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CLIMATE CHANGE AND THE ENERGY CHALLENGE: A PRAGMATIC APPROACH FOR INDIA

VARUN RAI AND DAVID G. VICTOR

Prepared for the conference, "India's Options in Climate Change Negotiations"

6-7 March 2009, New Delhi, India

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Climate Change and the Energy Challenge: A Pragmatic Approach for India

Varun Rai and David G. Victor

Abstract

India has been famous for arguing that it (and the rest of the developing world) should incur no expense in controlling emissions that cause climate change. The west caused the problem and it should clean it up. In the face of heightened concerns about rapid climate change, that argument is increasingly losing force—both in the fundamental arithmetic of climate change, which is a problem that is impossible to solve without developing country participation, and in the political reality that important western partners will increasingly demand more of India and other developing countries. India's own public is also demanding more. The Indian government has outlined a broad plan for what could be done, but the plan still lacks a strategy to inform which efforts offer the most leverage on warming emissions and which are most credible because they align with India's own interests. This paper offers a framework for that strategy. It suggests that a large number of options to control warming gases are in India's own self-interest, and with three case studies it suggests that leverage on emissions could amount to several hundred million tonnes of CO_2 annually over the next decade and an even larger quantity by 2030. (For comparison, the Kyoto Protocol has caused worldwide emission reductions of, at most, a couple hundred million tonnes of CO_2 per year.) We suggest in addition to identifying self-interest—which is the key concept in the burgeoning literature on "co-benefits" of climate change policy—that it is also important to examine where India and outsiders (e.g., technology providers and donors) have leverage. One reason that strategies offered to date have remained abstract and difficult to implement is that they are not rooted in a clear understanding of where the Government of India is able to deliver on its promises (and where Indian firms have access to the needed technology and practices). Many ideas are interesting in theory but do not align with the administrative and technological capabilities of the Indian

context. As the rest of the world contemplates how to engage with India on the task of controlling emissions it must craft deals that reflect India's interests, capabilities, and leverage on emissions. These deals will not be simple to craft, but there are many precedents for such arrangements in other areas of international cooperation, such as in accession agreements to the WTO.

I. Introduction

Anthropogenic (human-caused) emissions of greenhouse gases (GHG), mainly carbon dioxide (CO_2), are the main human cause of global climate change.[1] Many analysts and governments are now focused on the goal of limiting the total change in climate to 2°C. Achieving this goal would require, roughly, that global CO_2 emissions peak before 2015, followed by a 50% to 80% reduction in CO_2 emissions below 2000 levels by 2050.[2] Given likely global growth trajectories such massive emissions reductions are only possible through the large scale deployment of low-carbon technologies.

The sober math of climate change, which underscores the need for radical changes in the world's energy systems, has been known for some time although most governments have not made much investment in actually changing the status quo. All that is now changing, and policy efforts on climate change are becoming much more serious. The pivotal shift has been the emergence of real policy in the United States—the world's largest economy, the largest of per-capita emitter of greenhouse gases of the all the major economies, and an absent leader on many issues of international concern in recent years. The essential role of the developing countries is now widely known and appreciated, even in the key developing countries such as China and India. Indeed, the Bali Roadmap for the climate-change talks that are slated to conclude this year in Copenhagen envisions that developing countries will make efforts to control growth in their emissions.[3]

India is now responding—both to demonstrate its contribution to the global effort and because it realizes that India, too, stands to suffer from unchecked changes in climate. The country has crafted a national action plan on climate change (NAPCC),

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[1] *IPCC Fourth Assessment Report, Synthesis Report,* 2007.
[2] *IPCC Fourth Assessment Report, Synthesis Report,* 2007.
[3] Bali Action Plan, Decision -/CP.13, UNFCCC. Particularly see item 1b, p.1: "Enhanced national/international action on mitigation of climate change", http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf

which provides the roadmap for India's climate-change policy. India's NAPCC, while asserting its emphasis on adaptation to climate change and priority for economic development, also lays out, in general terms, the overall framework for actions in different spheres of its energy system in response to climate change. Specifically, it lays out eight national missions as the way forward:[4] national missions for solar energy, energy efficiency, sustainable habitat (public transport; building codes), water, Himalayan ecosystem, Green India (aforestation), sustainable agriculture, and strategic knowledge for climate change. The NAPCC is a positive first step in India's efforts to combat global climate change.

II. Scope of This Paper

The NAPCC is comprehensive in ambition—the agenda it sets for the eight national missions is wide-ranging. These missions span actions that are cost-effective and ready for implementation to those that are difficult to see achieved in practice. But the real opportunity each of the mission areas provide as a viable and a valuable response varies. In the eyes of India's foreign-policy partners, it is hard to assess the real leverage that the NAPCC will have on the country's GHG emissions.

In this paper we lay out a framework through which to evaluate which of the energy-related policies on global climate change are achievable in India and can be viewed as credible internationally. We then apply the framework to discuss what we believe to be most promising options available for India as the world tries to settle on a serious response to the climate change problem. Through a discussion of the political and economic aspects of the possible options, the purpose throughout is to highlight options that are not only materially relevant to climate change but are also feasible to attain.

We make three main arguments here. First, the diplomatic status-quo maintained by India (and other major developing countries) that developing countries are not responsible for most global warming and they will follow with efforts to control

[4] *National Action Plan on Climate Change* (NAPCC), India, June 2008.

GHG-emissions only once the industrialized countries have made decisive first steps is increasingly difficult to sustain politically and environmentally. Failure to substitute this policy stance with a more pragmatic and accommodating view will lead to a growing rift between India and the West. The United States, among others, will increasingly put climate change at the top of the list of foreign policy priorities and India will be under growing internal pressure to make more visible contributions to the global mission of protecting the planet. Second, in the context of international negotiations a viable engagement strategy by India must satisfy two critical conditions (the *viability conditions*). The strategy should align well with India's core *interests* (economic growth and energy security) while also making a material reduction in emissions of warming gases. Moreover, it should also be seen as credible internationally, which requires that other countries be confident that what India offers as promises to the world it can actually implement. Credible promises must be tailored to the administrative, regulatory, and technological resources that the Indian government has at its disposal and, in some circumstances, the resources it can also mobilize from foreign partners. Third, contrary to the view maintained that costs of mitigation will be very high for India (thus violating India's growth plans) we argue that there are several options available in India for large-scale CO_2-emissions reductions that satisfy the viability conditions.

III. Adaptation or Mitigation: Changing Dynamics of International Negotiations

Since the very beginning of international negotiations on climate-change, India has disavowed direct responsibility for emissions mitigation efforts and instead has emphasized adaptation to climate change as its preferred response. It has fiercely advocated that the international response to climate change be based on the principle of equity "that must allow each inhabitant of the earth an equal entitlement to the global atmospheric resource" (Figure 1).[5] India has also been a foremost proponent of

[5] *National Action Plan on Climate Change* (NAPCC), India, June 2008. India and other developing countries have maintained this position since the very beginning of international negotiations on climate change.

adaptation as a cornerstone of international response to climate change, and championed the Delhi Ministerial Declaration on Climate Change and Sustainable Development issued in 2002, which emphasized "urgent attention and action on the part of all countries" for adaptation. Although this stance has evolved, and somewhat softened, over the last two decades, the essence and tone remain the same.

Parts of India's climate strategy are unassailable. Adaptation must play a larger role; the deal crafted on climate change must be seen as fair and equitable. But the view that India is most famous for espousing—which is that the west caused the climate change problem and the emerging markets should not be expected to focus on this problem until they are wealthier—is increasingly unsustainable. India's rapid economic growth since 1991—mainly fueled with the most carbon-intensive fossil fuel, coal—has put India in a leading role for controlling emissions. Economic models predict that over the next two decades India's emissions will grow threefold to reach over 3.5 billion tons CO_2/yr in 2030 (but per capita emissions still remain lower than most other major countries; Figures 1 and 2).[6] At both the international level and within its domestic politics, the government of India is increasingly feeling severe pressure to take active part in the global response to climate change.

At the international level, India has been the most visible member of a coalition of nearly all developing countries that has firmly maintained that the moral and economic responsibility to combat global warming lies with the industrialized nations that, due to their industrialization based on fossil fuels, have caused most of the atmospheric buildup of greenhouse gases. Moreover, this coalition under India's banner has made their engagement conditional on financial and technological transfers. This view has held for nearly two decades-ever since the first climate change talks began in 1991—in part because the industrialized ("Annex II") countries,[7] especially United States, themselves did not advance a particularly coherent and significant action plan.

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[6] (i) *Integrated Energy Policy, Report of the Expert Committe*e, April 2006, Planning Commission, Government of India, p.50 "CO_2 Generation Comparison in 2030-31". The average of over ten scenarios yields about 4 billion ton CO_2/yr in 2030-31 (ii) *World Energy Outlook 2008*, IEA, p. 385

[7] Annex-II countries of the Kyoto Protocol are the industrialized countries responsible for helping developing countries with financial and technological support in their efforts to reduce GHG emissions.

But the situation is rapidly changing—GHG mitigation is a top priority for most Annex-II countries now. The new US administration under President Obama has been vocal about its seriousness on the issue. The $787 billion economic stimulus package has provided about $40 billion in new funding to the Department of Energy (DoE) for low-emission energy investments (notably renewable power). Within the US several economy-wide cap-and-trade policies are being actively debated. The Waxman-Markey discussion draft, "The American Clean Energy and Security Act of 2009", pushes strongly for national limits on GHG emissions and for aggressive use of renewable sources of energy. But crucial elements of climate-change action began to emerge bottom-up (at the state and local level) as early as 2002. Several states (most prominently California and the northeastern states) are well ahead of the U.S. federal government in promoting energy efficiency and electricity from renewable sources. The European Union, a longtime champion of aggressive mitigation actions by industrialized nations, too has notched up its own mitigations plans. In an agreement reached on the "20/20/20 by 2020" EU program, EU is committed to reducing GHG emissions by over 20% in 2020 compared with 1990 levels.[8] As the industrialized nations get more serious on climate change, action on mitigation efforts will form a crucial part of India's continued successful international relations with these countries.

At the domestic level within India, the debate has become a lot more dynamic over the years. The government and various ministries concerned with energy are engaged in the process in one way or another through the NAPCC. Awareness of the climate change issue is also increasing among the pubic, thanks to NGOs and other ad campaigns.[9] There is also increasing evidence that India will be one of the worst suffers of the consequences of drastic climate change.[10] Such evidence has done more to galvanize the attention of Indian people and policymakers alike than two decades of international negotiations.

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[8] European Commission. http://ec.europa.eu/environment/climat/climate_action.htm

[9] Among many others, see (i) "Greenpeace to launch anti-climate change campaign in India", ThaIndian News, 25 March 2008 (ii) Center for Science and Environment, New Delhi, India, http://www.cseindia.org/html/eyou/climate/index_climate.htm

[10] (i) IPCC Third Assessment Report (ii) *Coping with Global Change—vulnerability and adaptation in Indian Agriculture*, TERI, New Delhi, India, 2003.

The political equation on climate change is rapidly changing, and India's stances in years past are losing steam. It is imperative that India realizes this, and engages more constructively in global mitigation efforts.

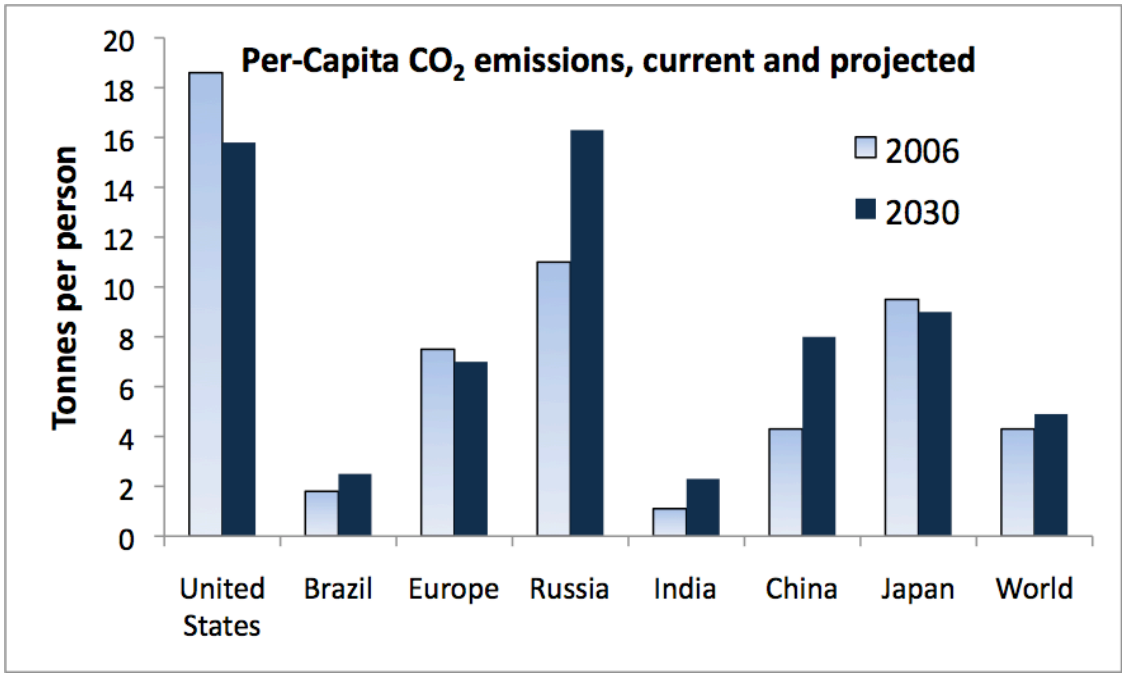

Figure 1: Per-capita CO_2 emissions at present (2006) and projected (2030) for India and other countries. Source: World Energy Outlook 2008

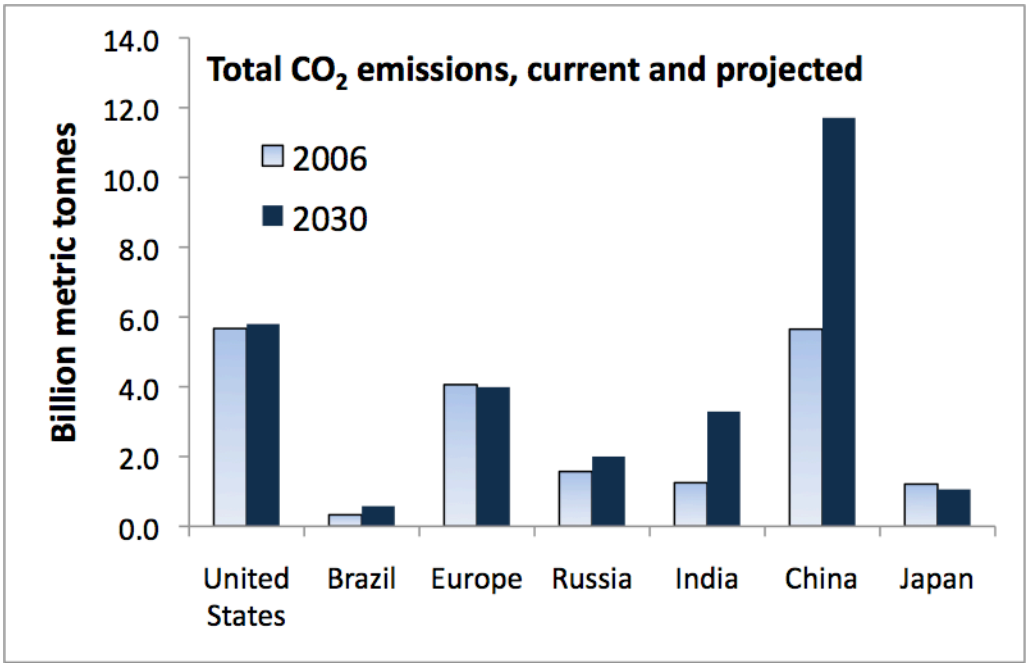

Figure 2: Total CO_2 emissions at present (2006) and projected (2030) for India and other countries. Source: World Energy Outlook 2008

IV. Framework for India's Engagement: Interests, Capabilities, and Leverage

The implication of this shifting political equation is that India must search for ways to engage with the climate change issue—not only in easing India's adaption to likely climate effects but also in mitigating emissions. In the face of that serious engagement, the international community must prepare to recognize (and where possible to facilitate) the positive efforts that India is making in that direction.

We suggest that the only serious and viable approach for India's engagement in global efforts to tame global warming is one that aligns with India's own core interests. Those interests are complex, but at their core are the goals of economic development and energy security.

Virtually every Indian policymaker agrees that a strong and sustained economic growth is essential to raise living standards and bring India's masses out of poverty. This belief is reinforced by the material difference that the growth since 1991 has brought. At the national level, any policy measure, whether related to energy or not, must further India's economic development, or at least align well with this agenda. Energy security is the other major issue that concerns India. The Indian political leadership considers energy security as the ability to "supply lifeline energy to all our citizens as well as meet their effective demand for safe and convenient energy . . .at affordable cost."[11] Moreover, India's continued economic success and energy security hinge on obtaining reliable and cost-effective energy supplies; increasingly, those supplies depend on delivery chains that are unsustainable. Central policymakers in India are quite aware of the situation, and they see energy-sector reforms and better energy infrastructure as the key to India's energy problems.[12]

All domestic and international strategies involving India must realize these core interests (shown on the horizontal axis in Figure 3) as boundary constraints on what

[11] *Integrated Energy Policy, Report of the Expert Committe*e, April 2006, Planning Commission, Government of India

[12] (i) *Integrated Energy Policy, Report of the Expert Committee* (ii) *National Action Plan on Climate Change* (NAPCC), India, June 2008.

India is willing to offer as part of its contribution to climate change. The vertical axis in Figure 3 shows the potential for CO_2 reductions. At the bottom of the chart (Boxes III and IV) are options with small or negative CO_2 reductions (i.e., large emissions)—these options offer no leverage in international climate-change negotiations. At the bottom left of the chart (Box III) are options that do not interest India—they are irrelevant to the discussion in this paper. The options at the bottom right (Box IV), where India's interests are high, may be irrelevant; or they may be potentially harmful for climate change (for example, coal-to-liquids projects pursued under the umbrella of energy security). At the left side of the chart (Boxes I and III) are options that fail the condition that they be seen in India's interest. The interesting box is the upper right (Box II)—also known in global-warming policy parlance as "co-benefits."

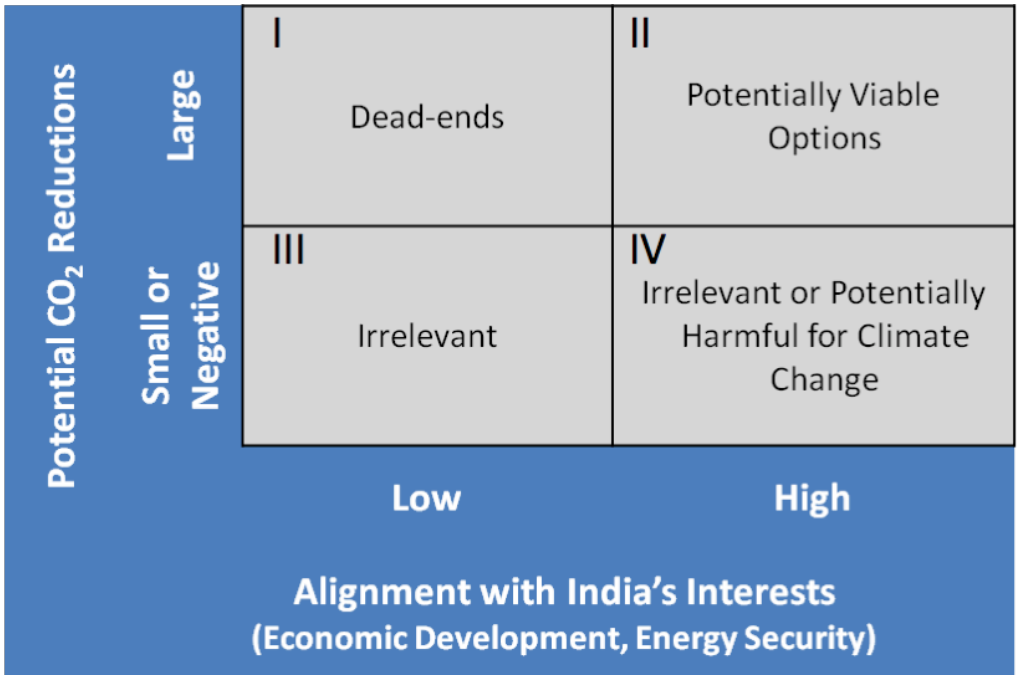

Figure 3: Framework for evaluating the viability of India's energy options as a credible response to climate change. The potentially viable options are in the upper right corner (Box II). The structure of Box II is further unpacked in Figure 4.

Thus India's search for a strategy must begin with Box II. But not all options in Box II are equal. Some options exist in theory but will be difficult to implement; those options will be viewed as much less credible (and thus less effective as part of India's strategy to engage with the world). As other countries look at India's choices, there is

much discussion about effectiveness, efficiency, and equity of climate-change policies,[13] but real progress in forging successful alliances for concrete action is often crippled by doubts about what parts of the strategy can be successfully implemented in the Indian context.[14] Irrespective of what India promises, only those promises will be valuable bargaining chips where the central government (the negotiator) *is seen* by outsiders to have real influence.

Figure 4 unpacks Box II and explores two major dimensions to the credibility of the options that India can choose. On the vertical axis is the government of India's (GoI) ability to administer policy. Across many areas of policy, GoI is unable to have much influence over what really happens in India—those areas of policy include topics for which competence is given to India's states through its federal system as well as areas where the central government does not have the administrative capacity to have much impact on outcomes. The options at the bottom of Figure 4, though they become viable options over time as the leverage of GoI's policy increases, are irrelevant now. The viable options for India's engagement, then, are those where the ability of GoI to make promises that it can actually deliver is high. Those are shown in Boxes IIa and IIb. Of those options, one more level of unpacking is needed. For some issues the government, state firms and the private sector have all the capability needed. For example, with technology already available to Indian firms it would be possible and cost-effective to make fuller use of natural gas or to shift to more efficient technology for new coal plants. These options are shown on the upper right side (Box IIb). For other options, outsiders may need to help—by providing technology or finance to make viable options that are not otherwise available (Box IIa).

This framework, then, transforms the debate about what India can and should do to mitigate emissions. India, working alone, can make credible offers to the

[13] (i) *Climate Change Mitigation and Sustainable Development*, Background Paper, TERI, New Delhi, India (ii) Adger, W. N. *et al.*, "Successful Adaptation to Climate Change Across Scales", Global Environmental Change, Vol. 15, 2005.
[14] Victor, D. G., "Climate Accession Deals: New Strategies for Taming Growth of Greenhouse Gases in Developing Countries",PESD Working Paper #82, Stanford University, January 2009.

international community in Box IIb. And the international community, working with India, can make options in Box IIa viable.

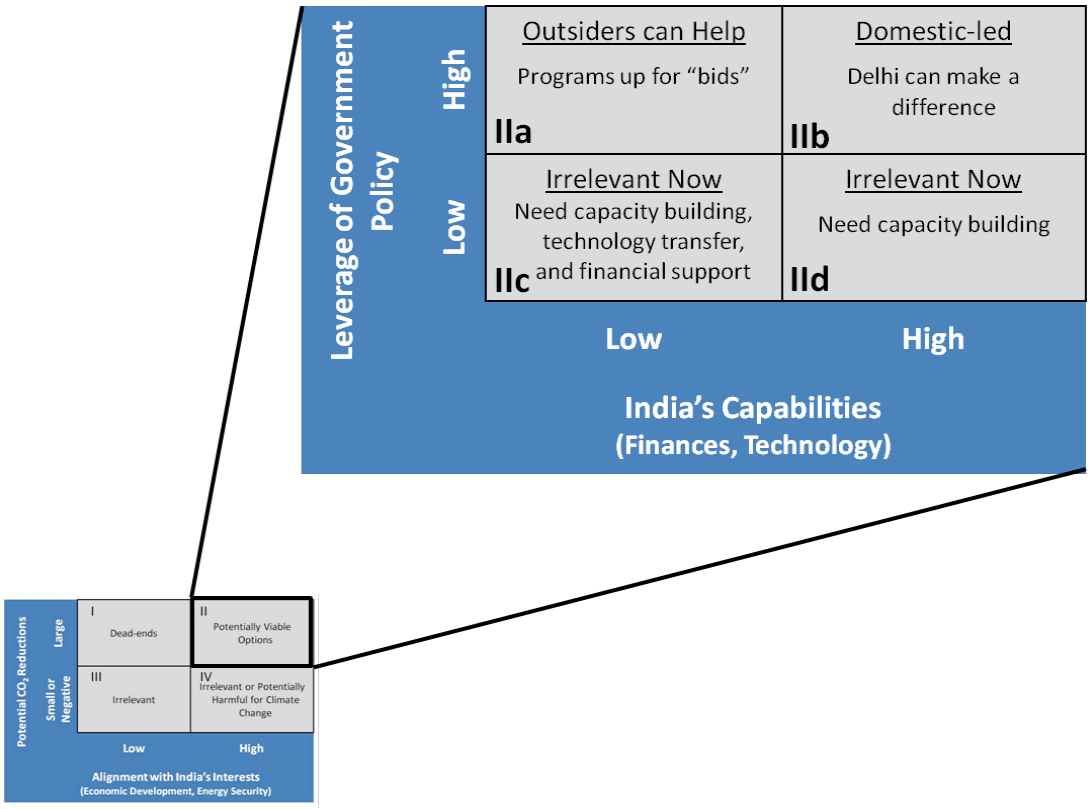

Figure 4: Exploring Box II of Figure 3 in more depth: Leverage inside and outside India

V. Making Boxes IIa and IIb Real: Some Concrete Suggestions for Action

The list of weak links in India's energy system seems endless, but most of it stems from how India historically has chosen to organize its energy sector—centrally planned to balance demand and supply, and run by state-owned companies.[15] Much of the present interest in India is to recast, if not completely undo, the policies of the past that have engendered the precarious energy-supply situation in India. Indeed, such sweeping changes—or intentions thereof—have even become a possibility due to

[15] Carl, J. C., Rai, V, and Victor, D. G., "Energy and India's Foreign Policy", PESD Working Paper #75, Stanford University, May 2008.

recognition that the present state of affairs in the energy sector is the biggest roadblock to India's economic prosperity.

Energy-sector reforms and better infrastructure are not only crucial for both economic development and energy security, but also are the necessary first step on which all other options must be built on—without reforming the energy-sector the positive impact of other options will be muted. The pressure to deal with climate change provides an external forcing that policymakers could use to address energy-related reform and infrastructure issues in India. Based on this observation, next we discuss some specific viable options that fit boxes IIa and IIb of the framework laid out in Section IV (Figure 4).

Power-Sector Reforms[16]

Reforms in the power sector offer one of the best options of the co-benefit approach outlined above, as it aligns well India's desire to provide reliable energy supply to its masses with the necessity to reduce global CO_2 emissions. Particularly interesting is the opportunity of using advanced technology in power delivery and metering combined with commercial incentives to power distributers to check the massive losses in the low-voltage electricity distribution across the country.

Defunct and bankrupt state electricity boards (SEBs) are the norm in India's power sector. A major issue is the widespread theft of electricity by end-users: in 2006-07 the Aggregate Commercial & Technical (AT&C) losses stood at 30%, i.e., there is no revenue generation for about a third of the supplied electricity. Besides, a large number of farmers across India are still provided with free (or very low cost) electricity, a clear manifestation of the political importance of this group of citizens. As the stolen and freely supplied electricity have no price tag, there is little incentive to economize on its use. Thus, irrespective of the cost of electricity generation, the demand from these consumers remains very strong. The ever increasing demand-supply gap for electricity (Figure 5) and SEBs' inability to respond to the needs were mainly responsible for

[16] Rai, V, Goel, A., and Victor, D.G., "Impact of Delhi's Power-sector Reforms on CO_2 Emissions", In Preparation, PESD Working Paper, Stanford University, 2009.

initiating reforms in the power sector. The Electricity Act 2003 envisaged massive restructuring of the SEBs and wider participation of the private sector as the way forward in the power sector. While a few states have made commendable progress with reforms, most states still have done little and remain extremely inefficient.

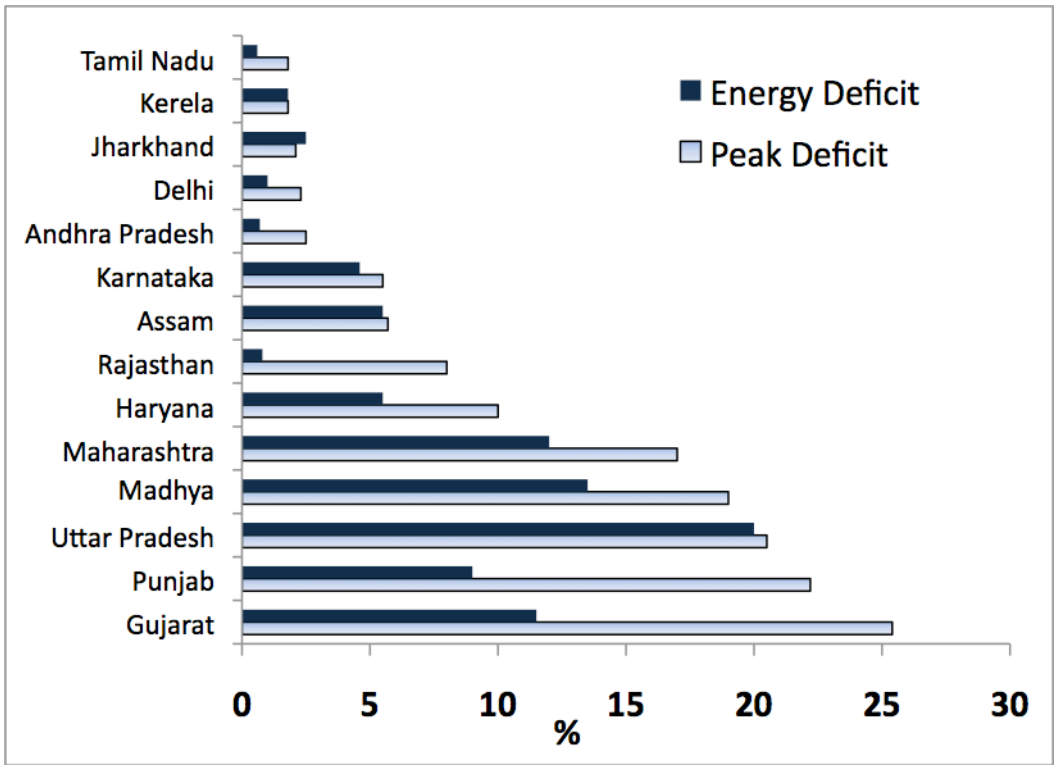

Figure 5: Energy shortages and peak power deficit in 2004-05 in some Indian states. Data: Integrated Energy Policy, Government of India.

The case of Delhi is particularly interesting. The Delhi Vidyut Board's (DVB) commercial losses were 1092 crores ($220 million) and AT&C losses were 45% in 2001.[17] It was against this backdrop that the Delhi government introduced power reforms in 2002.[18] The following reform process ultimately resulted in the unbundling of DVB and privatization of distribution. The main aims were to rationalize the tariffs, eliminate thefts, and bridge the increasing gap between the peak and off-peak demand. In 2002, three private companies were entrusted with the task of distributing power. Incentives were put in place to reduce AT&C losses and to reign in power theft. As a result, there

[17] *Annual Report on the Working of State Electricity Boards*, Planning Commission, Government of India, 2002.
[18] Delhi Government, *http://delhigovt.nic.in/power.asp*

has been a considerable reduction in the AT&C losses, which are down to below 30% in 2007-08.[19]

A completely unintended, nevertheless quite relevant to the climate change discussion, consequence of the Delhi reforms have been a significant reduction in growth rate of electricity demand, and hence, in CO_2 emissions. Rationalization of tariffs and stricter compliant mechanisms mean that the end users are now exposed to the true cost of power greater than ever. As electricity distributors have used innovative technologies to crack down on theft, electricity demand in Delhi has grown much slower in the last 5 years (i.e., post reforms) than in the pre-2003 state-of-affairs (Figure 6), despite a much stronger economic growth in Delhi post-2003.

As shown in Figure 7, our calculations indicate that for plausible power-consumption growth rate scenarios (see Table 1), *power-sector reforms similar to Delhi across India could lead to annual savings in the range of 200 to 250 Mt of CO_2/year by 2017*.[20] This is equivalent to nearly 50% of India's total power emissions in 2007 (520 Mt of CO_2)[21] and about 6% of Europe's total emissions in 2006.[22] Thus power reforms would not only have a positive financial implication but could also prove to be an efficient mitigation strategy against climate change.

	Electricity Growth Rate	
	No Reforms	**Reforms**
Scenario A	**5%**	**2.50%**
Scenario B	**7%**	**3.50%**

Table 1: Scenarios for growth of electricity demand in India, with and without reforms. The growth rates are based on Delhi's experience between 2003 and 2008, and were chosen so as to yield a conservative value (on the lower end) for potential reductions in CO_2 emissions.

[19] Source: Central Electricity Authority (CEA), India and Delhi Electricity Regulatory Commission (DERC), http://derc.gov.in

[20] Rai, V, Goel, A., and Victor, D.G., "Impact of Delhi's Power-sector Reforms on CO_2 Emissions", In Preparation, PESD Working Paper, Stanford University, 2009.

[21] *CO_2 Baseline Database, v4.* Central Electricity Authority (CEA), Government of India, September 2008.

[22] *World Energy Outlook 2008*, IEA.

Outsiders (international community) can help by co-funding such programs on a large scale across India. India should also be engaged early on in international efforts on advanced local-grid management systems that will enable further technical efficiency gains as India, under its "electricity for all by 2012" program, expands its electricity supply to encompass hundreds of millions that currently do not have access to electricity.

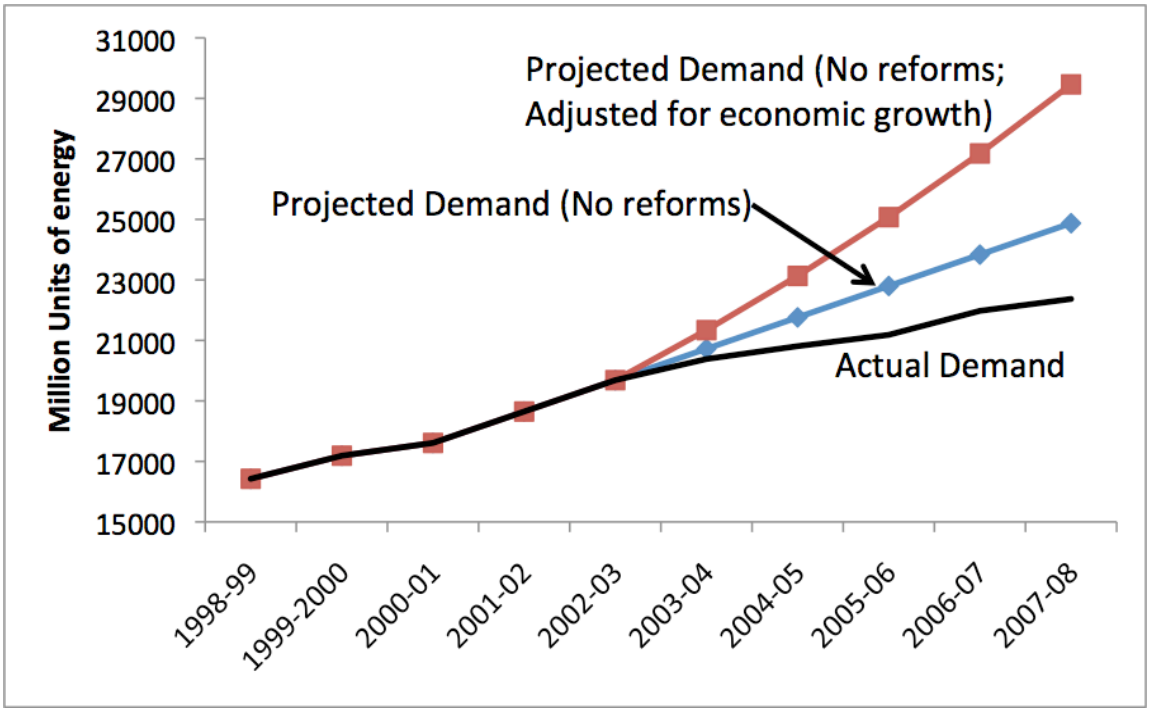

Figure 6: Impact of power-sector reforms on electricity demand in Delhi.

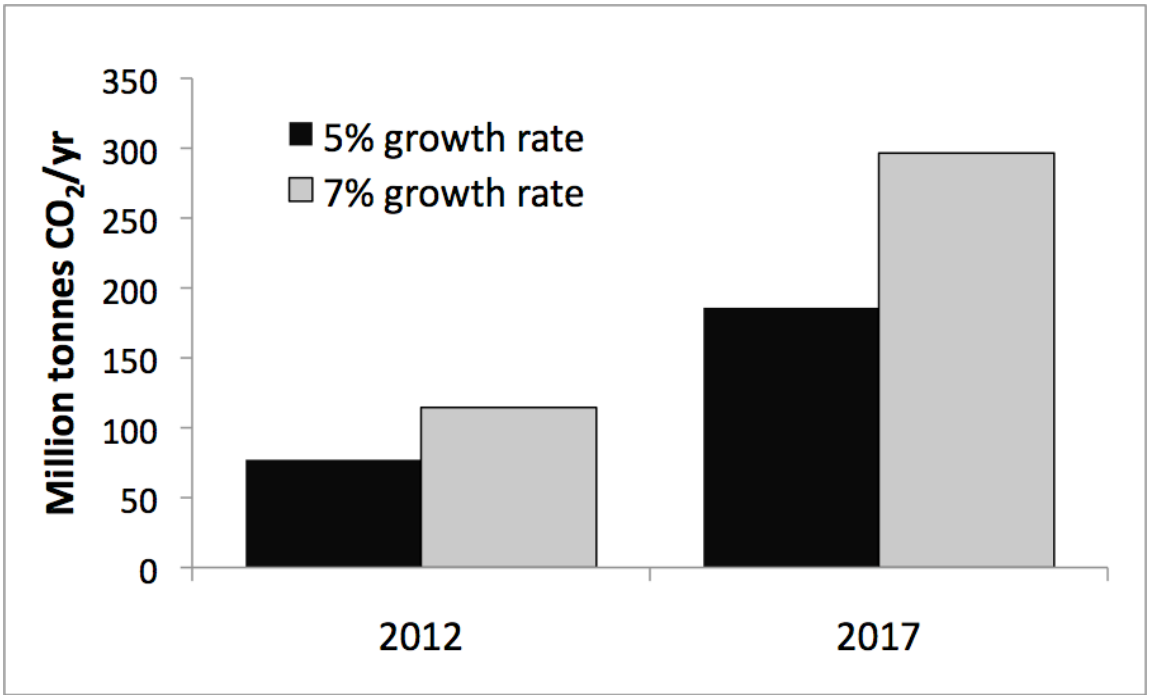

Figure 7: Potential CO_2 emissions reduction per year in India due to power reforms in India for scenarios in Table 1.

Efficiency of Coal-based Power Generation: The Indian Coal-Efficiency Program

As in the past, coal remains India's fuel of choice for expanding its energy supply to fuel continued economic growth. Coal is relatively abundant and cheaper than oil and gas in India. Absent significant new discoveries of oil and gas, domestic oil and gas reserves are likely to run out in 20 to 30 years, while coal is estimated to last well over 50 years even after accounting for 5% annual growth in coal consumption in the years to come.[23] The preference for coal is well demonstrated by the actual build and dispatch of electricity in India. Under any plausible scenario, this trend is likely to continue for at least the next couple of decades.

As demand for coal has soared in recent years, cracks in India's coal supply chain have appeared, owing mainly to commercial inefficiencies (price distortions) and infrastructure bottlenecks (poor technology, freight problems).[24] If this situation persists,

[23] *Integrated Energy Policy, Report of the Expert Committe*e, April 2006, Planning Commission, Government of India

[24] Carl, J. C., Rai, V, and Victor, D. G., "Energy and India's Foreign Policy", PESD Working Paper #75, Stanford University, May 2008.

India may be forced to import large quantities of coal in the next decade (Figure 8). From the viewpoint of India's energy security, this would expose India's energy supply to international energy markets on all fronts (oil, gas, *and* coal)—a scenario that Indian politicians dread, as control on energy prices have proven crucial in political battles. India recognizes this fact, and there is general consensus to streamline coal production while improving efficiency of coal use as a way of both improving energy security and continued economic growth.[25]

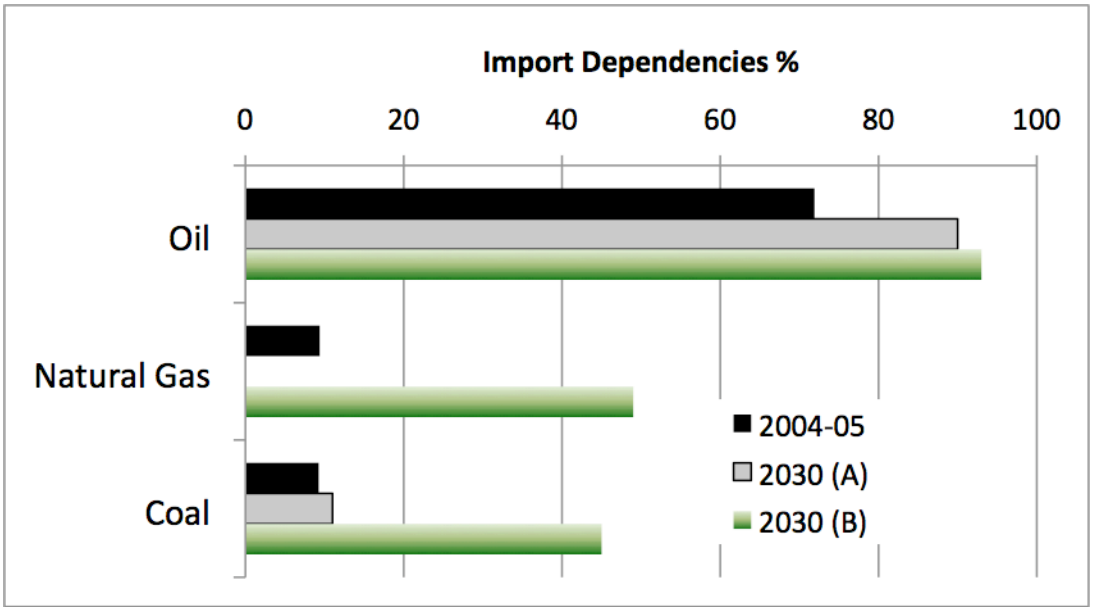

Figure 8: Import Dependencies. Scenario A: Minimum requirement, maximum domestic production. Scenario B: Maximum requirement, minimum domestic production. Source: Integrated Energy Policy, Government of India, April 2006.

But technology remains the main bottleneck when it comes to burning coal in India. The technology and efficiency of India's coal plants lag far behind the world standards. The average efficiency of India's coal-based power generation fleet is a paltry 30%—nearly all of India's coal-based power generation comes from low efficiency subcritical units.[26] Its first modern efficient power plant—a supercritical unit that delivers 39% efficiency, far behind the world's best practice—is slated to come online

[25] *Integrated Energy Policy, Report of the Expert Committe*e, April 2006, Planning Commission, Government of India

[26] *Report of the Export Committee to Recommend Next Higher Size of Coal Fired Thermal Power Stations*, Central Electricity Authority (CEA), Government of India, November 2003.

only this year even though the technology used in their new plant has been available for three decades. Even China started installing supercritical units nearly two decades ago (China's first supercritical unit come online in 1992). Low efficiency plants need more coal to be burnt for the same amount of power generated, and thus increase both demand for coal and CO_2 emissions (CO_2 emissions from coal-based power generation form about one-third, or roughly 450 Mt/CO_2, of India's total GHG emissions (1.3 billion tons in 2006).[27]

India's own deep interest to improve its coal and electricity supply situation offers yet another serious option for GHG mitigation. *An India coal-efficiency program (ICE program) to deploy 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*. As discussed below, outsiders will be a critical part of such a program both to support India with the necessary technology and with financial help where necessary. Looking to 2030, such a program could reduce India's emissions by about 400 million tonnes of CO_2 annually below the level that the power sector would have emitted otherwise.[28] The benefits of such a program for coal demand and installed generation capacity are equally staggering: compared with the business-as-usual scenario, in 2030 coal demand will be lower by about 250 Mt/yr and the required installed capacity will be lower by about 90 GW.[29] The program should also emphasize the early deployment of ultra-supercritical plants to create learning and expertise with this technology, which will build the platform for further reductions in future. Achieving these higher efficiencies, especially for new plants, then, offer a tremendous win-win opportunity for India's developmental goals and CO_2 emissions reductions, and should be a top priority for India and outsiders.

Outsiders can play an important role in helping India move forward with the ICE program outlined above. The best coal plants in the world—built in Germany and funded by expensive government research programs—now approach 50% efficiency.

[27] *CO_2 Baseline Database, v4.* Central Electricity Authority (CEA), Government of India, September 2008.
[28] Authors' estimates.
[29] Authors' estimates.

But these plants are rare, and India is years away from developing the technology cost-effectively at home. So far, little has been done to help India move up the technology curve for coal plants. Other than sell ages-old technology at commercial terms, the West has done little to help India burn coal more efficiently. One test of whether governments across the world are serious about global warming is to see if they encourage a speedy spread of best technologies around the world—a good example of which will be success of the ICE program.

Human Welfare through Improving Local Pollution Standards and Combating Climate Change: Advanced Cookstoves in India[30]

The Atmospheric Brown Cloud (ABC, previously referred to as the Asian Brown Cloud) is a layer of smog looming over South Asia and the northern Indian Ocean. While the cloud has long been known to have climatic effects,[31] the extent of the effect was not clear until recently. In the last few years research has revealed a strong net warming effect due to the ABC, increasing regional warming by approximately 50%.[32] Estimates of the net global-warming effect of black carbon range from +0.4 W/m^2 to +0.9 W/m^2, according to the IPCC and Ramanathan, respectively.[33]

Any Indian strategy to combat global climate change, and in particular any plan hoping to have near-term results, must address the role of the ABC. Reducing brown and black carbon may be one of the fastest ways to combat climate change. Brown and black carbon in the atmosphere last only a few days or weeks, as opposed to decades for carbon dioxide and other greenhouse gases. Several authors have recently outlined the importance of black carbon as an area of major leverage for climate, notably

[30] Slaski, X. and Victor. D.G. In Preparation, PESD Working Paper, Stanford University, 2009
[31] The aerosols, brown and black carbon particles that compose the cloud, have both warming and cooling effects, by scattering light and absorbing heat.
[32] See Ramanathan, V. Warming Trends in Asia amplified by brown cloud solar absorption. Vol 448. August 2007.
[33] IPCC, *Changes in Atmospheric Constituents and in Radiative Forcing*, in Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change 129, 132 (2007), and V. Ramanathan and G. Carmichael, *Global and regional climate changes due to black carbon*, 1 Nature Geoscience 221-22 (23 March 2008).

Stanford's Mark Jacobson. [34],[35] The UNEP also recently issued a report on ABCs, highlighting the degree to which the issue is moving to the forefront.[36]

While burning biomass has long been known to be a contributor to the ABC exact estimates of the share from biomass have varied wildly. A paper published by Tami Bond in 2004 estimated that only 20% of black carbon came from biofuel burning.[37] Recent efforts by Gustafsson to pin down the amount have determined a larger share from biomass than previously thought—about two thirds.[38] Thus, the most up-to-date research suggests that biomass burning is the main culprit of the Atmospheric Brown Cloud, meaning that any comprehensive plan to combat global warming in Asia must consider the ABC and therefore its main source—biomass burning.

The problem is that biomass burning is a non-point source of emissions, dispersed across the homes and fields all across the country. Further, requiring people to stop burning biomass is an untenable option, since for many it is the primary or the only source of energy.

While transitioning large segments of the Indian population away from biomass burning may be a long-term policy goal, a shorter-term or transitional way to burn biomass more cleanly is through improved cookstoves. Such stoves have been and are being distributed by numerous NGOs, companies, and governments worldwide, with varying degrees of success. Meant to replace the traditional three-rock stoves used in

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[34] Jacobson, Mark Z. "Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming." Journal of Geophysical Research, Vol. 107, No D19. 2002. See also Zaelke, D., "*Reducing Black Carbon May Be the Fastest Strategy for Slowing Climate Change,* Institute for Governance & Sustainable Development /INECE Climate Briefing Note. December 2008. Department of Civil and Environmental Engineering, Stanford University, Stanford, California, USA Received 9 October 2001; revised 5 February 2002; accepted 12 April 2002; published 15 October 2002.

[35] V. Ramanathan and G. Carmichael, *Global and regional climate changes due to black carbon*, 1 Nature Geoscience. 221-22 (23 March 2008)

[36] See *Atmospheric Brown Clouds: Regional Assessment Report with Focus on Asia.* United Nations Environment Programme Report. 2008.

[37] Bond, Tami C. et al. "A technology-based global inventory of black and organic carbon emissions from combustion" Journal of Geophysical Research, Vol. 109. 2004. Geophysical Research Letter, Vol. 27, No. 23, pages 4061-4064.

[38] Estimates range from 50% to 90%. Biofuel burning contributes to two thirds of bulk carbonaceous aerosols, according to the paper. See Gustafsson, Örjan et al., "Brown Clouds over South Asia: Biomass or Fossil Fuel Consumption?" *Science* 323, 495 (2009). For an earlier estimate see Novakov, T. "Origin of Carbanaceous Aerosols over the tropical Indian Ocean: Biomass burning or Fossil Fuels?"

many rural household, improved cookstoves use less fuel, reduce indoor air pollution, and drastically reduce emissions from cookstoves.

An initial calculation reveals that for a very low cost a cookstove program could drastically reduce the Atmospheric Brown Cloud and thus regional warming. Assuming that every Indian family has a stove, and that each family is comprised of six to eight people, it's reasonable to assume that there are 120 million stoves nationwide. Replacing just half of these stoves—60 million—with improved stoves would reduce the ABC by approximately third. And this program, even if fully subsidized, would cost $300 million, assuming $5 per stove.[39]

Such a program, in order to be effective in the long-term, would need to be accompanied by long-term improvements in the regulations of other sources of brown and black carbon, such as diesel engines. But the leverage from an improved cookstove program could be a major part of a portfolio of India's efforts to combat warming.

While such a large-scale effort is indeed feasible—China distributed more than 100 million stoves over a 15-year period, with only partial subsidization and minimal government involvement—India's track record on cookstoves is not stellar.[40] In *What Makes People Cook with Improved Biomass Stoves?,* Doug Barnes describes the high cost and failure of the previous Indian cookstove program.[41] However, the largest sources of biomass burning are concentrated in a few major states, meaning that a focused program in a few areas of India could have a major impact. Major heterogeneity in states' ability to administer such a cookstove program means that it is of crucial importance that one need only focus on a few states in order to have a large effect.

In a budget-constrained Indian government, there may be apprehensions about the cost of a cookstove program. But given India's obvious interests in such a program (the Indian government would like to and has attempted to distribute cookstoves, for reasons involving combating deforestation and improving health, among others),

[39] Total Anthropogenic Emissions of Carbon Dioxide in India were 1,165.73 million metric tons in 2005, according to the EIA. See *India Energy Profile,* Energy Information Administration.
[40] Smith, Kirk R. "One Million Improved Cookstoves in China: How Was it Done?" World Development, Vol. 21, No. 6, 1993.
[41] Barnes, Douglas F. et al. "What Makes People Cook With Improved Biomass Stoves? A Comparative International Review of Stove Programs. World Bank Technical Paper Number 242.May 1994.

outside assistance would likely be welcome in addressing the problem. What could an outsider do to strike a bargain and to assist the Indian government in a cookstove program? One obvious realm is in financing such a program, but also by helping craft a program that is sustainable, using the knowledge gained from other programs, notably the Chinese program.

Another possibility is that the Indian government need not be involved directly in the distribution of cookstoves at all, but may simply make the market attractive for some of the major corporations trying to roll out large-scale cookstove programs in the country. BP alternative energy until recently had a major cookstove program that could have in the long-term satisfied a large portion of demand. The Shell Foundation, partnering with EnviroFit, is selling stoves across India. The Philips Corporation also has a design and plans to sell across India. These major corporate programs offer a unique experiment, which may end in a sustainable, profit-driven distribution network for stoves across the country.

VI. Beyond Boxes IIa and IIb: Building Capability and Credibility

When planning international engagement strategies the key questions always hinge on credibility and enforcement—problems that are much more readily solved when the contributions of each country are broadly seen in that country's self interest. India's decision about what is in its interest depends on and varies with India's technological and administrative capabilities. India and outsiders can, together, shift that equation so that, in time, options that are "irrelevant now" (Figure 4) are transformed into viable options (Box IIa and IIb, Figure 4). That matters because it creates a greater potential for leverage on the climate problem and because it makes more of that leverage directly in India's interest. A couple of possibilities are outlined below.

Advanced Technologies and R&D

Cutting-edge technologies like carbon capture and storage, fuel cells, solar photovoltaic (PV), which are also very expensive, will not make a significant difference in

developing countries from a climate-change viewpoint in the next two to three decades. India must facilitate demonstration projects at home and participate in international research efforts. But that should be part of a long-term innovation strategy (supported with domestic institutional continuity), and not a medium-term strategy as a viable response by India. New technologies will lead the warfront against climate change. EU, Japan, and US recognize this well, and have been most aggressive in incentivizing inventions in green technologies since 1991. Historically too, just a handful of countries have led most of world's R&D efforts: only ten countries spend more than 90% of global R&D expenditure (Figure 9).[42] Success in technological inventions requires more than mere spending. It requires a robust national system of innovation with a long-term vision that closely integrates and coordinates basic R&D expenditure (mostly by the government) with commercial R&D through favorable policies to pull these technologies in the marketplace. In India, except matters related to national-defense (aerospace, military, nuclear energy), such vision and coordination has been lacking and the system of innovation has not kept pace with global advancements in science and technology. Indian policymakers recognize this lacuna, and there is increasing emphasis to resurrect technological innovation in India. But even if India fires all R&D cylinders and gets its act together in the next few years, the benefits will not be felt for years to come. Yet, a successful R&D program will be enabling for India to spearhead its own technology-based mitigation response in future.

[42] Dooley, J. J. and Runci, P.J., "Adopting a Long View to Energy R&D and Global Climate Change", Prepared for U.S. Department of Energy, February 1999.

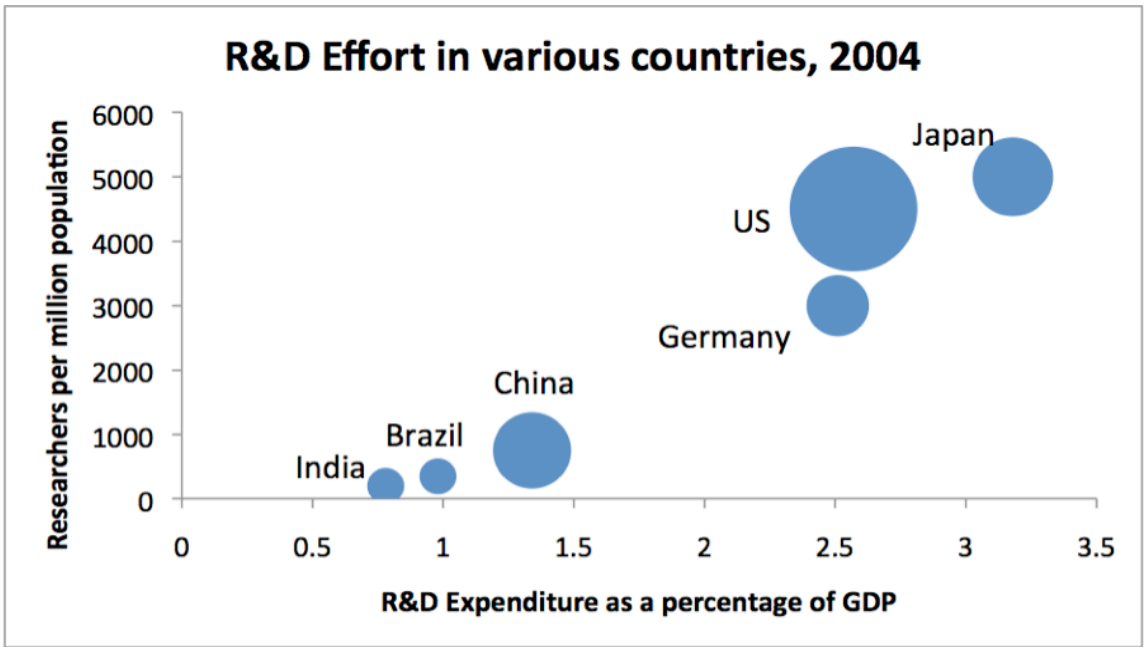

Figure 9: 2004 R&D expenditure of India and some other major countries. Source: EIA, World Bank.

Creating a National Information Administration for Energy

Besides research in energy technologies, economic modeling and forecasting are also important in the planning and negotiation process. So far energy-related data in India are quite dispersed, incoherent, and often contradictory. This not only hinders serious research on energy economics in India, but also hurts transparency (and hence credibility) of India's planning process in the climate-change arena. Accordingly, we urge the creation of a National Information Administration for Energy (NIAE) that would serve as the central repository of all energy-related data in India.

VII. Conclusion

Based on arguments of equity and per capita emissions, India has shied away so far from direct engagement in global efforts to mitigate emissions of green house gases. While essentially valid, such arguments are becoming increasingly unsustainable in the international politics of climate change. A serious climate-change policy, backed with necessary action, will increasingly become a part of India's relations with industrialized countries, especially the United States—as the world gears up for serious mitigation action, some kind of engagement on India's part may be unavoidable.

We have argued that in the Indian context the costs of engagement at the margins are not as high as many think and that the apparent dichotomy between economic growth versus de-carbonization of energy sources is not nearly as serious. Of a number of seemingly interesting options for significant emissions reductions, only those offer real leverage in the climate-change arena that align with India's core interests (economic development and energy security) while also aligning with what the Indian government can implement given its administrative, political, and technological resources. Successful design of such policies will help boost India's credibility and make still deeper cooperation possible in the future. This, we have suggested, is the framework through which all available options should be evaluated.

Within this framework, we have identified three major options that provide real leverage for reducing emissions in the Indian context: power-sector reforms, efficiency of coal-based power generation fleet, and large-scale distribution of efficient cookstoves (for biomass burning). Our intention here was not to prepare an exhaustive list of such options, but to apply the framework for identifying viable options—it is likely that other options fit this framework as well. Power-sector reforms that crackdown on illegal theft of electricity by end-users across India can help reduce CO_2 emissions between 200 and 250 million tonnes of CO_2/yr ($MtCO_2$/yr) by 2017. A national program (the ICE program) to improve the efficiency of India's coal-based power plants from 30% to 40% over the next two decades can provide about 400 $MtCO_2$-reductions/yr by 2030, while also reducing coal requirement by 250 Mt/yr. Finally, a national program to distribute efficient cookstoves will radically improve health standards in low-income households, but also will hugely reduce local-warming effects caused by aerosols from inefficient biomass combustion. Outsiders can help India in all these programs, but India will need significant help on advanced coal technologies for success of the ICE program. The extent to which outsiders come forth with serious technological help for India will be a direct measure of how serious outsiders are about global warming.

Further leverage for the climate problem could be available through building India's technological and administrative capabilities over time. For this, we have

suggested that India should be involved in advanced-energy-technology R&D efforts at home and internationally. But that should be part of a long-term technology vision for India, and not an option for a near- to mid-term mitigation strategy. Finally, we have urged the establishment of a National Information Administration for Energy (NIAE)—a central repository of all energy-related data in India—to facilitate energy-economics modeling by researchers around the world, but also as a way to establish transparency and credibility.

An important issue not discussed in this paper is the institutional aspect of how these self-interested "offers" (boxes IIa and IIb) could be crafted into international commitments/deals. In our view, key developing countries could make offers of what they would do on their own (IIb) and what they would like to have help for (IIa) and then negotiations would craft deals of those two elements plus outside support. As IIa would be contingent on that support, the program would be largely self-enforcing. A good model is WTO.[43]

[43] Victor, D. G., "Climate Accession Deals: New Strategies for Taming Growth of Greenhouse Gases in Developing Countries",PESD Working Paper #82, Stanford University, January 2009.