developing countries that are hosts for CDM projects there has been nearly unanimous support for the scheme.[26]

The political benefits of the CDM are real, but only a fraction of CDM projects actually reduce emissions. Michael Wara and I have looked closely at projects related to industrial gases and found that the CDM results in massive over-payment for emission reductions and also creates perverse incentives that encourage industrial facilities to embrace out-dated technology so they can earn compensation for installing better equipment.[27] We have also looked closely at fuel switching projects in China (the world's largest CDM host) and found

[23] Although recently released draft guidance on the EU ETS for the post-2012 period indicates that the European Commission has grown substantially less enthusiastic about the use of offsets for cost control purposes, mainly because of a desire to foster domestic abatement. *See* Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading system of the Community, 2008/0013 (COD) at 26, *at* http://ec.europa.eu/environment/climat/emission/ets_post2012_en.htm. For a careful look at the functioning of the ETS, including the role of international offsets, see Denny Ellerman and Paul L. Joskow, 2008, "The European Union's Emissions Trading System in Perspective," Pew Center on Global Climate Change.

[24] Government of Japan, 2006, Japan's Fourth National Communication Under the United Nations Framework Convention on Climate Change. This report envisions that only 1.6% of Japan's 12% reduction in emissions from baseline would come from the Kyoto mechanisms (ie, international trading) while most of the effort would come from domestic measures. In practice, it is proving very difficult to adopt the needed domestic measures and thus the role of international measures will rise in salience.

[25] Recent EPA analysis estimates that the inclusion of offsets and international credits in the Liebermann-Warner bill reduces the predicted allowance price for capped sectors from $77 to $40 in 2015. US ENVIRONMENTAL PROTECTION AGENCY, EPA Analysis of the Liebermann-Warner Climate Security Act of 2008, S. 2191 in 110th Congress (March 2008); US ENVIRONMENTAL PROTECTION AGENCY, EPA Analysis of the Climate Stewardship and Innovation Act of 2007 (July 2007); US ENERGY INFORMATION ADMINISTRATION, Energy Market and Economic Impacts of S.280, the Climate Stewardship and Innovation Act of 2007, Report #: SR-OIAF/2007-04 (August, 2007); S. Paltsev et al., Assessment of U.S. Cap-and-Trade Proposals, MIT Global Change Joint Program Report 146 (April 2007, updated February 2008); Richard G. Richels et al., Managing the Transition to Climate Stabilization, AEI-Brooking Joint Center Working Paper No. 07-01 (January 2007).

[26] Karen Capoor and Phillippe Ambrosi, World Bank Carbon Finance Unit, State and Trends of the Carbon Market 2007 (May, 2007); PointCarbon, Carbon 2007 – A New Climate for Carbon Trading (March, 2007).

[27] Wara, Michael. "Is the global carbon market working?" *Nature* 445, 595-596 (8 February 2007)

that few, if any, of these projects were actually motivated by CDM incentives.[28] Others have scrutinized the CDM portfolio as well, and many news accounts have examined proposed CDM projects to find that "additionality" is rare. [29]

While the CDM is still new, one central finding is already evident: the CDM is an extremely poor way to engage developing countries. Although the CDM is generating a thick pipeline of credits, most of those credits probably do not represent real reductions. While the CDM was politically expedient at the time it was crafted—because it hid and shifted the cost of the financial transfers—that expediency is not sustainable. The overpayment for CDM credits in industrial gases, along with the mounting evidence that many CDM credits probably don't represent actual reductions in emissions, will sap political support for expanding the CDM to the scale that might be needed to make a dent in developing country emissions.

There is a wide array of suggestions for how to improve the CDM.[30] Those efforts should be pursued because there may be areas where a reformed CDM could be effective, and there are huge political and economic advantages to a market-based mechanism that does not rely on explicit government-provided financial transfers. A full discussion of CDM reform is beyond the scope of this paper, but one avenue is worth highlighting. Too much of the debate over CDM reform has focused on procedures (notably within the CDM process itself); too few analysts and reform efforts focus on underlying incentives. A more aggressive political strategy in the largest markets for CDM credits—the EU's ETS today and, eventually, the US market—could use their market power to force higher quality by allowing only high quality

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[28] Wara, Michael. Victor, David G. *A Realistic Policy on International Carbon Offsets.* Program on Energy and Sustainable Development Working Paper #74, (April 2008)

[29] Lambert Schneider, Oko-Institut e.V., Is the CDM fulfilling its environmental and sustainable development objectives: An evaluation of the CDM and options for improvement, prepared for WWF (November, 2007); Barbara Haya, International Rivers Network, Failed Mechanism: How the CDM is subsidizing hydro developers and harming the Kyoto Protocol (November, 2007); Axel Michaelova and Pallav Purohit, Additionality Determination of Indian CDM Projects: Can Indian CDM Project Developers Outwit the CDM Executive Board (2007); Michael Wara, Is the Global Carbon Market Working?, 445 NATURE 595 (2007).

[30] See fuller discussion above at note [5]. Elsewhere, Michael Wara and I have offered suggestions for reform that are based on three elements. First, the 3rd party verification system that lies at the heart of the CDM needs to be fixed. Currently, many projects are undergoing supplementary review after 3rd party verification because the CDM EB does not believe the auditors. This has been held up as a toughening of standards within the CDM and a sign of its growing environmental credibility. However, this problem fundamentally points to dysfunction in the operation of verification services, mis-aligned incentives, and confusion about the role of verifiers. Currently, 3rd party verifiers are paid by project developers, with whom they do repeat business and thus are loathe to contradict. Further, they face an increasingly competitive market for their services, with severe downward pressure on price and few effective controls on quality. Second, the CDM should be concentrated on a smaller (and more manageable) number of larger projects, which would allow greater oversight resources to be concentrated on crucial tasks such as ensuring environmental integrity of projects. In part, this second reform would adopt the lesson learned nearly a decade ago when the World Bank sought to catalyze the early CDM through its Prototype Carbon Fund (PCF), which included rigorous (if still highly imperfect) project-by-project oversight. (The effort to shift to so-called Programmatic CDM projects might have similar effects, if well designed and administered.) Third, the CDM rules should be liberalized to allow all forms of carbon reductions. At present, the CDM has an eclectic (but growing) array of methodologies, many concentrated on projects that deliver small volumes of credits for projects of dubious additional effort. Adding other large sources of reductions for which it is easier to assign additionality—such as underground carbon storage projects as well the growing array of possible forest-based net reductions in emissions—would ease the task of reorienting the CDM to a smaller number of projects with higher integrity.

credits (or by creating a system of buyer liability or some other mechanism so that credits are price-adjusted for quality). Instead, the ETS has given almost no attention to encouraging CDM quality and most of the U.S. policy debate at this writing has focused on ways to generate as many credits as possible rather than devising mechanisms to reward high quality credits. Indeed, the ETS rules treat CDM credits essentially as fungible currency—once a CDM credit passes muster with the CDM's Executive Board it can readily become legal tender in Europe. In effect, the EU has handed its substantial market power over to the CDM's Executive Board.[31]

Smarter reforms can help, but none is likely to make the CDM a reliable, central mechanism for engaging developing countries. First, and fundamentally, the CDM rests on the assumption that it is possible to make a counterfactual assessment of the emissions level that would have occurred without the CDM investment. That assumption may be valid for a small number of projects with easy-to-assess (mainly end-of-pipe) and unambiguously marginal changes in technology. But the most consequential (and cost-effective) efforts to cut emissions in developing countries are difficult to disentangle for the normal development of the economy. Outsiders can't easily assess such projects, especially when there are strong incentives for the project sponsors to misrepresent the true nature of additionality.[32] These problems are not unique to the CDM—rather, they are generic to offset systems that require an external regulator to assess the true underlying cause of a change in behavior or technology.[33]

Second, serious fixes to the CDM's woes will require more aggressive administration, which will raise transaction costs and also make the delivery of actual credits from CDM projects more uncertain. The net effect of these reforms will be to make the CDM much less attractive for investors and thus much less important in engaging developing countries. A more

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[31] Such use of market power will probably lead to greater fragmentation in carbon markets, but that outcome is probably worth enduring if it pressures offset systems to ensure that they link rewards to real emission reductions. Elsewhere I address the tendency of real carbon markets toward fragmentation for such reasons. Victor, David G. . "*Fragmented carbon markets and reluctant nations: implications for the design of effective architectures* " *Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World.* Ed. Joseph E. Aldy and Robert N. Stavins. Cambridge University Press, 2007

[32] The host governments and investors that seek credit have a strong incentive to claim that their efforts are truly additional. The regulator—in this case, the CDM Executive Board—can't in many cases gather enough information to evaluate these claims. These problems of asymmetrical information are compounded in the CDM, to be sure, because the CDM Executive Board is massively under-staffed and the CDM system relies on third-party verifiers to check the claims made by project proponents. In practice, these verifiers, who are paid by the project developers, have strong incentives to approve the projects they check. Further, there is scant oversight on the integrity of the verification process and no record of punishing verifiers for misconduct. Lacking any other source of information about individual projects and facing pressure from both developing and developed country governments, the CDM Executive Board is prone to approve projects. Asymmetries of information are rampant; the incentives mostly align in favor of approval. This challenge is made all the more formidable by the sheer number of projects upon which the Board must decide. The CDM EB, on average, registers about one project every day as eligible to generate CDM credits. Thus the Board cannot afford to spend large amounts of time evaluating the complexities of financial data presented to justify a project's eligibility for CDM credits nor can it delve into a project's relationship to state energy policy. Furthermore, the CDM EB faces a financial limit on the costs it can reasonably impose on individual offset projects. In order to remain viable, relatively small carbon offset projects cannot afford the cost and uncertainty that would accompany truly extensive scrutiny. Indeed, there is strong pressure from CDM investors to limit such transaction costs and speed up approval.

[33] Hahn, R. W. Hester, G. L. "Where did all the markets go? An analysis of EPA's emissions trading programme." *Yale Journal on Regulation*, 6, 1989, 109-153.

effective CDM will be a smaller CDM because of the difficulty of determining additionality in projects and in monitoring progress with real projects.[34] That smaller CDM would be worthwhile, but as the CDM shrinks to a fraction of what the developing countries imagine it would be it will become even harder to rely on the CDM as the central mechanism for engaging those countries.

Third, none of the reforms contemplated for the CDM will fix the central problem of perverse incentives. Any system that rewards offset activities creates an incentive for host countries to adopt counter-productive policies (so that they can earn credit for altering those policies). And it creates incentives for project developers to pretend that their investments are irrational without the (uncertain and difficult to value) stream of carbon credits. Yet substantial, capital-intensive investments of the type that will be needed to make a dent in emissions are rarely planned in this way. Investors do not hunt for irrational activities whose fiscal viability hinges on marginal, uncertain and contested supply of credits. The brokers of carbon credits engage in such activities, but the core industrial investment activities that drive an economy follow a different logic. Investors focus on activities that fundamentally make sense for their business strategy and, if successful, they scale up those investments. The CDM system has little impact on that logic and, worse, it encourages investors to focus on other logics that are not fundamentally viable for the long-term. That reason alone probably explains the flood of new evidence of so many CDM projects that are not additional. Those projects arise not because of the CDM but, rather, the fundamental incentives that guide investments; then, after a project is already planned, the investor seeks to optimize any other benefits that may be available.

II. CLIMATE ACCESSION DEALS

Ultimately, the experience from the CDM market suggests that such mechanisms are unlikely to have much impact on developing country emissions nor their engagement with the global effort to contain the dangers of global warming. Serious reforms of the CDM will yield a niche effort that could be effective yet difficult to scale beyond end-of-pipe investments and other unambiguously additional activities. Broadening the CDM without reform could yield a much larger pipeline of investments that don't actually control emissions. Beyond the CDM there are few discussions of serious carrots to encourage developing country participation. Attempts to convince developing countries to spend more of their own resources to control emissions by demonstrating their vulnerability to climate change may ultimately be successful, but progress on that front is likely to be slow. And efforts to apply sticks, such as trade

[34] One proposal, now being embraced cautiously within the CDM system, is to allow for so-called "programmatic" initiatives—that is, to offer credits for broad policy reforms or for clusters of activities within whole sectors, rather than on a project-by-project basis. This approach would cut transaction costs and, in theory, allow for greater scrutiny. For many offset project types, however, information asymmetries are likely to be pervasive. Indeed, if the current system is unable to assess whether the current large projects in gas, hydro and renewable power in China are truly additional in their promised emission reductions it is hard to see how a programmatic approach would be much different for these types of projects. Such problems are likely to recur for any large-scale carbon offset regime, domestic or international, that operates at the relatively fine-grained level of the individual emission reduction project, at least in sectors where additionality determinations are particularly challenging.

sanctions, are likely to be plagued by administrative and legal troubles that make these threats marginally effective when brandished in the abstract yet increasingly unbelievable when real governments try to put them into practice. In addition, such sticks carry the potentially huge cost of undermining political support for the WTO and the wide array of broader benefits that the WTO-based free trade regime has delivered to the world economy. These carrots and sticks can be part of a strategy to engage developing countries, but alone they are unlikely to be enough.

Here I suggest a new way to think about engaging developing countries, focusing around the concept of climate accession deals (CADs). My strategy starts with these countries' existing interests, which are unlikely to change much in the next decade or two—the critical period for initiating efforts to control emissions. This is a severe constraint, to be sure, but it reflects the reality of international politics. Agreements that run contrary to national institutions are difficult to craft and usually require enforcement provisions to keep countries not prone to comply on track. But enforcement is difficult. Changing interests with side-payments—as in the case of the Montreal Protocol's technology fund—is possible but politically difficult and thus there is a high premium on reducing the level of overt transfer. Thus, to the extent possible, engagement is more viable and self-enforcing if it starts with an eye to what countries think is in their interest and then minimizes the need for politically difficult external incentives.

Briefly, my overall argument will be that CADs—because they are anchored in the host country's interests, administration and development plans—offer the opportunity for maximum leverage on emissions with minimal and well-focused external resources. In most cases these CADs will require external incentives that, to be most effective, must be tailored to the circumstance. In some cases those incentives will include financial transfers; often, however, the best assistance will not be money but other kinds of resources. The size and political visibility of external assistance is a severe constraint because most governments that would provide resources are not able to mobilize large amounts of on-budget expenditure for transfer to their most fierce economic competitors. Yet it is those competitors who matter most in the effort to control emissions because the same factors that make them formidable economic competitors also cause rapid growth in emissions. How those resources are mobilized and applied will be the subject of a later section of this essay. In this section I provide some practical illustrations of the activities and projects that could lead to CADs. Throughout, I focus on governments—and offer a tour of the most important reluctant countries—because ultimately governments will need to be accountable for CADs. In practice, of course, a wider array of actors will also be essential, notably firms as well as the wide array of state-controlled firms that dominate such a large fraction of the economies in the reluctant countries and are often the most capable actors in the economic landscape.

China

We start with China because that country's emissions are the largest and its growth the highest, which offers the greatest potential for leverage. Those high emissions stem from the country's heavy dependence on coal, which accounts for 69% of its primary energy system.[35] Throughout the 1990s structural reforms in China caused a decoupling of energy demand from economic growth, with the former growing at about two-thirds the rate of the latter. All that changed around 2000 as Chinese economic growth turned more aggressively to heavy industry and thus hinged, to a greater degree, on energy.[36] Since then the country's stellar economic growth has driven a similar rise in energy demand which has in turn caused shortages in energy supply and upward pressure on energy prices that had been felt worldwide. (Since October 2008 the pendulum has swung in the opposition direction—steep declines in economic growth have caused surpluses of commodities and energy supplies. Most analysts expect these surpluses to be short-lived, but they could stop the growth in Chinese emissions for a year or two.) Chinese officials know that this rapid growth poses a danger for their economic health and thus have initiated a broad program with the aim of, once again, decoupling economic growth from energy consumption. Those efforts include pressure on power generators to install more efficient coal fired power plants (and now that the power supply is growing in tandem with demand, incentives to close older inefficient plants), standards on energy-using appliances from refrigerators to automobiles, and an aggressive economy-wide goal of reducing energy intensity 20% by 2010. These efforts are under way on their own logic and will also reduce growth in CO_2, although the ambitious 20% goal probably won't quite be met.

In addition to what China is already doing, what more could be done with a fuller focus on the effort and perhaps external assistance? I concentrate here on the power sector because it is still under strong direction from the central government and the governments of the major provinces. All five of the country's nationwide generating companies and both of its grid companies, for example, are owned by the central government. The power sector is interesting for our analysis because if deals were struck between the central and provincial governments in China and outside suppliers of technology and expertise it would be administratively feasible for China actually to put those deals into place and be held accountable for them. In other sectors—for example, the production of cement which remains highly inefficient and is a theoretical gold mine of opportunity for energy savings—the relevant firms are too decentralized and evasive of government control to hold much promise for reducing emissions. Before a deal could be struck in the cement sector Beijing would, first, need to create the capability to control the sector. Similar administrative difficulties plague the building sector, another area of great potential for energy savings.

In the power sector there are four broad opportunities.

First, the electric power supply system could be more efficient. In practice, that can be achieved by efforts mainly in three areas. One is creating incentives to operate existing power plants more efficiently, such as through more rational pricing of coal and creation of better

[35] China Energy Brief: Coal. Energy Information Agency of the United States. (August 2006)
[36] Dan Rosen and Trevor Houser,2007, *China Energy: A Guide for the Perplexed* (Washington: Peterson Institute for International Economics).

incentives for managers to operate plants with closer attention to fuel consumption and environmental side-effects. Studies have documented that great potential, although it is unlikely that outsiders can have much impact.[37] It is also possible to encourage a more rapid and fuller shift to efficient power plants. On this front, external forces can make a difference. The high and rising delivered cost of coal in the coastal regions of China has already encouraged the deployment of extremely efficient "ultrasupercritical"—that is, high pressure and high temperature and therefore more frugal in consumption of fuel—power units that are among the most advanced in the world. But this pattern is highly isolated to the provinces that are wealthiest and most willing to spend their own resources on advanced equipment. Across the rest of the country the plants that get built reflect, in part, what the equipment manufacturers are able to build cheaply—often the less efficient plants are cheaper because they do not require imported equipment, which is less familiar and usually requires more costly license payments. China could accelerate this trend by concentrating deployment of these plants in provinces and with contractors and operators who are likely to deploy additional units once they gain some initial experience. Outsiders can help by offering to finance the exports through ExIm banks—funding that is politically easier to mobilize because it is linked to national commercial sales rather than simple financial transfers.

The grid, itself, could be managed more efficiently. Already the Chinese are already in the midst a massive effort to improve efficiency, notably in end use of energy, to meet the country's self-declared energy intensity targets. I doubt outsiders could help accelerate what the Chinese are already doing to improve individual components of the energy system. But relatively little investment is going into making the Chinese grid "smarter," which could allow more efficient dispatch of power plants and interconnection between supply and demand. Yet the Chinese grid—because it is expanding rapidly and it must contend with suppliers and users of highly varied quality—is an ideal setting to test and deploy smarter real-time grid management systems. A technology demonstration program at large scale would align with China's interest in improving efficiency and making the country's grid system work at larger scale with greater reliability. External assistance and financing in setting up such a technology demonstration would be essential, given the lack of domestic knowledge and resources for such a project. It would also allow Chinese firms to test technologies that they might eventually build and sell. And it would open a market for outside vendors of that technology—the components of smart grids are in areas where non-Chinese firms have a notable advantage yet are searching for real markets to deploy their wares—while offering potentially massive leverage on CO_2 emissions. On this third front, too, external help can make a difference. China already is a world leader in ultra high voltage long-distance power lines, but outsiders can help the country adopt more efficiency-oriented grid management, including advanced technologies for digital control of the grid system.

In total, these opportunities in efficiency add up to 234 million tonnes of CO_2 emissions annually by about 2025.[38]

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[37] E. S. Steiner et al, "Greener Plants, Grayer Skies? A report from the front lines of China's energy sector" *Massachusetts Institute of Technology Industrial Performance Sector*, (2008).

[38] These are rough estimates based on the assumption that, by 2025 as new practices and technologies diffuse into widespread use: a) better operational incentives could improve plant efficiency about 0.5%; b) improved combustion efficiency could raise power plant efficiency by about 3% (the difference between a supercritical

Second, China can make greater use of natural gas for generating electricity. Given the extremely low cost of coal it seems unlikely that China will make a strong turn to gas in the foreseeable future. But it has already indicated that it wants to shift to a greater share of gas to help balance its power generation portfolio away from its high reliance on coal, but so far it has fallen short on its own goals for gas due to rising costs for the fuel (most gas that the country would import has been offered on terms that are linked to the price of increasingly volatile oil) and due to fears of insecure supplies. China has little gas of its own except in the far west—that the country's first major gas supply project was a long and uneconomic pipeline from the western supplies is a sign of the priority the country places on security. China can speed its shift to gas by tightening local air pollution rules—a move it already favors to clear the skies in polluted cities—since tighter rules also tilt the balance away from coal (which requires costly pollution clean-up equipment) toward cleaner fuels. It can also build a network of LNG reception terminals with a diversity of suppliers, which would give the country more options in case a particular supply were curtailed. It can also work to reduce transit interruptions in gas supply such as from pirates or through interdiction on the sea lanes. With other large LNG importers (and countries that depend on safe sea lanes) there could be joint exercises, confidence building and anti-piracy squads in crucial straights such as Malacca. China must also engage more directly with the fact that its most cost effective gas supplies come from its neighbor Russia. To date, Chinese-Russian wariness along with Russian Gazprom's vision that it should send its gas to Western Europe for the best price have made China wary about depending on Russia. Outsiders can't fix this problem, but they can make it easier to strike deals that will be self-enforcing once new pipelines are in operation, just as the big Soviet pipelines built in the 1970s and 1980s to Western Europe have been remarkably reliable suppliers of gas once they have been put into operation.[39] A compact with Russia, China and Europe might be needed to give Russia and China, alike, the confidence they need to develop a bilateral gas supply arrangement. Western nations offering diplomatic assistance provides a degree of assurance that would not otherwise be possible. Because gas emits about half the CO_2 per unit electricity generated there is huge potential leverage in shifting to gas. Elsewhere we have calculated that just one province in China (Guangdong) could cut its annual CO_2 emissions 50million tons by 2020 if it tightened local air pollution regulations.[40]

Third, China might do more on nuclear power. In principle, nuclear offers even more leverage than gas because it is carbon free (excluding carbon released during construction and perhaps some emissions from equipment during operation). One of the traditional complaints

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dominated power sector and one that has a large share of ultra-supercritical plants and more rapid replacement of older subcritical units) and c) improved grid operations could, at best, lower line losses about 0.5%. Overall, total efficiency in the delivery of electric power could be about 4% higher. IEA (2008) estimates power emissions of CO_2 from China for 2025 at 5861 million tonnes CO_2 per year; a 4% savings is about 234 million tonnes per year.

[39] Russia's less reliable supplies in 2006 and 2009 are rooted in pricing disputes with Ukraine. When the Soviet Union existed gas exports required crossing few transit countries before they reached lucrative western markets. The collapse of the Soviet Union yielded many more independent transit countries, notably Ukraine, and is a lesson that China knows it must heed. A direct gas export route from Russia is likely to be much more reliable than one that depends on transit countries. That logic helps explain China's interest in circumventing Mongolia with a possible gas pipeline from Russia and also its keen interest in direct export of gas and other products from Kazakhstan in the west.

[40] B Jiang et al, "The future of natural gas consumption in Beijing, Guangdong, and Shanghai: An assessment utilizing MARKAL" *Energy Policy*, 36 (2008) 3286-3299.

against nuclear power is that it is plagued by high capital costs, which may be less debilitating in the Chinese context where construction costs for other state-favored capital-intensive projects are among the world's lowest. (There are other complaints, such as waste disposal, safety and avoiding nuclear proliferation; I will set those aside for the moment.) My sense is that China is presently moving as rapidly as it can toward a greater role for nuclear power. Perhaps the Chinese government (and favorable provincial governments, such as in Guangdong) can do more to accelerate this trend, and perhaps there are ways for outsiders to increase leverage—such as through ExIm-like financing of critical imported components. A similar logic applies to renewable power sources, notably wind, where a big push is already under way. Perhaps there are ways to accelerate that trend.

Fourth, outsiders could gain some long-term leverage on CO_2 emissions with joint research projects on wholly new systems for electric supply. Much is already under way in China and likely to proceed without the extra push that could come from external worries about climate change. For example, the leading Chinese equipment manufacturers and power generator are far advanced in an all-Chinese consortium to develop and test IGCC technologies. Their interest is efficiency, though they also claim they will test carbon storage systems in tandem with IGCC. Outsiders are unlikely to have much impact on that trajectory and, indeed, will be wary about the effort because the Chinese program is already so well advanced that the odds of losing important intellectual property are high while the opportunity to gain access to a lucrative market is relatively low. But other technologies offer more promise—among them is underground coal gasification; natural gas synthesis from coal with combined carbon storage; and the use of CO_2 injection to enhance methane production from coal seams, which offers the advantage of storing CO_2 while providing additional supplies of low-carbon methane that can replace carbon-heavy coal as a source of primary energy.

India

Like China, India's energy system hinges on coal. Thus, like China, achieving leverage on India's energy system requires finding ways to use coal more efficiently or supplanting coal. Beyond those similarities, however, the details of a viable engagement strategy in India vary markedly because the organizing of India's energy system is distinct and thus so are the challenges and opportunities for engagement. Here I focus on four such cases.

First, the greatest opportunity for leverage on India's emissions lies in boosting the efficiency of converting coal to electricity. (As with China there is great theoretical opportunity in boosting efficiency for direct coal combustion, such as its use in brick kilns, but it is hard to see how outsiders could have much impact since the Indian government itself is barely able to administer such uses.) Electricity is interesting not only because it is the largest single user of coal but also because nearly all of the coal-fired power system is owned by the state. India has a federal system of governance, and in the power sector competence is shared between the central government and the states. The single largest operator of coal-fired power plants is the centrally owned National Thermal Power Corporation (NTPC); I will focus there since it offers the greatest potential for leverage, though similar opportunities may also exist in some of the so-called State Electricity Boards (SEBs) the regional state companies that also build and operate power plants. The SEBs are a more challenging source of leverage, though,

as all are technically bankrupt, pulled in many directions by local political priorities, and most are badly managed. NTPC, by contrast, is remarkably well managed for a government-owned corporation; it is in touch with technological opportunity, attentive to cost, and steeped in competence.

NTPC, while the most efficient of India's government-owned power generators, is notable for sitting far back from the world technological frontier. It is building the nation's first "supercritical" coal-fired plant—a less efficient version of the "ultrasupercritical" plants that are the world's most efficient conventional coal-fired power units. Yet NTPC has realized that it has a strong incentive to find more efficient ways to burn coal because the era of cheap coal is over, but NTPC has little experience with these more efficient plants. Its counterparts in developed nations can assist in this process. Nearly all coal in India is supplied from a consortium of government-owned coal mining companies held by the behemoth Coal India Ltd (CIL). The consortium members of CIL vary radically in their performance, but all are running into trouble as they dig into more difficult to mine coal seams, lower coal quality, and a creaking transport infrastructure of railroads that are barely able to keep up with demand. Over the last two years the stockpile of coal on hand at key power plants has dwindled to days. Efforts to reform the coal supply system—such as by allowing private ownership of mines, forcing better accountability in CIL, rationalizing rail rates—are making only halting progress due to massive political obstacles. Even seemingly obvious steps such as encouraging more pre-washing of coal have been difficult. (Coal washing removes impurities before shipping so that the product actually moved contains more useable content; by some estimates perhaps one-third of the "coal" actually moved in India is actually rocks that don't burn, but a pricing system that is based on tonnes rather than btus does not reward diligent washing.)

These problems in coal supply are hard and slow to fix. Part of the solution is to allow coal prices to reflect scarcity and to encourage a shift to more reliable supplies of imported coal. Efforts on both fronts are under way—for example, a rising share of India's coal is priced in electronic auctions rather than through the government's central planning system of "linkages"—and that means that coal is becoming much more expensive. Imported coal, too, is much costlier than a decade ago and the fundamentals in international coal supply portend high prices into the future. For NTPC these patterns put a premium on efficiency; arrangements that offer the prospect of more efficient combustion are offering an option that NTPC already seeks. A program to rebuild old coal-fired power plants with advanced supercritical units could help the country lift its average coal-combustion efficiency from 30% to perhaps 40% over two decades. Looking to 2030, such a program could avoid about 110 million tonnes of CO_2 annually for the 77GW coal-based power generation that exist in India today. In addition, such a program could lift the average efficiency of wholly new plants built between now and 2030. In total, these improvements could reduce India's emissions about 400 million tonnes of CO_2 annually below the level that the power sector would have emitted otherwise. Achieving these higher efficiencies, especially for new plants, will benefit from early deployment of ultrasupercritical plants to create learning and expertise with this technology, which will build the platform for further reductions in future. The Indian government has already removed the most serious obstacle to this approach by dismantling in the 1990s the requirement that coal combustion technologies be supplied only by Indian vendors. A viable plan to work with NTPC (and perhaps some of the better managed SEBs) to

apply new technologies could work on two tracks—one with outside vendors (perhaps using ExIm financing from countries keen to export the technology) and the other in consortium with India's main equipment manufacturer (Bharat Heavy Electrical, Ltd) so that the two ventures compete. NTPC would be a welcome partner not only because this aligns with its severe problems in coal supply but also because it is suffering, a bit, the reputational harm that comes from being the world's third largest source of CO_2. Scrutiny of its footprint on the planet is already growing in India since that news was first reported in April 2008.

Such a program would operate under the useful shadow of competition from private investors in power plants as India has just embarked on a program to build up to 14 "ultra mega power projects"—all based on private investment for power parks that would rely partly on captive coal mines and mainly on imported coal. All of the ultra mega power parks are expected to use supercritical technology; it would be useful to explore whether some might even use ultrasupercritical technology or even IGCC a decade or so down the road when the technology is further along.

Second, the search for leverage over India's CO_2 emissions must begin with coal because that fuel accounts for such a large share of the energy system and therefore it is politically naïve to envision clever and big schemes to remove coal. CIL is the single largest employer in a country where jobs are scarce; it is well-connected in pivotal state governments. But other fuels, at the margin, can make a difference. Hydro is already the country's second largest source of electricity; more might be done to advance hydro, though I am skeptical that outsiders can make much of a difference because the biggest obstacles to hydro are siting problems that are appropriately matters for Indians, alone, to settle. (The Indian hydro industry is owned entirely by the government and it dreams, like most dam builders, of much greater progress if public opposition could be curtailed. India's courts are particularly open to public complaint, and my sense is the days of easy hydro building are over.) Other sources of renewable power, notably wind, are already advancing; Indian firms are among the world's leaders in this technology and it is unlikely that outsiders can help much. Gas also offers a great potential to tame carbon, but here too outsiders don't offer much leverage. The most important news to brighten the prospects for Indian gas combustion is the discovery of large indigenous reserves that can be used to supplant extremely costly LNG. Those discoveries and their marketing are matters entirely for Indian companies and regulators. Outsiders might help by clearing the way for international gas pipelines that could offer still more cheap gas, but the practical difficulties are massive. It isn't clear that enough demand could be assured to make those pipelines profitable, and the politics are debilitating. A pipeline from Bangladesh has been quashed by that country's fear of selling its heritage to Indian enemies. A pipeline from Myanmar (Burma) hinges on politically unattractive bedfellows that will deter the best commercial partners. A long-dreamed pipeline from Turkmenistan must cross Afghanistan which is not a hospitable place to lay costly soft infrastructure. Today's dreams center on a pipeline from Iran across Pakistan. But that project must contend with the inconvenient truths that Iran's poor political climate is plunging it into a crisis where the country has barely enough gas production to meet its own demands. Pakistan, too, is in crisis and periodically threatens nuclear showdown with India. Engineers, never to be frustrated by political reality, have also drawn interesting lines for pipes from Oman offshore around Pakistan directly to

India; but the cost and practicality of that dream are hard to square with the reality that it is better to look for more gas at home. The Indian neighborhood is a tough one for pipes.

Nuclear power offers great potential in India. Elsewhere I have advanced the argument that the US-Indian nuclear partnership—which is on the cusp of approval at this writing—is perhaps the single greatest contribution that the Bush administration and the Indian governments have made so far to cutting carbon. By our estimates the partnership, which would make nuclear technology and materials available to India and thus allow the country to purse a commercial nuclear strategy that is much more commercially viable than the Thorium cycle that has preoccupied the nation so far, could avoid 150 million tonnes of CO_2 annually by about 2025.[41] Cutting CO_2 through the use of nuclear power in India hinges on outsiders.

A third opportunity for outsiders to help in India concerns the country's weak system for power delivery. There may be opportunities, akin to the plan I have suggested in China, to improve general operation of the grid. However, the high voltage grid, relative to the rest of the power delivery system, is already in the best shape thanks to a system of guaranteed returns for investment in long-distance power lines. (That system might be improved to better reward performance, but such improvements are unlikely to yield much leverage on CO_2 and, in any case, are matters for Indians to address. Outsiders can't help much.) But the lower voltage systems for regional power movement and final delivery are a mess. Pilferage of power is high because many users, notably farmers, are not metered and power companies have little idea where the electrons are sucked from the system. These problems are not easy to fix since they are rooted in the dysfunctions of government enterprises—especially the SEBs that are particularly prone to political interference—but halting efforts are under way and some are yielding huge improvements. One lesson from these efforts is that advanced power delivery and metering technologies can make it much easier to reduce theft and thus, in effect, raise the price of electricity from zero to something that approximates the real cost of scarcity. Better grid management thus encourages much greater efficiency by users and also allows more optimal operation of the whole electric system. This lesson is already evident in the city of Delhi which has shifted management of its local grid to three private companies and has also encouraged deployment of new power lines and meters that have sharply reduced pilferage from 50% to about 30%.[42] A few other jurisdictions have had similar experiences, but these successes require a difficult alignment of political interests and also generally higher incomes so that the power consumption and available resources are adequate for investment in these advanced systems. Outsiders could help tilt the balance by co-funding these systems in areas of the country that are willing to apply these better management approaches but unable to afford them. Overall a large program to make fuller use of advanced local grid management

[41] The Nuclear Non-Proliferation Treat (NPT) is an international treaty designed to prevent nuclear-capable states from transferring weapons to non-nuclear capable states, as well as hasten nuclear disarmament. More than 190 countries have joined the treaty, although notably India is not a signatory. Unable to access international fuel supplies and technologies, India has centered on Thorium (which is available domestically but probably more costly and less reliable a fissile material).

[42] A calculation done by Varun Rai and Ankur Goel at Stanford University suggests that electricity reforms (improved grid, advanced metering) in Delhi since 2003 have helped reduce about 13 Mt CO_2 in the last five years, or 2.5 Mt CO_2/yr. A simple extrapolation of this number to entire electricity generation in India suggests the potential to reduce about 100 Mt CO_2/yr from such simple reforms.

might encourage a national improvement in energy efficiency of a few percent, or several hundred million tonnes of CO_2 annually after a decade of sustained effort. [43]

Fourth, it is impractical to look for leverage in India without considering the most glaring fact of India: perhaps half of the population does not have access to modern energy services. This is a striking difference with China where economic growth along with tens of thousands of local energy projects (notably small hydro) connected nearly all of the Chinese population to the power grid over the last three decades. India has set the ambitious goal of "electricity for all" by 2012 and measures progress to that goal by the presence of a single power point in a village. Even by that measurement the country is likely to fall far short, and when measured at the level of individual households the country will be lucky to get 60% connection. Doing better matters for Indian politicians because the rural population often holds the key to electoral success and because modern energy is an important element of economic development.[44] A game plan that helps on this front could also help engage India in efforts to address climate change because the country's low level of economic development—and thus low per-capita emissions—is the centerpiece of its claim that India should not be expected to do much at this stage. That argument has merit and political traction, though it also masks the much higher per-capita emissions of India's wealthier urban population as well as the country's huge opportunities for leverage.

The political logic in favor of doing something about energy services for the poorest has always been frustrated by inconvenient arithmetic. Extending access probably increases emissions.[45] Extending access more efficiently could reduce those emissions, but the absolute quantities of CO_2 from these new potential uses of fossil fuels are small. For example, if the whole of the world's 1.6 billion people not connected to the power grid were suddenly given access and used 50 kWh per household per month (a generous allotment based on South

[43]Restructuring the State Electricity Boards has always been extremely difficult and moved slowly. See generally Rahul Tongia, 2007, "The political economy of Indian power sector reforms" in David G. Victor and Thomas C. Heller, eds., 2007, *Reforming Electric Power Markets in Developing Countries: Politics, Law and Institutions* (Cambridge: Cambridge University Press. On the options for advanced metering R. Tongia, "IT and Advanced Metering for the Indian Power Sector." *World Bank*, New Delhi, January 5, 2005.

[44] E.g., Douglas Barnes, 2007, *The Challenge of Rural Electrification: Strategies for Developing Countries* (Washington: Resources for the Future)

[45] A popular argument is that extending access can cut emissions by supplanting unsustainable uses of biomass. While true in some settings, that argument has never withstood much serious scrutiny because costlier modern energy systems usually create new energy demands (e.g., high quality lighting) rather than supplanting bulk heating and cooking. Moreover, careful studies of biomass usage suggest that in most settings it is sustainable and that household biomass use is not the primary cause of deforestation. For example, local cooking and heating needs often rely on waste straw or on specially maintained hedgerows between crops. There are strong incentives to be sustainable in local villages since failure has immediate consequences. However, while completely combusted firewood produces only carbon dioxide and is therefore carbon neutral, unimproved cookstoves produce many incomplete products of combustion such as methane and carbon monoxide which have a greater global warming potential than carbon dioxide. In such cases, dispensing improved cookstoves can lead to a new GHG reduction, as less wood is used and it is burned more completely. Preliminary calculations done by the Rural Wood Energy Development Program in Asia cite that a metric ton of carbon can be reduced for less than $2 by implementing improved cookstoves, primarily by reducing methane. See W. S. Hulscher, "Stoves on the Carbon Market", *Rural Wood Energy Development Programme*, 1999.

Africa's experience with electrification) then world CO_2 emissions would rise just 1%.[46] (These reasons explain why I will not explore most of Africa as a source of climate accession deals. Africa is pivotal for development, but the core of the development challenge does not always fit with the goal of greenhouse gas abatement.)

India, though, offers an interesting opportunity—not through CO_2 but the particulate emissions that arise from traditional biomass usage. There is new but intriguing evidence that a large cloud of particulate pollution originating mainly in India is a major source of greenhouse warming. (Black carbon particulates cause warming and other climate impacts partly because their dark color makes them good absorbers of sunlight energy, which affects the reflectivity of the planet and also accelerates the melting when they land on more reflective ice.) A program to use that biomass more efficiently would cut emissions of black carbon because less material would be burned and it would be burned at higher temperatures leading to fuller combustion. There's a large experience and some analytical literature on the kinds of efforts that could be needed which probably involve deployment of advanced cookstoves for heating and cooking. Measurements from drones flown into the brown cloud suggest that just a few states in India are the main source of the pollution and thus the effort could initially concentrate in those locales.[47] Designing effective programs requires attention to real costs and scalability at the level of the household; subsidies and grants for equipment must be targeted carefully. Often the best purveyors are for-profit ventures, at times working in tandem with microfinance. Local governments and outsiders alike must plan their interventions with these commercial realities in mind. When they do they find local customers keen to embrace the opportunity since advanced stoves not only can save money but also produce enormous health and economic benefits.[48] Those benefits are most felt by women who cook but rarely have a voice; the men, though, also notice the gain from reducing in-house pollution by a factor of ten or more. Getting a handle on the exact global warming benefit of a large-scale deployment of advanced cookstoves is difficult but it could be on the order of the equivalent of one third of India's anthropogenic greenhouse gas emissions.[49]

South Africa

After China and India, among the reluctant countries the third largest consumer of coal is South Africa. All the reluctant countries that use coal offer potential leverage through

[46] This order of magnitude comes from a simple calculation that assumes all households currently without access to electricity would get 50 kwh/household/month of electric power supply and that power could come from the most carbon-intensive (coal-fired) sources.

[47] Venkataraman, C. "Residential Biofuels in South Asia: Carbonaceous Aerosol Emissions and Climate Impacts." *Science* **307**, 1454 (2005);

[48] While in the past cookstoves were often see as part of an anti-deforestation strategy, this perspective has gone by the wayside with the "fuelwood myth" being dispelled. For a more in-depth discussion see G. Leach, R. Mearns *Beyond the woodfuel crisis: people, land and trees in Africa*, (London: Earthscan, (1988).

[49] For a discussion of the warming effect of the Asian Brown Cloud see Ramanathan, V. et al. "Warming Trends in South Asia Amplified by Asian Brown Cloud." Nature 5 Vol 448 575-578 (2 August 2007) This paper suggests that "atmospheric brown clouds contribute as much as the recent increase in anthropogenic greenhouse gases to regional lower atmospheric warming trends." While the literature differs in its estimates, about one third of the Asian Brown Cloud comes from biomass burning for household use. It is important to note that emissions reductions from the Asian Brown Cloud (ABC) are not exactly analogous to traditional emissions reductions, as the ABC has a "regional" warming effect.

arrangements similar to those outlined above—though with less leverage because their markets are all much smaller—and thus I won't detail the opportunities any further. South Africa, though, offers a special opportunity and thus merits a brief analysis.

South Africa depends on coal for a greater fraction of its energy system than any other large country on Earth. Nearly all power comes from coal (except a small fraction from two nuclear plants near Cape Town) and coal is also used to make liquid fuels that displace oil. This heavy role for coal reflects the legacy of apartheid era sanctions that encouraged the country to become self-sufficient (and thus offer proof that "energy independence" is often costly and harmful). The country is now trying to fix that legacy at a time when awareness of the risks of global warming is rising. And South Africa's state-owned power company, Eskom, is perhaps the best managed state power company in the world. It has high technical competence and thus is able to deploy advanced coal-fired power plants that lesser enterprises would find too finicky (and thus unreliable). It also has a strong incentive to burn coal more efficiently as the country's demand for electricity is rising (indeed, it faces regular blackouts at present) and the days when it paid just one-tenth of the world price for coal are over. The country used to segment its coal supplies between low-cost internal deliveries and higher priced exports, but the lost opportunity of that pricing scheme is becoming evident and internal prices are rising steeply.

South Africa is too small to develop and deploy advanced coal plants on its own. Responding to its own internal incentives the country will opt for more efficient plants, but outsiders could amplify that trend by offering easier access to the most advanced technology and by engaging Eskom in consortia to test and deploy the most advanced equipment. With a more sustained effort to map the country's geology it is also feasible that the next major investment in coal-fired plants in South Africa could include carbon storage. Eskom is already under pressure to control its CO_2 emissions and has outlined an ambitious plan to do that, but it is unlikely to deploy the most expensive options (e.g., carbon storage) without external assistance as its rate payers are already wary about investments that would lift the country's notoriously low power prices. A program to deploy the most advanced power plants for new units might increase power plant efficiency from current levels of 35% to 43% saving [50-100] million tonnes of CO_2 annually by 2025; a carbon storage scheme might increase that amount another [20] million tonnes.[50]

Brazil

Throughout I am focusing mainly on energy-related emissions for they account for most of the warming problem. But changes in land use—notably the clearing of land for timber, grazing and crops—also play a role and account for a significant portion of world CO_2 emissions. Brazil is a hotspot for deforestation as it is the main host for the world's largest

[50] South Africa's power sector emissions are currently 218 $MtCO_2$ (see Carbon Monitoring for Action, Center for Global Development Resource) The five most polluting power plants in South Africa—Kendal, Majuba, Matimba, Lethabo, and Tutuka-- amounted to 118.8 $MtCO_2$ of that total. A few well-designed carbon storage projects centered around those concentrated sources of carbon could lead to major reductions in emissions. For more information on carbon storage in South Africa, see B. Naidoo, "SA pushes ahead with carbon dioxide storage Atlas project" Engineering News, 2009.

forest; economic growth and the opportunity to produce minerals, meat and crops have put relentless pressure on the Amazon. After steady improvement in the 1990s the rate of deforestation has risen in the 2000s and been particularly high in the last several years, with 1,250 sq miles cleared in the last five months of 2007.[51] If those accounts are expanded to include fragmented forest—which itself is a major source of net CO_2 emissions and is often nearly as bad for biodiversity as complete deforestation—then the Brazilian footprint on the land is even larger.

Schemes to avoid such deforestation were left out of the Kyoto treaty because it was thought, correctly, that it would be too hard to monitor them precisely. Efforts are now under way to reverse that decision—including through possible future awards of emission credits under the CDM.[52] I am skeptical that such efforts will bear fruit because the uncertainties surrounding measurement of a counterfactual land use—that is, the avoidance of deforestation—are probably impossible to narrow sufficiently to quantify the credit that should be awarded. Worse, as with much in the CDM, the scheme would create perverse incentives because it encourages countries to make credible threats to clear forests and to avoid wise policies that could slow deforestation. Getting paid to quiet a chainsaw requires, first, the brandishing of a noisy and visible chainsaw.

Slowing deforestation in Brazil's Amazon will not work through marginal incentives such as the CDM. Most of what is needed is for Brazilians, themselves, to improve management of the Amazon region by asserting clearer property rights to create a stronger incentive for stewardship and to enforce existing laws more fully. (Brazil has good forest laws on the books but has perennial difficulties enforcing them—especially along the Amazonian frontier where lawlessness is a general condition and Brazil's central government has little sway.) Incentives for action exist already. Brazil is under closer scrutiny at home and abroad for its emissions from all sources. Local NGOs and scientists are mobilizing pressure for change by noting, in part, that the Amazon may become especially vulnerable to fire if climate changes. And better land tenure will attract investment with a longer time horizon (including, perhaps most notably, investors who seek to buy and deed whole tracts of forest) and will allow fuller tax collection on activities in the forest. [53]

It is hard for outsiders to have much impact on the choices that rest entirely with Brazilians, but one area of assistance could be the provision of surveillance radar, drones and helicopters for a much larger police force. Such systems would allow Brazil to better use the personnel it already has in place to monitor deforestation and regulate illegal logging. Some will object to an offer of police assistance, but those difficult choices will be needed to get much leverage on a forestry problem that, at its root, rests on poor assignment and enforcement of land rights. Similar offers of assistance could be made to other countries that are rich in forests but poor in enforcement, such as the forested nations of West Africa and Southeast Asia. Below I look in some more detail at Indonesia.

[51] "Brazil Amazon deforestation soars" BBC News January 2008. For more information consult the Brazilian National Institute for Space Research, which tracks deforestation using satellites.
[52] See "CP .13: Bali Action Plan" United Nations Framework on Climate Change.
[53] See Filho et al in "Modelling Conservation in the Amazon Basin" in *Nature* (March 2006), pp. 520-523.

Brazil's energy sector offers relatively little leverage on CO_2 because most (76%)[54] of its electric power system is based on hydro and burns no fossil fuels. Its automobile fleet relies on sugar-grown ethanol for about 13% of its liquid fuels.[55] (Sugar is biologically an efficient way to produce ethanol and yields a big reduction in CO_2 when compared with oil. Brazil's sugar ethanol scheme dates to the late 1970s when the country was trying to wean itself from foreign oil. It succeeded in that venture mainly by discovering and producing more oil at home, but along the way it built a powerful and commercially viable sugar ethanol industry that, fortuitously, also yields lower CO_2 emissions.)[56]

Leverage over energy is available in at least two areas. First, Brazil can do a much better job in documenting greenhouse gas emissions from its dams, predicting emissions that could come from new dams, and devising systems for cutting those emissions. Some of this is in Brazil's interest already because one strategy for reducing emissions is to clear and sell valuable timber from areas that will be flooded by reservoirs (and to cut, with underwater logging, timber that may already be under water). There have been enormous improvements in underwater logging in the last two decades that make this more attractive.

Some schemes to cut emissions from dams will require external assistance. Outsiders can help with some resources, but even more badly needed is credibility—which requires a broader engagement with international scientists. Brazilian scientists have been locked in a nasty and inconclusive debate over exactly how bad dams are for global warming, with those who argue that the impact is minimal wrapping themselves in the Brazilian flag of nationalism (as befits a country that depends on dams for electrons more than any other major country on Earth). Sorting through the evidence is an essential first step to designing and implementing schemes to cut those emissions during planning and operation of dams. The emissions vary markedly with the exact location and biology of the land displaced and the water accumulated, as well as the design of the dam.[57] Such arrangements could be crafted for other countries that are prone to rely on hydropower and have biology prone to yield greenhouse gas emissions

[54] IEA number for 2005. Hydroelectric power as a portion of total electricity supply in Brazil (including net imports, not just domestic production).

[55] According to the BP statistical review, Brazil consumed 2,192 thousand barrels of oil a day in 2007 (about 800 million barrels for the year). By contrast, Brazil's production of ethanol in 2007 was 5019.2 million gallons, or about 119 million barrels at 42 gallons to the barrel. Ethanol production data obtained from *Changing the Climate: Ethanol Industry Outlook 2008*. Renewable Fuels Association Publication. February 2008.

[56] While the production and burning of sugarcane ethanol itself leads to substantial CO_2 reductions, there has been a significant controversy about the effect including land use. Critics of sugarcane ethanol claim that additional clearing of land for sugarcane diverts crops like corn and soy into other land, leading to deforestation and massive associated emissions. A complete analysis of the CO_2 impact of ethanol would need to include such a calculation. For an analysis that includes land use changes and determines that ethanol has a much higher carbon footprint than gasoline, see Fargione, Joseph. Hill, Jason. Tilman, David. Polasky, Stephen. Hawthorne, Peter. "Land Clearing and the Biofuel Carbon Debt." Science Express Report, (February 2008)

[57] Fearnside, P. M.: 2004, 'Greenhouse gas emissions from hydroelectric dams: Controversies provide a springboard for rethinking a supposedly "clean" energy source,' *Climatic Change* 6(6): 1–8.; "Chapter 3: Ecosystems and Large Dams: Environmental Performance" in *Dams and Development: The Report of the World Commission on Dams*. (November 2000)
Abril, Gwenael et al. "Carbon dioxide and methane emissions and the carbon budget of a 10-year old tropical reservoir (Petit Saut, French Guiana)." Global Biogeochemical Cycles, Vol. 19, GB4007 (2005).; Kimenes, Alexandre et al. "Methane release below a tropical hydroelectric dam." Geophysical Research Letters, Vol. 34 (2007) C

from dam flooding—such as Indonesia and perhaps Congo if the massive Grand Inga dreamed dam on the Congo River is ever pursued.[58]

A second area for leverage is nuclear power. Brazil has two operational reactors and is restarting construction on a third that had been left half-finished in mothballs. Nuclear power plays a small role in the country. (Already, though, its nuclear units may displace some coal-fired power that might have been built to balance against the country's extreme dependence on hydro—a dangerous dependence when times are dry.[59] The country has some low-quality coal reserves in the politically well-connected South and has explored options for coal imports.) But nuclear matter in Brazil because the country is a pivotal part of the international fuel cycle. Until recently, the country has been content to purchase its fuel from overseas (mainly Canada), but specious fears that the country might be cut off has led to a massive investment in a self-contained system for enrichment and fabrication. Getting Brazil to recraft that system as part of an international fuel cycle could improve the prospects for safe nuclear power worldwide. Other nuclear powers such as South Africa as well as the large number of potential new entrants (e.g., Indonesia) could make a calculus similar to Brazil's and build their own fuel cycles unless they were confident that fissile material would be available. (And, for new entrants, the absence of a reliable fuel cycle could remove nuclear power as a considered energy option or vastly inflate the cost to include a fuel apparatus in addition to reactors.) The subsequent rise in proliferation dangers from many national fuel cycles under varied safeguards could make the dangers of nuclear power much greater than the enormous environmental benefit of much lower CO_2 emissions. Fixing these problems requires confidence in a fuel supply system that no single country is able to manipulate and which takes advantage of the economies of scale in fuel manufacture to offer cost-effective fissile material.

There are various proposals for international fuel cycles and fuel banks that would provide exactly such assurances and cost advantages. What is missing, however, are schemes that are seen as credible by fuel importers. Brazil's leadership could make the difference. Outsiders—notably the other countries that have fuel enrichment, reprocessing and fabrication facilities—must also play an essential role by offering to supply services and to help fund an international bank of fuels under multilateral control so that fuel importers do not fear an unjustified cutoff. Along with Brazil, China and Russia are also pivotal. China is building more reactors than any other country, and Russia has one of the world's largest fuel services industry.[60] Thinking about its own interests Brazil has already revealed that it will build its own fuel services industry; with outside pressure and support it could help build a backbone

[58] In mentioning these other countries I am just speculating. Indonesia already has a substantial inventory of logs under water that are probably contributing to greenhouse gases that accumulate in reservoir water and degas when they run through the dam. The Congo project would not be a high priority at the moment because a) it is exceptionally difficult to plan and build a massive dam in that country, as it has been ever since the site was first identified, and b) initially such a project would have a relatively small reservoir and would rely mainly on run of river flow.

[59] A. Oliveira, "Political economy of the Brazilian power industry reform" in D. G. Victor and T. C. Heller (eds.), *The Political Economy of Power Sector Reform* (Cambridge University Press, 2007), 31-75.

[60] I have focused here on the "front end" of the fuel cycle as that is the most urgent proliferation challenge. Similar international consortia could be constructed for the "back end", including reprocessing. For more on both ends see Burton Richter, 2008, "Reducing Proliferation Risk," *Issues in Science & Technology*, Fall, pp. 45-52.

for a much larger (and safer) worldwide use of nuclear power that could displace huge quantities of CO_2.

Indonesia

After Brazil, Indonesia is the world's biggest deforester by area.[61] A deal to stem deforestation could be crafted along terms similar to those outlined for Brazil. Uncomfortable choices will be needed to help arm the Indonesian police; assurances will be needed so that such resources are actually used for enforcement. Corruption, long rampant in the forest regions of Indonesia, will need special scrutiny. The challenges to such a deal will be many, but such is the nature of getting a grip on carbon.

Indonesia offers a special opportunity because its deforestation occurs in many different types of soils, and one type of deforestation—by fire on peat soils—is the country's main source of CO_2 emissions. Peat soils are a particular concern because they are especially rich in carbon and while any clearing will release some peaty carbon, fires are particularly intensive in their carbon release. In the past, regional efforts in Southeast Asia have attempted to ban all land clearing by fire, the main cause of a regional haze that appears across the region—reducing visibility and causing severe health effects. The clearing season during the dry years of 1997/1998 was particularly bad and animated such regional attempts. So far, however, they have not had much impact because they run contrary to the interests and capabilities of pivotal players—notably Indonesia, which hosts most of the fires. A fresh attempt, animated not just by regional haze but also global climate change, could navigate around this problem by focusing first on the fires that have the largest externality (i. e., peat) while posing less threat to the underlying agricultural and palm plantation activities that give rise to the need for forest clearing. With success, a peat-focused effort could expand to other soils.[62]

In practice, focusing on peat probably would require two elements. First would be an effort to help build Indonesian capacity to map the country's soils and understand the major sources of threat. Monitoring and technical assistance, in the context of a broader engagement with international scientists, could be essential. That force would also police a program that could, in time, ban fire clearing on peat lands. There may be places where such a ban would be impractical because it would be seen as an effort to ban commercially productive use of the land altogether. In those cases a fund could be established to pay the extra cost of manual non-fire clearing. (Clearing by fire is preferred by land owners when there are no constraints on their actions because it costs about one-fourth the amount of manual clearing.) While the exact

[61] "Chapter 2: Extent of Forest Resources" Global Forest Resources Assessment 2005: Progress toward sustainable forest management. FAO, Rome. (2005).

[62] This proposal for a peat-focused program is inspired by Tacconi et al (2008), "Local causes, regional co-operation and global financing for environmental problems: the case of Southeast Asian Haze pollution" *International Environmental Agreements*, vol 8, pp. 1-16.

emissions are difficult to calculate, an analysis of the 1997 wildfires in Indonesia found that the emissions from that event were approximately equal to 13-40% of worldwide annual emissions from fossil fuels.[63]

Russia

We also explore the opportunities to engage Russia. While not a developing nation, Russia is, to be sure, a reluctant nation on the climate issue. It is a cold country where heating is costly and agriculture struggles to survive. Conventional assessments of Russia's exposure to climate change correctly find that the country is poised to gain (barring some abrupt or unexpected change in climate).[64] Its negotiating behavior in Kyoto was consistent with this view, as Russia refused to accept any target more stringent than its highest expected emissions during the Kyoto compliance period.[65] It agreed to join Kyoto so long as the treaty would not constrain its behavior and, most likely, would allow it to pocket unearned cash by selling surplus emission credits. Despite these extraordinary concessions—which are evidence of the danger of letting reluctant nations sit at the negotiating table when setting commitments that are relevant only for the enthusiastic set—Russia still nearly balked. Only after European members threatened sticks and offered carrots (such as promises to buy Russian credits and probably also to back Russia's membership in the WTO) did Russia come around and ratify the treaty. (Without Russia the treaty would not have entered into force and thus the EU had an especially strong incentive to ensure the Russians came around.)

Russia can be engaged by the same logic that inspires other possible deals with reluctant countries. Already the country is doing much, on its own, that aligns with the external interest in cutting CO_2. After the collapse of the Soviet planning system it rationalized its rail rates which, in turn, decimated the Siberian forest industry. Woody biomass is now accumulating in Russia which has become, perhaps, the world's largest forest carbon sink.[66] It has raised internal fuel prices—fully to world levels for oil products and more gradually for gas and coal—which is encouraging conservation. Outsiders have played only small roles in these efforts—contributing advice on fuel pricing, for example—and Russia's brimming nationalism makes it unlikely that outside influence can do much more. However, in at least one area Russia could make a big contribution. At present Russia flares about approximately (accounts vary) about 60 billion cubic metres of natural gas annually—mainly from oil operations that are not controlled by Gazprom and thus generally not allowed access to Gazprom's pipelines. When pipe access is difficult it is much cheaper to flare gas that is a

[63] The paper estimates that between 0.81 and 2.57 Gt of carbon were released during the 1997/1998 forest fires. See Page et al, "The amount of carbon released from peat and forest fires in Indonesia during 1997" *Nature* **420**, 61-65 (7 November 2002) While the event was a unique one, and a forest fire rather than clearing of land for agriculture, it demonstrates the enormous amount of carbon at stake in burning Indonesian peat forests.

[64] Nordhaus, W. D. , and Boyer, J. *Warming the World: Economic Models of Global Warming.* MIT Press, Cambridge, Massachusetts. 2000. Cline, William r. Global Warming and Agriculture: Impact Estimates by Country. Peterson Institute on International Economics. (July 2007).

[65] David G. Victor, Nebojša Naki?enovi?, Nadejda Victor, 2001, "The Kyoto Protocol Emission Allocations: Windfall Surpluses for Russia and Ukraine," *Climatic Change*, vol. 49, pp. 263-277

[66] Linski, Jari. "Soil carbon budget in Northern forests", Academy of Finland, Pending.: Kauppi et al, "Returning forests analyzed with the forest identity." Proceedings of the National Academy of Sciences of the United States. (September 2008).

byproduct of oil production, and flaring converts the gas to about 175 million tonnes of CO_2 annually.[67] In addition, the Gazprom-dominated pipeline system is leaky, which results in about 3% of its total throughput venting to the atmosphere without combustion, which is even worse since methane (the main component of natural gas) is 25 times more potent as a greenhouse gas than CO_2.[68] Outsiders could help Moscow frame a better policy, which would include third party access to the pipeline network near oil fields and a system of monitoring and penalties for leaky pipelines. Plausibly, these efforts could reduce the leak rate to one-quarter of one percent (a typical value in the best pipeline systems) and virtually eliminate flaring. The outsiders engaged in this venture might need to provide the advice and help fund upgrades for pipelines that would otherwise remain in poor condition. Some projects of this type are already under way in Ukraine (across with nearly all of Russia's export gas flows) with European financing, but the higher payoff will come inside Russia and focused on the lower pressure regional and urban distribution pipe-lines which are probably the source of most leaks.

Gulf States

Finally, I speculate whether the countries that have been most wary of climate policy—the oil-exporting Persian Gulf states such as Kuwait and Saudi Arabia—might be engaged in useful ways. These are not reluctant nations—rather, many are hostile to the mission of cutting carbon Engaging them, if feasible at all, will require measures that strictly align with their interests. Their largest sources of emissions come from consuming oil, and unlike most other countries—which are becoming more efficient in their oil consumption thanks to higher international prices—the Gulf states generally insulate their populations from the real cost of oil. Thus, ironically, as oil prices rise so does their consumption because the wealth effect of more valuable exports swamps any incentive to conserve. Outsiders can provide advice—as the International Energy Agency and other experts have done repeatedly—but the politically difficult decision to curtail subsidies rests with these countries themselves. A different strategy, though, might be more effective. All the Gulf states—notably Saudi Arabia and the United Arab Emirates—are trying to develop partnerships with western purveyors of technology on non-oil energy systems, notably solar electric power and solar thermal osmosis systems for purifying sea water. The logic behind these partnerships is that oil is more lucrative as an export but replacing its local use requires demonstration of other technologies. Many of these partnerships rest on government-to-government agreements. The western governments should explore making these agreements contingent on the oil exporters raising prices—initially for the applications that new technologies are expected to supplant, such as electric power. Artificially low prices for the main competitors to these new technologies make it highly unlikely that these technology partnerships will actually lead to much deployment and thus the technology partnerships are unlikely to have much value without internal price reforms.

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[67] Accounts on the amount of gas flared differ. The Russian government official states that it flares 15 BCM of gas (43 $MtCO_2e$) but the IEA estimates through remote sensing that it it much likely closer to 50-60 BCM (175 MtCO2e). For more information, see *Optimising Russian Natural Gas*: *Reform and Climate Policy.* International Energy Agency (2006); *Using Russia's Associated Gas.* Global Gas Flaring Reduction Partnership and the World Bank. PFC Energy (December 2007).

[68] See table 2.14 in IPCC, 2007, *Climate Change: The Physical Science Basis* (Cambridge: Cambridge University Press), chapter 2. Such an approach to comparing gases is enshrined in the Kyoto treaty although the actual effect of different greenhouse gases is impossible to summarize in a single number such as the global warming potential.

Politically difficult reforms, notably rationalizing gasoline prices, might be deferred until later since gasoline does not compete with the renewable energy sources that have been the base for most of these partnerships.

The Gulf is emerging as an interesting test bed for carbon storage which, if successful, could help lower that region's emissions and also accelerate deployment of the technology worldwide. BP is far advanced in the region's first demonstration plant—an enhanced oil recovery and carbon storage venture in Abu Dhabi. The Gulf, by virtue of its rich oil production, is well endowed with empty pore space suitable for carbon capture and storage. Other Gulf states might follow suit after Abu Dhabi's demonstration, and the West should be willing to help clear roadblocks and share technology where needed although most of these projects will probably proceed on their own commercial merits. It is hard to assess how much CO_2 could be stored through such ventures, but a Gulf-wide initiative in this area might scale up over the lifetime of large new investments in the power sector and new oil production fields (i.e., about 15-20 years) and the level of effort could be on the order of magnitude of 100 million tonnes CO_2/yr. An effort on that magnitude would involve 50-100 projects on the scale of the large CO_2 injection projects already being tested in Norway or Algeria and is roughly comparable with all planned CO_2 injection projects worldwide today. [69]

[69] Injection rates for particular projects and for the totality of world efforts in carbon storage are reported in V. Rai, N. Chung, M. Thurber, D. G. Victor. "PESD Carbon Storage Project Database." Program on Energy and Sustainable Development, (2008) Working Paper #76.

Country	Deal	Description	CO_2 Savings
China	Improved Grid Efficiency	Improved technology (such as "ultrasupercritical") that saves money (in addition to GHGs), but require additional licensing and imported equipment. Smart grid technology to more efficiently link between demand and supply locations for electricity, and stronger incentives for better plant operations.	234 $MtCO_2$ annual by 2025
China	Securing China's Natural Gas Supply	Natural gas to replace 50 GW coal power	~213 $MtCO_2$ (nationwide, annual by 2020)
China	Increased Nuclear Power	ExIm financing of critical imported components to accelerate nuclear power production.	
China	New Systems for Energy Supply	Joint research projects, for example on IGCC, coal gasification, etc.	
India	Boosting Efficiency of Coal Plants	Improving efficiency by 30% to perhaps 40% over two decades. Looking to 2030, such a program could avoid about 110 million tonnes of CO_2 annually for the 77GW coal-based power generation that exist in India today. In addition, such a program could lift the average efficiency of wholly new plants built between now and 2030.	Total of 400 $MtCO_2$ annually by 2030 below the level that the power sector would have emitted.
India	US-India Nuclear Power Deal	Partnership to provide technology and materials to aid in nuclear power production.	~150 $MtCO_2$ (annual by 2025)
India	Improving the Indian Power Grid	Advanced power delivering and metering technologies, along with better grid management	National improvement in energy efficiency of a few percent, or several hundred $MtCO_2$ after a decade.
India	Reducing the Asian Brown Cloud	Providing cookstoves to reduce black carbon from biomass burning	Potential reduction in regional warming approximately equivalent to one third of

			India's anthropogenic emissions.
India	New Systems for Energy Supply	Joint research projects, for example on IGCC, coal gasification, etc.	
South Africa	Advanced Power Plants	Providing easier access to the most advanced technology and engaging Eskom in consortia to test and deploy the most advanced equipment	50-100 $MtCO_2$ (annual by 2025)
South Africa	Carbon Storage	External assistance to finance carbon storage, given Eskom's motivation but inability to raise rates	~20 $MtCO_2$ (annual by 2025)
Brazil	Combating Deforestation in the Amazon	Providing surveillance equipment to aid Brazil in policing illegal logging and clearing	
Brazil	Improved Monitoring of Hydro Power	Engagement of foreign and Brazilian scientists to document GHGs from Dams	~20 $MtCO_2$ (annual by 2025)
Brazil	Revamping Nuclear Power Production	Recrafting international fuel system to provide assurance of reliability of supply and low cost in a credible way.	
Indonesia	Slowing Burning of Peat Soils	Providing technical assistance and resources for better monitoring.	An analysis of the 1997 wildfires in Indonesia emissions approximately equal to 13-40% of worldwide fossil fuel emissions
Russia	Reducing Natural Gas Flaring and Leaks in Russia	Third party agreements to reduce flaring, improve infrastructure	~150 $MtCO_2$ (annual, by 2012)
Gulf States	Curtailing Oil Subsidies	Partnerships with western purveyors of renewable energy, to free up oil for more lucrative export.	
Gulf States	Carbon storage	Enhanced oil recovery and carbon storage demonstrations, using copious pore space	~100 $MtCO_2$ (annual by 2020)

III. INSTITUTIONS FOR ENGAGEMENT

The previous section outlined a set of opportunities for deep cuts in emissions across a relatively small number of efforts. All these share a few essential attributes:

- They are anchored in host countries' interests and capabilities and thus do not require the extremely difficult task of crafting international agreements that run contrary to a country's core interests;
- They are limited in number and all yield large leverage—on the order of 100 million tonnes of annual emissions within a decade, growing as the investments become more pervasive in the host economy and society;
- All involve a complex array of interests and institutions, notably in the host country, and thus must engage private enterprise and government ministries that are far beyond the environmental and foreign affairs ministries that have dominated climate diplomacy to date.
- All are replicable and scalable. Where they succeed they offer paths for similar "deals" (at lower cost) in other countries and are self-reinforcing in the original host country. This self reinforcing attribute makes them the opposite of the CDM logic, which rewards only reductions below a baseline. These "deals" are about changing the baseline, not crediting against it.

So far, however, it is not clear that these deals rectify the central problem of the CDM—the assessment of "additionality" of an external investment. To be sure, the large leverage offered by these deals provides a much larger volume of emission reductions over which the cost of tailoring complex sticks and carrots can be amortized. Nonetheless, how will the backers of these deals know whether the host country is making any additional effort or just repackaging the existing pulse of activities as a program to tame emissions of greenhouse gases? Answering that question is the task of this section. The answers require building institutions that manage a process of bidding and assessment of CADs. That process can also, in time, manage the convergence between the reluctant countries (who engage in the collective effort only through CADs) and the enthusiastic countries (who engage by spending their own resources on policies such as applying a price on carbon in their home economies, supporting novel technologies, and providing the external resources needed to make CADs work). The rest of this section addresses those three functions—bidding, assessment and convergence.

Bidding

The process of assembling CADs must begin with the host country—in particular, its government. This is due to the fact that the host government has four advantages that no other actor enjoys. First, it can make the most credible long-term commitments on behalf of its territory and thus it is the best locus for accountability. Second, nearly always, the host government is able to mobilize the most reliable and widely accepted information about the actual baseline of policies and efforts that are planned, and it can best contemplate how those might be adjusted as part of a CAD. Third, the host government knows the most about what it can actually implement in different sectors of its economy. And fourth, there is rarely any

other actor that can better assemble the complex array of stakeholders needed for high leverage CADs—the industrial and economic development ministries, state-owned power corporations, etc. Thus the bidding must begin with the host government.

To make these CADs feasible, outsiders—the enthusiastic nations—will be expected to offer incentives that combine with real efforts by governments in the reluctant nations to alter development trajectories. The previous section outlined the incentives that may be required—such as financial resources in some cases, technology, provision of security guarantees for delivery of low-carbon fuels, political support for initiatives such as easier access to more secure fissile material, and a host of other initiatives. But the central question remains: what can be done to elicit accurate information from the host governments (in the reluctant nations) on exactly what they really need? CDM has faltered on exactly this front because it has encouraged host governments and project investors to claim incentives that they did not actually need for the policies and investments they pursued.

This problem is not new in international cooperation—it is analogous to the accession problem in international institutions. The key task in accession is to entice a new member into the club (and thus create broader benefits for the club) while not over-paying (or under-charging) the new member. When the terms of accession *ex ante* are relatively straightforward and vary in only a few important dimensions then the problem can be fixed readily. An auction, for example, can be used to force new entrants to compete and lower the price they charge for entry. When the terms are more complex broad competition is less feasible. The CDM has tried to operate on the former philosophy, and most proposals for CDM reform envision an even larger market and thus more effective commodity-style competition. In reality, almost every interesting mode for engaging developing countries involves efforts and investments of the latter type.[70]

The WTO offers a model through its accession process.[71] Potential new members assemble bids of promises that they will offer in exchange for external benefits. In the WTO case those external benefits are particular tariff concessions and, ultimately, most favored nation status and the other core benefits afforded to all WTO members.[72] Negotiations then proceed with any interested WTO member allowed to join the "working party" that shapes the final accession agreement, which includes transition provisions and other concessions that often require radical changes in host government policy.[73] For small countries with clear benefits and few interested parties the negotiations can proceed over a brief period; for larger countries the effort requires years. On average, WTO accession negotiations require about 5

[70] The many visions for new international funds to invest in developing countries also, in general, seem to be based on the former philosophy and thus may be prone to fail unless their backers develop more sophisticated visions of the bidding and assessment process.

[71] Here, for simplicity, I will speak of the "WTO" although the relevant experience extends much earlier than the formal creation of the WTO in 1995.

[72] On WTO accession broadly see Constantine Michalopoulos, 2004, "WTO Accession," in Bernard M. Hoekman, Philip, English and Aaditya Mattoo,eds, *Development, Trade and the WTO: A Handbook* (Washington: World Bank), chapter 8.

[73] The most recent and important example of such large changes are China. For reviews of the accession process and its real impact internally in China see, e..g., Paolo D. Farah, 2006, "Five Years of China's WTO Membership" *Legal Issues of Economic Integration*, vol 33, pp. 263-304.

years. In the case of CADs the benefits might come in two forms—general benefits afforded to all members of the umbrella regime under which CADs are negotiated and then specific benefits tailored to each member. The general benefits, akin to the general benefits of WTO membership, could include access to the carbon markets in the enthusiastic nations for CDM-like offset trading as well as access to general purpose funds (such as those being established at this writing within the World Bank) for emission abatement projects, adaptation and capacity building. The particular benefits, where I will focus the rest of this essay, would include the external elements needed for the efforts under the CAD to proceed. While the WTO model is imperfect because it concentrates mainly on the negotiations that yield a transition to the general benefits of membership, it is nonetheless apt because the WTO experience reveals that the international community can organize such bidding and sustained negotiation.[74] In every significant case of WTO accession those first bids are not accepted—rather, each interested WTO member begins bilateral negotiations with the candidate and through the normal process of bargaining arrives at a final, agreed package. The negotiation process focuses on both what the host country is willing to concede and also what the WTO members think the host country is actually able to deliver.

A key to success with CADs will be the rules of transition. If CADs are seen by the reluctant governments as single one-off deals then they will be reluctant to make the investments and adjustments needed for the deals to help put the country on a different development trajectory. Moreover, a series of one-off deals probably will be more costly for donors because they could actually create incentives for reluctant nations to avoid making internal adjustments such as imposing a positive price on carbon and beginning to regulate sectors of the economy toward lower emissions. A solution to this problem is to ensure that the individual, tailored elements of each CAD are coupled to a broader set of expectations and a clear transition path for the country to adhere to general norms. (Those general norms might be codified into the UN Framework Convention on Climate Change or a protocol—akin to the general norms that were codified into the General Agreement on Tariffs and Trade.) That transition process could include milestones as well as visible commitments to extinguish external support as a country develops. By combining these transition commitments into a broader agreement their enforceability will rise because the commitments will be connected to a broader set of membership benefits. [75]

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[74] In other ways the WTO model is also not ideal. For example, open access rules for joining access working parties allow, in effect, veto membership. The climate process might eventually arrive at that state, but when launching the first round of accession deals it would probably be better to limit the number of negotiating forums by establishing voting rules that are more permissive—for example, countries that account for half of the enthusiastic countries' emissions could block approval of a country's accession deal. (Approximately that rule was adopted in the Kyoto negotiations, and such rules are important because they protect the enthusiastic countries from adopting strict emission controls only to find that their most important economic competitors do not face such regulations.) Such a rule would force the industrialized countries to negotiate in blocks rather than singly. It would also tilt the balance, initially, in favor of encouraging expansion of membership and then, as the rules tighten, toward more demanding accession talks. Encouraging larger early membership would help broaden the climate regime in helpful ways. The WTO, back in the 1960s when it was still the GATT, also had accession rules that tilted much more strongly in favor of approving new members when compared with today's rules (which are not only tighter but also cover a much broader spectrum of trade-related activities).

[75] Such a broader norm-based process might make it easier, eventually, to apply stronger sticks in future, including trade sanctions. A general agreement on climate change and the negotiated transition with each of the new entrants would create higher legitimacy (and expectation) of future enforcement than a series of one-off deals.

The reluctant countries would bid packages of efforts such as those outlined here. Some of those efforts might be grand and interlocking—requiring a major intervention by a complex array of other countries. For example, China might bid the creation of an East Asian gas pipeline grid that connected Russia's continental gas supplies with markets in China and South Korea. (That grid, in turn, would facilitate the greater use of gas for power generation and thus lower CO_2 emissions.) Initially, however, most bids would probably rest on proposals that are less complex and thus more attractive to single donor countries or small groups of countries because those deals would be easier to organize and less fragile politically. For example, India might bid to test and deploy ultrasupercritical power plants through its state-owned power company. Enthusiastic countries that harbor the relevant technologies would then negotiate—and compete—to provide financing, training and other elements that help realize a greater deployment of these advanced power plants. (Those countries are numerous and include the EU and Japan and, for some of the equipment, the United States. A useful competition between suppliers could help lower the cost to the donor countries.) Many countries might bid a wide array of possible CADs to ensure that donor countries compete across a variety of opportunities. Those negotiations would then codify the expectations for both parties as well as milestones that can be used to judge progress.

To a small degree, these kinds of investments are already under way through the normal process of bilateral and multilateral development assistance. The CADs approach is different for two reasons. First, CADs would include an explicit transition to more general norms and thus reduce the most costly (for donor countries and the climate) perverse effects of one-off deals. (One-off deals discourage reluctant countries from policies that change their baselines because they offer the promise a stream of payments for continued avoidance of serious emission control policies.) Second, by integrating CADs into a broader "general agreement on climate change" the CAD system more readily gives donor countries credit for their efforts. Under the present Kyoto-style system of targets and timetables the enthusiastic countries earn credit for investments in the reluctant nations only when those investment are monetized as an emission reduction under the CDM. Part of the CAD negotiation, by contrast, would include the appropriate credit that the enthusiastic nation would earn—in some cases, that credit might be quantified and monetized, but in others it would simply be part of the explicit package of commitments that the enthusiastic nation makes to its peers. For example, the EU (led by Britain) has a project under way to develop advanced coal combustion technology in China. The only forces that hold that project together are British altruism and Chinese tolerance. If both countries gained credit for the effort as part of broader commitments to address climate change then the odds would be much higher that the effort would be focused on activities of real utility. As the collective effort to address climate change becomes more demand it will become increasingly important to offer flexibility for nations—reluctant and enthusiastic—to tailor their efforts to the interests and capabilities rather than requiring all effort to be measured along a single (often difficult to control) dimension of quantified emission reductions.

I have focused here on the WTO accession process as a model, but of course there are many other examples that offer similar guidance. EU accession occurs through a similar process of negotiation, although the resources mobilized are much larger and the scrutiny much

more intense because much more is at stake. Indeed, the EU itself arose from a core group of countries that focused on collective management of a few of the "commanding heights" of the 1950s economy (coal and steel) and then expanded to address other topics with new members.[76] The original formation of the OECD arose through a process of negotiation among recipient states—the war ravaged economies of western Europe—for the Marshall Plan funds provided by the United States. Each European member bid for a share of the pie by proposing a complex array of policy reforms that it would implement; its peers evaluated the bids and negotiated a full package of resources and policy efforts that all the members would implement.

Assessment and Monitoring

What keeps countries from promising much more than they actually deliver? That question is a shadow over all efforts to negotiate effective solutions to the climate problem. Simply measuring compliance with output targets—such as emission targets and timetables—reveals little because even the enthusiastic countries can simply move the goalposts (and move them again, such as through the use of offsets of dubious quality). What's really needed is an assessment of whether countries are honoring the *efforts* they have promised. (Governments can control efforts; they have a harder time controlling emissions—and governments with poor administrative apparatus, which is true across most of the reluctant nations, have an especially difficult time controlling emission outputs rather than more tightly specified effort inputs.) In time, that assessment process can make it easier to negotiate more meaningful commitments. The monitoring and assessment has always been a weak link in international environmental governance. While there are some decent precedents in environmental cooperation, those cases mostly arise in instances where the implementation effort needed by governments is fairly simple and thus monitoring and assessment are relatively easy to organize.[77]

The answer to this question comes in two parts. First, the negotiation of commitments can help ensure that governments promise genuine efforts that they are likely to implement. A process focused on CADs, along the lines I suggest here, is designed to elicit negotiations over whether the host governments are actually willing and able to implement their commitments and to demand external resources only in the area needed. For the reluctant countries, these negotiations will concentrate on the carrots needed, and failure to honor commitments will put the carrots in jeopardy. (I discuss sticks later.) For the enthusiastic countries—who are expected to make donations and other contributions to the carrots—these negotiations will concentrate on minimizing the demand for resources while maximizing the leverage on emissions because the CADs they sponsor will be part of their overall effort toward managing the climate change problem. And the enthusiastic countries will also negotiate with their peers

[76] Much of this thinking goes back to what used to be called "functionalism"—the argument that deep integration arises through technocratic cooperation between governments that then spills over into a broader need for cooperation. For an origin along those lines see: Ernst Haas, 1958, *The Uniting of Europe: Political, Social, and Economic Forces, 1950-1957* (Stanford: Stanford University Press); for a look at the broader array of domestic political forces that shape which countries are willing to integrate (and under way terms) see: Andrew Moravcsik, 1998, *The Choice for Europe: Social Purpose and State Power from Messina to Maastricht* (Ithaca: Cornell University Press).

[77] See generally part I on "systems for implementation review" in Victor et al., eds, 1998, *The Implementation and Effectiveness of International Environmental Commitments* (Cambridge: MIT Press).

about the proper credit they should earn from supporting CADS toward broader collective goals of managing global emissions and exposure to climate change. Falling short (or overpaying) for CADs will require additional effort on other fronts.

Second, a new institution is needed to provide regular assessments of implementation. Such institutions are rare in environmental negotiations but increasingly common in areas of economic cooperation.[78] The creation of the WTO in 1995 included an agreement to launch a trade policy review mechanism (TPRM) that would regularly review nations' compliance with WTO commitments. That model is imperfect, however, because its architects could not agree on whether the TPRM would connect to the WTO's real enforcement system (its dispute resolution process) and thus there is no connection; TPRM, in practice, has been overshadowed by the WTO dispute process.[79] Better precedents are probably found in the OECD, IEA and the IMF. From the outset, the OECD included an intensive review process because the original members wanted to hold each other accountable to the commitments they had made collectively. (Some of those commitments—such as on public budgets, exchange rates, and customs—were interdependent and prone to deteriorate unless each country had confidence that the others were in compliance.) That OECD review process continues today with regular reviews of its members' economic policies, science & technology policies, and environmental policies. While the economic reviews have atrophied in importance, OECD's environmental reviews remain an area where the institution has particularly high visibility and, in many cases, influence. IEA, an independent arm of OECD, conducts regular reviews of its members' energy policies that are also, often, influential.[80] The IMF's Article IV process includes an intensive review of policies when members are allowed to suspend some of the institution's norms. Through an intensive process of review the IMF (and its members) learn about the political and economic forces that lead to a member's noncompliance and to work with the target country to outline a path back to compliance.[81]

Applied to the climate problem—in particular, the role of CADs in a general agreement on climate change—these experiences suggest design of an assessment institution that could look broadly at a country's promised efforts (as in the WTO, OECD and IEA policy reviews)

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[78] Such institutions are also increasingly common in collective arms control agreements—especially agreements that require complex (and often contest) implementation efforts. Examples include the increasingly complex monitoring systems under the IAEA. But the security shadow over arms control agreements is so strong that I am wary about drawing too many parallels.

[79] Victoria Price, 2007, "GATT's New Trade Policy Review Mechanism" *The World Economy*, vol. 14, pp. 227-238.

[80] For example, see IEA's review of the EU's energy policy—which is an extraordinary event in revealing the extent to which large, industrialized economies will allow intrusive reviews of their policies by institutions that they trust for an even-handed assessment: IEA, 2008, *IEA Energy Policies Review—The European Union 2008* (Paris: IEA). OECD's reviews occur in a much wider array of issue-areas—such as innovation and competition policy—which reflects OECD's origins and functioning as a general purpose agency for international cooperation. The U.S. is noticeably less engaged in OECD policy reviews than most other members, and one of the important challenges will be the design of an institution that is tolerable to the United States—a problem that arises in nearly every area of international institution-building. OECD, increasingly, even reviews policies (by invitation) of non-members, notably China, where OECD has reviewed innovation policy (in 2008) and other policies, such as: OECD, 2003, *OECD investment policy reviews. China* (Paris: OECD).

[81] Abram Chayes, A. Chayes, 1991, Managing the Transition to a Global Warming Regime, or What to Do 'til the Treaty Comes," in Jessica Mathews, ed., Greenhouse Warming: Negotiating a Global Regime (Washington: World Resources Institute, 1991).

and then probe in detail where those efforts seem to be falling short (as in the IMF Article IV reviews). Benchmarks and milestones promised during the negotiation process could be used to measure broad compliance, but the real value in this review would lie with the detailed assessments and negotiations with host governments that would determine (and make transparent) the factors that are blocking fuller implementation. With experience and demonstrated competence the review process might also make assessments of the degree to which efforts have fallen short (and thus external donors should not earn credit for their contributions) and also where efforts have exceeded expectations (thus leading, perhaps, to bonuses). As a practical matter, this under- and over-compliance might not take the form of quantified emissions but would be an assessment of effort that could feed into negotiations among the enthusiastic countries about whether each is meeting its obligations.

Converging to Global Norms

The scheme proposed here—CADs as part of a broad general negotiation on climate change, backed by new institutions to assess and shape the efforts—will seem cumbersome. But that is intrinsic to the climate problem for two reasons. First, serious strategies for addressing climate change will require a complex array of efforts and thus collective action will be much more complex (and time consuming) to organize than evident in the experiences under the UNFCCC and the Kyoto Protocol. Second, important players in that process presently do not have an interest in spending their own resources and thus mechanisms must be created to compensate these countries. These countries will have low or zero prices on carbon in their economies and thus normal economic pressures to reduce emissions will be absent. CADs are an effort to address that problem of reluctance.

The first problem is intrinsic to the issue of climate change and won't go away. The institutions for negotiating and assessing collective efforts will always be complex and multidimensional—they will always have characteristics more like the WTO than the simple targets and timetables negotiated under the auspices of the UNFCCC and the Kyoto Protocol. If the complexity is managed well then such a broader negotiation can actually lead to more effective management because it will allow deal-making on a broader set of dimensions.

The second problem, however, is transient. It will disappear as the reluctant countries converge with the enthusiastic. The faster that transition the less inefficient the global effort and the less difficult, politically, for the enthusiastic countries to maintain the system of resource transfers and special arrangements that their populations will find difficult to tolerate. The question I address here is how to shape and accelerate that convergence. International environmental agreements offer few good models for convergence because none of the major international environmental regimes has actually converged. The major agreements of the 1970s applied similar norms to all members, but since the late 1980s essentially all international environmental agreements have, at their core, a permanent distinction between industrialized and developing countries. Essentially all expect the former to compensate the

latter for the "agreed incremental cost" of all efforts to comply.[82] Even in obvious cases—such as Mexico and South Korea, both of which are OECD members yet have traditionally been included in the ranks of developing countries—it has been extremely difficult to undo this norm in environmental diplomacy. Convergence is difficult to orchestrate when the founding principles of a cooperative regime enshrine the exact opposite—two worlds, permanently distinct, with developing countries not expected to spend their own resources to help solve global problems.

Better models for convergence are found in the international regimes for economic cooperation. In the WTO system and the IMF, for example, all members subscribe to common norms. Accession packages (and Article IV negotiations in the case of the IMF) are extended negotiations and performance reviews focused on tolerable breaches from those common norms. The core idea behind these cooperative regimes is commonality in basic obligations; the practical political and administrative efforts concentrate on achieving such convergence—even if, as is notable for the IMF, the alignment takes decades.

Applied to the climate problem, the core principles could be numerous and complex. Here I focus on a few that probably matter most:

- Pricing of carbon (through trading or taxation) and linkage of carbon markets;
- Direct support for low carbon technologies;
- Minimal trade and other barriers to application of low-carbon technologies
- Transparency in policies and their expected effects on emissions and deployment of technology so that all members of the agreement can learn from and scrutinize the efforts of others;
- "Most favored" treatment for all members so that any concession offered to others—such as linkage of a trading system or reduction in a tariff for low-carbon technologies—is available to all other members;
- Good faith participation in regular reviews of the performance and adequacy of the regime and each member's efforts to implement the regime's norms;
- Good faith in research on the causes, consequences and remedies to the problem of climate change.

These norms will seem abstract and general, but meaningful common norms often arise through particular applications of common understandings. Some have already attracted widespread agreement although such agreement is highest where ambition and effort are the least. Each nation—through bidding and assessment along the lines discussed earlier—would then make commitments to "opt out" of some norms (e.g., economy-wide carbon pricing) for delineated periods of time. The review process, as in IMF Article IV reviews, would then assess regularly whether avoidance of compliance with those norms is acceptable.

The final task is to explore why any nation—in particular in the developing world, which has been wary of becoming entangled in climate commitments—would ever agree to this scheme. The answer lies in conditionality and contingency. The enthusiastic nations have

[82] The experience with the Montreal Protocol was most pivotal in establishing this approach to developing country compensation and the permanent "two worlds" division between industrialized (donor) and developing (recipient) countries. See generally Elizabeth DeSombre and Joanne Kauffman, op cit, note [18].

large resources to offer—technology, funding, linkages to valuable carbon markets and the like—that will be available only to members in good standing. And the enthusiastic nations will also threaten the eventual use of sticks—such as trade sanctions—to large countries that avoid such commitments. (Eventually, depending on how the climate and trade regimes evolve, the two could merge in some respects.) And the regime would evolve as quickly as possible to a system that includes linkages between carbon pricing systems and technology markets so that the "most favored" provisions have real value. The deeper the linkages the greater the benefits from membership.

The effort to craft such a regime requires rejecting the principle of universality that has guided essentially all international environmental negotiations (and all efforts under the auspices of the United Nations). Universality is a liability because, by design, it does not allow discrimination between countries based on their level of effort; it means that countries that invest few of their own resources have as much influence on the rules and procedures in international organizations as those that have a lot more at stake. Combined with the difficulty in enforcing international obligations and the permanent "two worlds" approach that pervades environmental negotiations, a system that is unable to discriminate is rarely able to achieve outcomes that require massive efforts by countries that have very different interests. Instead of universality, a better approach starts small—with a "club" of countries that matter most to the climate problem (i. e., the large emitters) and who are willing to make concessions. The core agreements crafted in that club can then be replicated and extended. To the extent that those agreements can be made conditional on like-minded efforts by other members of the club then membership in good standing will offer big benefits that countries will be keen to obtain. This kind of evolution exactly mirrors the origins of the WTO which began as a club of willing countries that made reciprocal (and thus self-enforcing) agreements with each other that then deepened and expanded with experience and confidence.[83] Political scientists and anthropologists have long studied such evolutionary regimes using simple permissive "tit for tat" models and shown that a regime with built-in enforcement and gains from membership can evolve into wider and full-blown cooperation.[84]

IV. CONCLUSIONS

For too long, analysts and practitioners in the field of international environmental cooperation have had a blind spot on how to solve the problem of developing country participation in a global climate regime.

[83] In other settings this kind of evolution has been called "core to periphery", "bottom up", "oilspot" and "coalitions of the willing." That last term, unfortunately, was appropriated for the disastrous regime to invade Iraq, but the rest stand untarnished.

[84] Robert Axelrod, 1984, *The Evolution of Cooperation* (New York: Basic Books); Paul Seabright, 2005, *The Company of Strangers: A Natural History of Economic Life* (Princeton: Princeton University Press).

Analysts have imagined two ideal worlds that do not exist. In one ideal world all countries would apply carbon pricing. That world does not exist because most countries (and soon most of the world economy) have neither the interest nor the ability to apply effective carbon pricing. In another ideal world the industrialized countries would simply compensate developing countries for the full cost of compliance. But that world does not exist because the industrialized nations are hardly ready to mobilize the tens or hundreds of billions of dollars needed for such a compensation scheme when official development assistance stands at just $100 billion for all purposes—such as reconstruction in Iraq—and the countries that would get the most compensation (e.g., China) are also the most potent economic competitors. The politics of mobilizing resource transfers under these circumstances are probably impossible to organize. These two worlds have combined into imaginary schemes such as global allocation of emission credits and full blown global trading.

The practitioner, meanwhile, is painted into a box—a world that exists but is dangerous for the planet's climate system. Well-tested tools such as financial transfers along the lines of the Montreal Protocol are not available because the scale of transfer is much too large to be politically tolerable. The norm of universality requires the practitioner to treat all countries on equal terms and thus the tool of discrimination is difficult to wield. Yet the practitioner is well schooled in the sound logic that the ideal strategy would apply a common price to carbon emissions worldwide. The practitioner has navigated through all these constraints to produce the Clean Development Mechanism (CDM)—a scheme that offers, in theory, to pay developing countries the full cost of cutting emissions while also laying a theoretical foundation for global emission trading. The funds paid are kept off the public budget and thus less vulnerable to political backlash. The credits issued are legal tender in the countries (mainly Europe) that are most enthusiastic to cut global emissions.

This essay has argued that the current approach to engaging developing countries is a dead end. The CDM has done little to cut emissions and its flaws so fundamental that it will never amount to a serious strategy. And the existing norms and practices in international environmental diplomacy are a poor guide for solving the problems that arise as enthusiastic countries (mainly the industrialized world) attempt to coax reluctant nations (mainly the developing world) into a common global effort.

The solution, I suggest, is to look to the GATT/WTO, IMF, OECD and other international economic regimes. All have had to contend with this problem of differential interests and capabilities. The most apt solution to the problem would create a common set of norms that apply to all member countries and then focus negotiations on the terms of accession. Reluctant countries would bid a variety of policies and programs that make sense for their development trajectory, and their bids would include information on the barriers (funding, technology, windows to carbon trading markets, access to international institutions, etc). The negotiations that follow would determine the resources that enthusiastic nations would provide and the metrics for assessing compliance. Those negotiations would also determine the role that support for CADs could play as part of an enthusiastic nation's contribution to the collective goal of managing climate change. And, if managed well, the CADs process could also accelerate the reluctant countries down the path of adhering to global norms on the need to control emissions.