

# *The role of the clean development mechanism in a post Kyoto climate agreement: effective participation by China and India.*

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## **Abstract**

The key objectives of the Clean Development Mechanism (CDM) are to cut the cost of compliance with the Kyoto greenhouse gas (GHG) reduction obligations of Annex 1 countries and to promote sustainable development in non-Annex 1 countries. However the program has been criticized for supporting projects that would have been undertaken by investors in the absence of the CDM subsidy thereby increasing overall GHG emissions, and also for contributing very little to sustainable development in developing countries. This critique of the CDM projects is examined empirically considering a sample of projects that generate electricity for supply to a national or regional grid in China where the marginal source of new supplies of electricity would be a coal-fired thermal plant (data on a similar sample of Indian projects is work-in-progress). We do this by calculating the marginal cost (MAC) of cutting GHG emissions for each project in our sample using UNFCCC project design document data. We also attempt to quantify the health benefits from the reduction in emissions of pollutants such as sulfur dioxide and particulates when electricity is generated from alternative energy sources rather than coal. We consider this measure of ancillary benefits a lower bound of the value of sustainability benefits from these projects. Our results so far indicate that in the electricity generating sector CDM projects have lowered the cost of emission reduction for Annex 1 countries and brought significant sustainability benefits to the host countries. However, for a significant number of these projects, the MACs are higher than the value of credits (CERs) that an investor can earn in the international markets for GHG emission reductions and the value of health benefits only partly offsets the difference between MAC and CER values. On the other hand, we find that a group of small hydro projects has negative MAC. On the face of it the latter group of projects would have been undertaken by investors in the absence of the CDM subsidy. We speculate that these projects nevertheless merit approval by the UNFCCC because they experience barriers to realizing the proposed returns on investment. We discuss the policy issues generated by this sample of projects in the context of improving the effectiveness of the CDM and the participation of the developing countries in the post Kyoto climate change agreement.

Paper to be presented at the Association for Environmental and Resource Economists workshop on Energy and Environment at the Resources for the Future, Washington DC, June 18-20, 2009

JEL CODES: Q42, Q 54

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<sup>1</sup> This research was supported by funds from the Robert S. Strauss Center for International Security and Law, University of Texas at Austin. Ian Partridge is a Ph D. candidate at the LBJ School of Public Affairs and Shama Gamkhar is an Associate Professor at the LBJ School of Public Affairs. The authors would like to thank Shanu Pant, Masters in Public Affairs (graduate class of 2010) at the LBJ School for excellent research assistance on the project.

## 1: Introduction

The Clean Development Mechanism (CDM), created by Article 12 of the Kyoto Protocol, is a market based mechanism intended to cut the cost of compliance with emission reductions mandated by the Protocol and promote sustainable development in developing countries. However its real importance is that it is a first attempt to bring the developing countries into an international agreement aimed at limiting green house gas (GHG) emissions. The mechanism allows countries with emission reduction commitments under the Kyoto Protocol (called the Annex 1 countries) to earn credits for reduction of emissions of GHGs in countries that do not have such commitments. The US has consistently stated that one of its bottom line demands in the current negotiations over a successor to Kyoto is an agreement that ties the developing countries, particularly China and India, into making cuts in GHGs. China is the biggest emitter of greenhouse gases in the world (it recently took over this title from the US). China and India are the biggest beneficiaries of CDM projects and projects in these countries have also been the target of much of the criticism of the CDM. In a report on climate change, the Council on Foreign Relations Independent Task Force said that the CDM has been “largely unsuccessful in encouraging real and significant changes in developing countries” and the Task Force suggested that the US should promote a “conceptually similar but more robust effort focused on a small number of high-payoff areas.....where leverage on emissions is the greatest.”(Council on Foreign Relations 2008)

In this paper we evaluate the performance of the CDM program by analyzing a sample of CDM projects to assess whether they have delivered what the CDM promised to deliver. An objective and quantified assessment of the performance of the CDM enables us to take an initial look at two related policy questions: how to approach the design of a market-based or hybrid scheme that might meet the specification laid out by the CFR as a “more robust” version of the CDM that focuses on “high-payoff areas”, and that fully engages the developing countries in the Kyoto process; and whether US companies should be allowed to participate in offset schemes. As a potential large buyer of carbon emission credits, the US is in a position to influence the rules for ensuring the environmental integrity of the CDM.

The CDM has been the target of much criticism, both in academic journals and in the press. Some of this criticism arises basically because the scheme covers such a diverse range of project types – many of its rules are somewhat vague so they can be applied to many types of project; and much research on the CDM in its early days (it has been operating only since 2006) was necessarily based on small samples because only a few projects had been put forward for registration. Previous researchers have criticized the CDM on three specific grounds that have to be seen as serious: that some projects that are accepted for registration are not “additional”; that the CDM results in a net increase in GHG emissions; and that it does not promote sustainable development in countries that host CDM projects.

- **Additionality and potential increase in emissions:** a project is additional if it is not economically viable without the subsidy provided by the CDM. If a project that is not additional receives emission allowances from the CDM, the firm that buys those allowances avoids making cuts in its own operations but no compensating cuts are made elsewhere because the project would have been built on its own merits. The net result is that emissions are higher than they would have been without the CDM (Schneider L. 2007).

- **Sustainability:** a very frequent criticism concerns the CDM's objective of promoting sustainable development<sup>2</sup>. Projects that eliminate certain by-products of chemical plants – notably a substance called HFC-23 – are cheap to implement, lead to huge reductions in GHG emissions, but bring essentially no benefit to the host country other than the revenue from the CDM itself (Olsen K. 2007; Sutter C. and Parreno J. C. 2007). As of mid-February 2009, only 4% of projects have been of this type, but they were responsible for 76% of all emissions reductions by the CDM. In our view, most criticism of the failure of the CDM to achieve its sustainability objective relates to this type of project.

In this paper we have made our own assessments of additionality and sustainability, focusing on a narrowly defined but important subset of projects: grid-connected electricity generation plants located in China and India that use renewable energy (wind and hydro) or low emission technology (natural gas combined cycle). This project category was chosen because both countries are growing rapidly and have experienced electricity shortages; both have large coal reserves; in both it is reasonable to assume that the marginal new generation plant is coal-fired; and, finally, both countries have severe problems of pollution caused by coal burning. In fact, this subset of projects accounts for a significant proportion of the CDM: as of May 2009, 60% of all registered CDM projects were located in China or India, and 54% of all projects in these two countries were grid-connected power generation schemes based on one of the three technologies. Although we assessed projects in both India and China, we are reporting only our results for China in this paper, as we are not yet happy with the quality of the data that we have for India. However, on the basis of results so far, the conclusions we draw for China are likely to be valid also for India.

By taking this focused approach we believe that we avoid the fog of general conclusions that is inevitable in an analysis of the CDM as a whole. We can design an assessment methodology around one specific type of project - our methodology is based on calculation of the project's marginal abatement cost per ton of CO<sub>2</sub> equivalent, or MAC<sup>3</sup>. This calculation provides the same information on additionality and baseline emissions as the standard UNFCCC methodology and it also provides us with some added understanding of the project. The MAC is a direct measure of additionality, because a project with a negative MAC is, other things being equal, profitable in its own right and therefore not additional. We can compare the MAC to the price of a CER (Certified Emissions Reduction - a GHG emissions permit issued under the CDM scheme). It is rational to assume that the market price for CERs provides a measure of the marginal abatement cost in developed countries because emitters in those countries can arbitrage between making cuts and buying permits to cover their emissions. If a CDM project's MAC is greater than the expected value of the CERs that it will generate, then on the face of it, it would be cheaper to cut emissions in a developed country. Finally, the MAC provides a standard against which to compare any secondary benefits of CDM projects for the host countries that might be seen as enhancing

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<sup>2</sup> The Kyoto protocol envisaged that benefits over and above the value of the emissions credits awarded would accrue to the host country of a CDM project in the form of sustainable development.

<sup>3</sup> Marginal abatement cost: the cost to the country of cutting CO<sub>2</sub> emissions by one ton. For an electricity generation project, this is the added cost of generation as compared to the generation cost of a marginal new plant.

sustainable development, provided we can attach a monetary value to those benefits. In some cases these secondary benefits provide an economic rationale for a CDM project that might otherwise seem irrational because the incremental generation cost is greater than the CDM revenue to the project.

Our findings indicate that generalizations about the CDM based on previous research often do not apply to the sub-set of projects that we examined.

1. Wind farms and gas-fired thermal power stations generally meet the UNFCCC criteria for additionality. We tentatively concluded that small hydroelectric projects in China do not meet these criteria, which means that inclusion of these projects in the CDM leads to a net increase in global emissions of GHGs.
2. The majority of projects are economically rational in that they are profitable if the value of their CER revenue stream is taken into account – at least in normal times<sup>4</sup>. Also, if we can assume that the CER price is a proxy measure for the MAC faced by power generation firms in the developed world, then the CDM does cut the global cost of emission reductions.
3. The public health benefits of cutting emissions of criteria pollutants such as SO<sub>2</sub> and particulates can be quantified and are significant. Some individual projects that do not seem to be rational based on the expected value of the CER revenue stream are likely to be economically justifiable if the value of these sustainability benefits is taken into account (particularly because there are other likely sources of benefits that we have not attempted to quantify).

In the next section (2) we provide a description of the CDM program administration and its composition. A brief review of an early critique of the program in the existing literature in section 3 lays the ground work for our evaluation. Energy policy in China and India has critical implications for CDM projects in these countries: this is discussed in section 4. Our research methodology for examining the cost and sustainability performance of the CDM program and the findings of our study are in sections 5 and 6 respectively. Finally, Section 7 discusses the conclusions and directions for future research.

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<sup>4</sup> The price of CERs has collapsed in the last few months in line with the general reduction in economic activity in the EU.

## ***2: Background - description of the CDM***

Developed countries that have ratified the Kyoto Protocol accept an obligation to cut their emissions of greenhouse gases (GHGs). They pass on this obligation to firms such as electrical utilities by setting a limit (the “cap”) on the emissions that each firm can generate. The firms can cut emissions from their own operations, or they can buy emission reduction units in the market if this costs less than making cuts themselves. The effect of GHGs on the world’s climate is the same whether they are emitted in (say) Uganda or in Germany – in this, they differ from more typical pollutants, which affect primarily the area where they are emitted.

The designers of the CDM tried to set up a win-win situation: acting on the (widely accepted) belief that the marginal cost of reducing greenhouse gas emissions (marginal abatement cost, or MAC) is likely to be lower in a developing country than in a developed one, they set up a scheme that awards emission reduction units (CERs<sup>5</sup>) to projects that cut emissions in developing countries. The CERs can be sold in the market to firms that have an obligation to cut emissions – the practical effect is to enable cuts in GHGs to be made wherever the cost is lowest. If the target level of cuts can be made at lower cost, total global welfare is increased.

In fact, the CDM has two objectives: in addition to minimizing the cost of cutting emissions at the global level it is intended to promote “sustainable development” - the Kyoto Protocol envisaged that benefits over and above the value of the CERs awarded would accrue to the host country of a CDM project. Sustainability is notoriously hard to define, and harder to quantify, however we can quantify at least one benefit that accrues to China and India from our sample of projects. Both countries have serious air pollution problems due to their dependence on coal for energy; studies have quantified the costs to their economies of this pollution (WorldBank and SEPA 2007); the generation technologies used for CDM projects produce lower levels of pollutants, and it is possible to calculate the economic benefit of the reduction.

### ***How is the CDM program administered?***

The integrity of the CDM depends on careful verification of projects and the emission cuts they generate. CDM participation is voluntary for developing countries. Their incentive to participate depends on the value of the emission credits they can generate along with the sustainable development benefits received. The definition of sustainability and the judgment as to whether a project entails sufficient such benefits to be worth putting forward for CDM registration is left to the host country, which is responsible for pre-vetting of projects<sup>6</sup>.

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<sup>5</sup> Strictly speaking, the EU Emissions Trading Scheme (ETS) is based on EUAs (EU Allowances) while CDM projects receive CER (Certified Emission Reductions) credits (also referred to as CERs). CERs and EUAs are interchangeable for purposes of compliance with the EU ETS and both trade on the same markets. Logically their prices should be identical, but in practice the market price of CER futures is €1 - €2 below that of EUA futures, either because of lower liquidity or greater risk of non-delivery.

<sup>6</sup> The UNFCCC has encouraged developing countries to set up designated national authorities (DNAs) to prioritize projects that can then be offered to domestic or foreign investors.

The next stage is the responsibility of a “designated operational entity”, or DOE. This is a firm licensed by the UNFCCC (United Nations Framework Convention on Climate Change) to vet projects and to monitor emission reductions once the project is operating. The key points to be verified are the project’s additionality (defined above) and the forecast level of emissions relative to a “baseline” – i.e. the emissions that would have occurred if the project did not exist. Some researchers have questioned the impartiality of the DOE, who is paid by the project developer (see Literature Review below).

If the DOE is satisfied with the project it forwards the proposal to the UNFCCC Executive Board, which oversees the activities of the DOEs. The Board may challenge the DOE’s decision, but in most cases it accepts the project for registration. Emissions reductions that can be attributed to the project are monitored by the DOE and the appropriate number of CERs awarded. Until recently the market in CERs was not particularly transparent – most transactions were “over the counter,” with no obligation on the parties to publicly announce the details of their deals. However since early 2005 there has been a transparent and liquid market in EUA futures, enabling researchers and investors to put a value on emissions reductions generated by CDM projects. Since early 2005, EUAs for delivery in December 2009 have been valued between €8.20 (US\$11.08) and €32.90 (US\$44.47) per ton of CO<sub>2</sub> equivalent (usually abbreviated to tCO<sub>2</sub>e).<sup>7</sup> A similar futures market for CERs has operated since early 2008 – prices in the CER market have consistently been €1 - €2 lower than EUA prices per ton of CO<sub>2</sub>.

### **Composition of CDM projects**

During the early years of the CDM, emission reductions, and hence CERs issued, were dominated by projects that destroy HFCs and other gases. As of February 2009<sup>8</sup>, only 4% of projects that had achieved registration were of this type, but they accounted for about 76% of CERs issued (see charts 2.1 and 2.2). Almost half of these projects are located in China. This imbalance is expected to reduce, largely because of the decision by the UNFCCC not to register new projects of this type<sup>9</sup>. By 2012, the proportion of CERs issued to HFC and similar projects should have been reduced to about 47% of the total for the year.

This paper focuses on grid-connected power generation projects based on wind, hydro or natural gas combined cycle technologies. This project category accounted for 40% of projects registered worldwide as of February 2009, but only 8% of CERs issued. However, by 2012, it is expected to account for 20% of CERs issued in that year. An analysis by number of projects (see table 2.1) shows that China and India account for 60% of all CDM projects registered as of May 2009 and that the three categories of generation in which we are interested account for 32% of Indian projects and 72% of projects located in China.

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<sup>7</sup> All CER and EUA prices quoted in this paper are futures prices for these instruments quoted on the European Climate Exchange (ECX) – see [www.europeanclimateexchange.com](http://www.europeanclimateexchange.com). The conversions above are made at exchange rates current on May 15 2009.

<sup>8</sup> We are in the process of updating our data to take account of projects to mid-May.

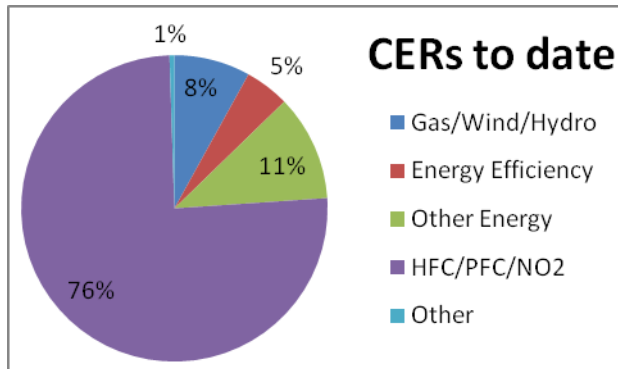
<sup>9</sup> To be registered, these projects must now have an operating history of at least three years prior to the end of 2004.

**Table 2.1: Project count at May 2009**

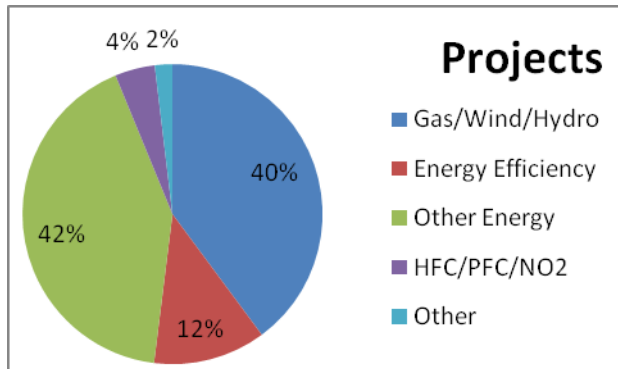
	Hydro/Wind/ Gas	All Other	Total
India	134	286	420
China	380	150	530
Other	158	488	646
<b>Total</b>	<b>672</b>	<b>924</b>	<b>1,596</b>

Source: UNEP Risoe

**Chart 2.1: CERs issued as of mid-February 2009**

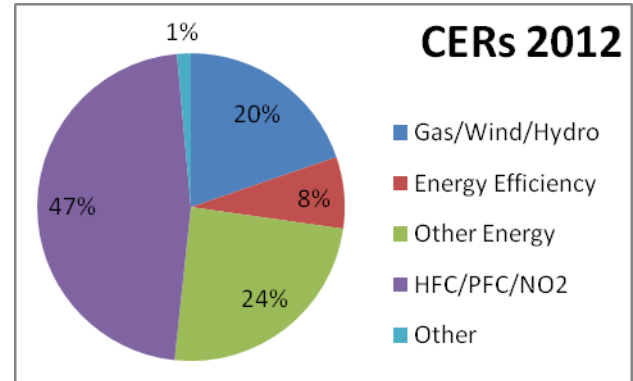


**Chart 2.2: CDM projects registered as of mid-February 2009**



**Chart 2.3: expected number of CERs to be issued in 2012 to projects proposed to**

date



The charts provide a breakdown of projects registered as of February 2009 in five categories:

- Commercial scale natural gas combined cycle (NGCC), wind and small hydro. Our definition of NGCC excludes all plants of capacity less than 100MW. For wind and hydro we include all registered projects, regardless of size.
- Energy efficiency.
- Other energy: this category includes all projects that generate either electricity or gas (methane), including those that simply flare the gas produced. (This is common with projects that produce gas in very small quantities that are not worth collecting for use as fuel; the flaring produces CO<sub>2</sub>, but the greenhouse gas effect of the CO<sub>2</sub> is far less than that of the methane). The category includes gas from landfill, coal mines and agricultural sources, fugitive gas (mainly from flaring of associated gas from oil production), together with combustion of biomass and geothermal energy.
- Destruction of HFC, PFC and N<sub>2</sub>O.

- Other – the largest category of projects included here is aimed at optimizing the process of cement production to reduce the quantity of CO<sub>2</sub> emitted.

### 3: Literature review and critique

Recent literature identifies a number of issues that contribute to the complexity of the CDM scheme and may reduce the value of its outcomes. Particular criticisms have been made of the rules for determining baselines and additionality, of the nature of sustainability benefits that are intended to attach to the projects, of the problems created by inadequate institutional capacity in many developing countries, the level of transaction costs involved in setting up a CDM project and of some aspects of the scheme's administration. Researchers have suggested various reforms to the CDM program, though it is worth bearing in mind that it is arguably better to lower the cost of emissions reductions by encouraging participation by developing countries in the CDM program, than it is to devise ever more complex rules for project approval, particularly in view of the nascent institutions and governance systems in many of these countries (Fischer C. 2005). The main issues in this literature are summarized below.

The baseline is the key element in calculating the level of emission reductions that should be credited to a project. It is an estimate of what emissions would have occurred if the CDM project did not exist. Where a CDM project produces a valuable output<sup>10</sup>, this means defining how that output would have been produced in the absence of the CDM – i.e. it means defining the baseline project. If we underestimate the emissions of the baseline project then the CDM project generates fewer credits than it should but overall emissions are reduced; however if we overestimate baseline emissions, emissions overall will be higher with the CDM program than without. Either way global welfare could be lowered. If the baseline is determined correctly, overall emissions of GHGs do not change from the pre-CDM situation but the reductions are shifted from a developed to a developing country or from a higher marginal abatement cost emitter to a lower MAC emitter. This reduces the overall cost of GHG reduction and increases global welfare. (Fischer C. 2005)

In the initial phase of the CDM program baseline definitions were so flexible that there were concerns about the program adding to GHG emissions rather than reducing them.(Fischer C. 2005) These concerns were partly addressed by the UNFCCC Marrakesh agreement (UNFCCC 2001), which initiated a process of agreeing to standardized methodologies for project review – for example, projects in our sample should use the *consolidated baseline methodology for grid-connected electricity generation from renewable sources* ((UNFCCC 2009). However, the CDM covers such a wide range of projects that a very large number of methodologies would be needed to cover them all. The early criticism of excessive flexibility is still valid in some instances.

**Additionality** “has probably been the most contentious point in the development of the CDM and also resulted in great confusion amongst project developers”.(Wara M. and Victor D. 2008) There are three generic approaches to proving additionality: investment analysis, barrier analysis and common practice – in addition, certain types of projects are simply assumed to be additional (destruction of HFC/PFC/N<sub>2</sub>O).

- **Investment analysis** demonstrates that the proposed project is financially less attractive than at least one credible alternative or fails to meet a standard commercial benchmark. Project developers are permitted some degree of latitude in deciding how to do this, even under the new standardized methodologies. However, where a method is well defined, it can still be subject to distortions due to information asymmetry: project details and input prices are better understood by firms than by those charged with

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<sup>10</sup> Not all CDM projects do. For example, for a HFC-23 destruction project, the baseline is no project at all – the gases would simply be released into the atmosphere.

verification (Fischer C. 2005). Additionally, the sensitivity of the investment analysis to changes in key parameters of the project is typically weak (Schneider L. 2007).

- **Barrier analysis** demonstrates that the proposed project faces barriers that prevent it from taking place without CDM financing and these barriers do not affect at least one alternative. Schneider points out that the barrier analysis is typically weak and subjective, with limited data provided in the project design document to confirm the problems identified. Sometimes projects may simply establish that they are the first of a kind or claim that the prevailing price for the product or inputs they use is a barrier. Most small scale projects are approved using a barrier test.(Schneider L. 2007)
- **Common practice** demonstrates that the proposed project uses a technology (or other critical dimension of the project) which is not a common practice in the relevant sector or region. A number of projects in the pool considered by Schneider claimed common practice barriers—for example, small hydro and wind power projects claimed that their technology accounts for only a small percentage of overall electricity generation.<sup>11</sup> There is no clear definition of what constitutes common practice in the UNFCCC's methodology. This lack of clarity often leads to defining the control group of prevailing practice very broadly and the technology under consideration very narrowly.(Schneider L. 2007)

If one considers the CDM over the whole of its existence, these criticisms are valid. However our review of CDM projects found a more hopeful picture. Of the 141 Chinese projects in our sample (of which six were excluded from the analysis as we could not calculate the project MAC with the data given), only three (2%) did not use investment analysis at all (it is quite common to use investment analysis supported by some other methodology). As regards calculations of additionality, the picture we found is more complex because of the distorting effect of high energy prices, particularly in 2008. This potentially important issue is not mentioned in any prior research that we found. For a full discussion of our results, see section 6.

Additionally, Schneider makes several useful suggestions for changes in UNFCCC policies regarding barrier and common practice analysis. These include: clarification of instructions on what constitutes acceptable types of barrier analyses (those that are not attributable to the host country's domestic policies); requiring a time-based phasing out or reform in the relevant areas of domestic policy-based barriers as a condition for receiving CDM credits and; identifying threshold levels of penetration of technologies for determination of whether the technology is common practice or not.

While **sustainable development** is a stated goal of the CDM program, the UNFCCC does not require any evaluation of this dimension of the project during the project approval process. The Marrakesh Accord left it to the host countries to define their own sustainable development requirements and vet their CDM projects by these criteria before proposing it to UNFCCC. This has created a bias in favor of low cost, end-of-pipe technology projects such as HFC-23 destruction, as mentioned earlier (Resnier M. et al. 2007; Schneider L. 2007) among other researchers). Various ways to encourage sustainability of CDM projects have been suggested in the literature such as rating of CER quality based on sustainability of the projects that generated the CERs (Schneider L. 2007; Nussbaumer P. 2009) or mandating a quota of CERs from projects with higher sustainability rating in the portfolio of such credits held by an Annex 1 country. Finally, some researchers

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<sup>11</sup> Schneider, amongst his other criticisms of barrier analysis, points out that in a diverse power sector, this can easily apply to all power generation technologies.

suggest taxation of CER revenues, with higher taxes on less sustainable projects for enhancing the sustainability of CDM projects.(Resnier M. et al. 2007)

On the administrative side of the program, initially it was feared that projects would be burdened with high **transaction costs**, particularly smaller scale projects. However the magnitudes of average overhead costs associated with the projects approved even in the early phases appear to be reasonable, though there are likely to be variations across countries and by project size.(Michaelowa A. and Jotzo F. 2005). A more serious problem is one of **conflict of interest** arising in various stages of the projects—whether it is the selection and payment of the DOE (responsible for validating and verifying the emission reduction from CDM projects) by the project participants (Schneider L. 2007)<sup>12</sup> or ownership of CDM projects and possibly competing projects in the same industry by the governments that are responsible for the monitoring and enforcement of host country regulation (particularly important in this context is environmental regulation and the regulation of market competition in the sector)(Williams J. and Kahrl F. 2008). In both cases there is serious risk of CDM program goals being undermined. More oversight by the UNFCCC Executive Board of DOE operations is clearly needed to eliminate these problems. In addition, the UNFCCC needs to invest in capacity building in Non-Annex 1 countries to ensure effective monitoring and enforcement of domestic regulations with direct and indirect relevance for the CDM projects.(World Bank 2006) Broadly, there is need to build the institutional, fiscal and managerial capacity of host country participants.

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<sup>12</sup> The UNFCCC Executive Board suspended the accreditation of the largest DOE (DNV, of Norway, which has a share of almost 50% of the DOE market) for reasons that amount to no more than bureaucratic oversights, but could be indicative of work completed hurriedly and under pressure. See Annex 2 of UNFCCC (2008a). Report of the 44th meeting of the Executive Board of the Clean Development Mechanism.

#### 4: Energy policy in China and India – complementarities and conflicts with the CDM

China and India both have rapidly evolving economies that are growing at an unprecedented rate, which brings about a rapidly increasing requirement for energy. With domestic energy sources being actively consumed, imports have increased and also the importance and need for adopting renewable energy sources. In both countries, the principal fuel for electricity generation is coal, followed by hydro electricity; other forms of renewable energy sources are in relatively smaller proportion in the energy mix (See Table 4.1 below)..

**Table 4.1: Electricity Generation in 2006**

	India		China	
	TWh	%	TWh	%
Coal	508,362	68.3	2,301,402	80.4
Oil	31,475	4.2	51,469	1.8
Gas	62,092	8.3	14,217	0.5
Nuclear	18,607	2.5	54,843	1.9
Hydro	113,599	15.3	435,786	15.2
Wind	7,994	1.1	3,868	0.1
Other Renewable	1,949	0.3	2,619	0.1
Total	744,078	100.0	2,864,204	100.0

Source: IEA Energy Statistics (<http://www.iea.org>)

Since the 1980s both countries have liberalized their power sectors, opening them to private capital and ownership while maintaining some significant regulatory controls in government hands. Both countries have set ambitious targets for development of renewable energy in their national five year plans (see Tables 4.2 and 4.3). Government control of prices has been an issue in both countries, working sometimes to the disadvantage of renewable sources, but both countries are also offsetting these disincentives with active support and subsidies for renewable energy technologies.<sup>13</sup> There are issues with the efficiency levels of India's coal plants that could yield significant increases in energy supply without augmenting the use of coal. In China, recently built plants are highly efficient but there are many small and inefficient plants still operating.

**Table 4.2: China: NRDC targets for renewable energy in 2020<sup>14</sup>**

Fuel type	2006 capacity <sup>15</sup>		2020 target	
	GW	%	GW	%
Natural gas	8	5.4	60	13.0
Hydro	128.57	87.3	300	65.0
Wind	1.87	1.3	30	6.5
Solar	0.06	Neg	1.8	0.4
Nuclear	6.85	4.6	40	8.7
Biomass	2	1.4	30	6.5
Total	147.35	100.0	461.8	100.1

Source: various – table is taken from (Williams J. and Kahrl F. 2008)

<sup>13</sup> Despite these recent measures, developers still cite barriers to investment as the key argument for inclusion of (for example) small hydro projects in the CDM. This is particularly surprising because our analysis indicates that many small hydro projects should be profitable. We discuss this paradox briefly in our conclusions.

<sup>14</sup> These targets apparently include small generation units not connected to the grid.

<sup>15</sup> The figures for natural gas, solar and biomass are for 2004.

**Table 4.3: India: Renewable Energy targets in the 11th Plan**

Fuel type	2006 capacity		2012 target	
	MW	%	MW	%
Small Hydro (up to 25 MW)	1,850	20.6	3,250	14.1
Wind	6,070	67.5	16,570	72.1
Biomass <sup>16</sup>	1,073	11.9	3,173	13.8
Total	8,993	100.0	22,993	100.0

Source: (Ministry of New and Renewable Energy 2006)

## 5: Methodology

### Data and sampling

As of mid-May 2009 the UNFCCC database listed 1,596 CDM projects that had achieved registration. Of these, 507 are grid-connected power generation projects in India or China in one of our focus categories: wind, small hydro or commercial scale natural gas. In this paper we report results for the Chinese projects in our focus categories.<sup>17</sup> There are 380 such projects in the UNFCCC database – our data is a sample of 141 of these projects. Six projects in our sample could not be used in the analysis as the Project Design Document posted on the UNFCCC website did not provide sufficient data to calculate a marginal abatement cost (MAC). The “inadequate data” group did not display any obvious bias towards any category of project. Our final usable sample contained 135 projects (note that, due to the small number of gas projects actually registered, our sample includes some projects that are in the late stages of the registration process).

**Table 5.1: Details of Sample**

Project Type	Registered	Sample
Commercial scale gas	12	17
Wind farms	120	42
Hydro	248	76
TOTAL	380	135

Source: UNEP Risoe and authors

Our selection of projects was non-random in that we ensured that the full range of project sizes (in terms of generation capacity) was represented in our sample: we also ensured that we obtained a spread of registration dates including early projects and those registered only recently.

### Method of calculation

We describe below the UNFCCC method of assessment of additionality and our modification of this method for the purpose of this research as well as our method of measuring the sustainability benefits. Please contact the authors if more detail is required, including information on sources of data.

<sup>16</sup> Classification includes biomass, cogen and waste to energy.

<sup>17</sup> We are not presenting our results for Indian projects because we are not yet happy with the quality of the data we have for the baseline coal-fired plant in that country – we are working on improving this. Our results so far indicate that our conclusions for India are likely to be very similar to those for China.

**Definition of baseline:** emissions from the project under assessment are compared to emissions in a counterfactual scenario known as the baseline - i.e. the source from which electricity would have been supplied in the absence of the project. The UNFCCC methodology for definition of the baseline (UNFCCC 2008b) is fairly flexible, however we see no reason for such flexibility in a country that is experiencing continuing growth in electricity demand and where the design of new power stations is fairly standardized. In this situation the marginal plant is a new coal fired plant using technology typical of new plant in the country concerned and located within the area served by the same regional electricity grid as the CDM project. We were able to obtain data on such plants for both China and India, including their levels of emissions of both CO<sub>2</sub> and other pollutants when burning local coal.

Our calculations differentiate between regions – i.e. we compare a CDM project that supplies electricity to (say) the North China regional grid to a baseline plant that supplies the same grid. The precise location of the baseline plant matters because the cost of transporting coal to the plant is a significant part of overall generation cost. We made our own subjective assessments of the most likely locations of a new plant in each region. Many plants built with CDM subsidies are located in rural areas and both the Indian and Chinese governments have ambitious targets for rural electrification. We ignore transmission losses primarily because it would not be appropriate to burden these plants with the costs of sending their power to some distant industrial center, nor to burden the baseline coal-fired plant with the losses involved in supplying sparsely populated rural areas.

**Additionality:** the UNFCCC requires (for large projects) the use of investment analysis to determine that the proposed project is either: 1) not the most financially attractive, or 2) not economically feasible without the subsidy provided by the CDM. We reach the same end by a somewhat different route: we calculate the marginal abatement cost (MAC) of each project in our sample by first calculating its generation cost of electricity and the quantity of GHGs it emits (using data obtained from the PDDs posted on the UNFCCC website), then calculating the same parameters for the baseline plant. The MAC is the increased cost of the electricity generated by the CDM plant per ton of emissions reduced.<sup>18</sup>

$$MAC_p = \frac{C_p - C_b}{E_b - E_p}$$

Where: MAC<sub>p</sub> is the marginal abatement cost for project p;

C<sub>p</sub> is the generation cost per kWh for project p, and C<sub>b</sub> is the generation cost per kWh for the baseline;

E<sub>p</sub> is emissions for project p in tons of CO<sub>2</sub>e per kWh of electricity generated and E<sub>b</sub> is the same measure for the baseline plant.

Calculation of the MAC enables us to make a number of observations about the economic nature of the CDM project – not least, we observe that a project with a negative MAC is, other things being equal, not additional.

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<sup>18</sup> With one exception, leakage effects have been ignored (leakage, in UNFCCC parlance, means emissions of GHGs that are caused by the project or baseline, but occur elsewhere. An example would be emissions during the mining of coal). The analyses included in the PDDs indicate that net leakage effects are generally negligible. The only leakage that we take account of is emissions that occur in the liquefaction of natural gas, for NGCC plants that will use imported LNG.

**Rate of return:** under the investment analysis method for determining additionality, it is common to claim that a project is economically unattractive because it fails to pass some benchmark rate of return, or hurdle rate<sup>19</sup>. Typically, Chinese projects are compared to a project IRR (Internal Rate of Return) while Indian projects are compared to a ROE (Return on Equity) benchmark<sup>20</sup>. There is no theoretical reason why ROE should not be used, but we prefer IRR, which is more common in the private sector. The hurdle rate enters into our calculation as a required return on capital in the calculation of generation cost. For a normal commercial project we use the standard set by the Chinese government,<sup>21</sup> which is an 8% (in real terms) IRR - this is more or less in line with benchmarks used by major energy companies in the developed world. For wind and small hydro projects we adjust that rate to reflect the lower proportion of debt financing that is appropriate for a project that produces an intermittent revenue stream (this reflects some fairly subjective comments about project risk made by project developers and quoted on various websites). For these projects we use 8.7%, which allows for a move from (say) 70% debt financing to 50%. The adjustment method used and the figures adopted are in line with commercial practice. (Richard Brealey et al. 2006)

**Electricity price:** the economic viability of a power generation project is determined significantly by the price of electricity. This is typically set by some government body. Even if prices are market-determined, regional grid dispatching practices determine whether the producer actually gets to sell any power. In this situation there is a clear conflict of interest, particularly if the government wants to minimize electricity cost for political reasons, or where competing plants are owned by some arm of the government that does not act as an economically rational market participant. The same problem occurs when the price of an input – natural gas, or coal to the competing baseline plant – is not a market price. As we base our calculation on cost of generation rather than profitability of the plant, the electricity price is not relevant to our calculation. Our view is that what matters to the country is the overall cost of power. How revenues are divided between the project developer, the consumers and the government is up to the host country.

**Sustainability benefits:** although one of the key objectives of the CDM is to advance the cause of sustainable development, the UNFCCC does not define what this term means. This is not really surprising – sustainable development is hard to define and harder to quantify. However, where a country that would normally generate new electricity supplies from coal uses renewable or low carbon energy instead, the health of its population benefits because of the low or zero level of emissions of pollutants such as sulfur dioxide.

The electricity generating projects under consideration here would, at the margin, replace coal fired generation capacity based on conventional technology. The latter has significant negative externalities that are to a large extent avoided in the former. The externalities arise primarily due to three major air pollutants: Sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>) and particulate matter (PM) – in US parlance, all of these are criteria

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<sup>19</sup> The UNFCCC does not provide a standardized benchmark – our sample included an Indian project that was stated to be unattractive because its return on equity was below a target rate that seemed to us to be remarkably high – it was effectively the return on the Indian stock market over a short period during which Indian markets were in the midst of a bubble. The developer could plead lack of financial sophistication, but it is surprising that the DOE allowed this calculation through.

<sup>20</sup> We suspect that ROE is used by Indian firms because it is a component of the formula used by state regulatory bodies in India to set electricity tariffs.

<sup>21</sup> The PDD for CDM project No 1734 quotes the Chinese *Interim Rules on Economic Assessment of Electric Power Engineering Retrofit Projects* on this subject.

air pollutants. A simple approach to quantifying the value of this negative externality avoided by a renewable energy project is to calculate (Resnier M. et al. 2007):

$$Ext_i = \sum_p Em_{pi} * Dc_p$$

Where,  $(Ext_i)$  is the dollar amount of external damage avoided per kilowatt hour of electricity generated by project  $i$ ;  $(Em_{pi})$  is the level of emissions of each pollutant  $p$  avoided per kilowatt hour of electricity generated by project  $i$  - this can be calculated from the technical characteristics of the plant concerned - and  $(Dc_p)$  is the damage cost per unit of emission of pollutant  $p$ .

Our estimates of  $Dc_p$  - the damage cost per ton of pollutant - are based on (Meier P. 2003). They utilize the willingness to pay method which is commonly used in the developed world, though at the time that Meier was writing, no willingness to pay study had been conducted in China. Meier's damage costs for Chinese provinces were calculated by the Hong Kong based Political and Economic Risk Consultancy (PERC), based on willingness to pay data published in *Economic Evaluation of Environmental Impacts – a Workbook* (Asian Development Bank 1996). The estimates are ultimately based on a willingness to pay study conducted in New York State - PERC adjusted the data using per-capita GDP figures for New York State and for each Chinese province.

The ADB methodology provides estimates for the cost of damage to human health due to emissions of Sulfur Dioxide, Nitrogen Oxides and particulates, on the local, regional and distant scales, by emissions from a stationary source. PERC considered local, regional and distant population densities relative to typical locations in each Chinese province (taking account of the prevailing wind direction). Obviously this process involved some heroic assumptions – Meier indicated that the margin of error might be  $\pm 100\%$ . We have readjusted the same data using the most recent figures for Chinese GDP per capita and total population. It hardly needs to be said that the margin for error around our figures is extremely wide.

## 6: Results

We calculated the marginal abatement cost (MAC) for each project in our sample – the results for the 135 Chinese projects are shown in table 6.1 below. As noted above, we have not shown results for Indian projects as we do not yet have sufficient confidence in our data. However, based on our work so far, the messages to be drawn from consideration of the Indian projects are about the same as for China.

**Table 6.1: MAC by year and project type**

€/tCO <sub>2</sub>		Mean	Standard Deviation	Range
<b>Wind farms</b>	2007 (9 projects)	<b>18.5</b>	7.6	8.8 – 30.8
	2008 (33 projects)	<b>13.8</b>	11.5	(14.3) – 41.0
<b>Hydro</b>	2006 (2 projects)	<b>(0.4)</b>	N/A	(10.0) – 9.2
	2007 (12 projects)	<b>(10.3)</b>	11.1	(22.7) – 9.5
	2008 (60 projects)	<b>(31.1)</b>	10.7	(44.9) – (13.6)
	2009 (2 projects)	<b>(10.4)</b>	N/A	(5.0) – (15.9)
<b>Natural Gas</b>	2007 (9 projects)	<b>9.4</b>	11.9	1.2 – 35.9
	2008 (6 projects)	<b>(21.4)</b>	16.0	(33.2) – 10.6

### Comments on results:

- The difference between project MACs by year is very marked. It arises because the price of coal is a key influence on the generation cost of the baseline plant, and all energy prices followed a rising trend during 2006-2008, peaked in the latter year then declined.<sup>22</sup> Neither wind nor hydro was directly affected by this trend, however the MACs for these technologies were affected by the generation cost increases for their baseline coal-fired plant. For the gas-fired plants in our sample we took the gas prices from the Project Design Documents (PDDs) available on the UNFCCC website. Our calculations, and the dates in the above table, relate to the year that the project sponsors applied for registration - we assume that their data was current at the time of application. Given the volatility of energy prices we prefer to use data for one year rather than attempting to forecast Chinese domestic coal and gas prices over the thirty years or so that a new plant would operate. This approach creates problems in interpreting results, but the alternative of using deterministic long term energy price forecasts simply pretends that those problems do not exist.
- Our conclusion for wind farms is clear: for all the years we examined, the mean MAC for wind farms in China was positive but less than the average value of CER revenue to the project. There is a wide spread of results, but we can conclude that wind farms in China are additional; they are economically rational in that they are likely to be profitable over the long term when the CER revenue is taken into account; and their MACs are probably lower than the MACs facing power generation companies in developed countries. MACs for Chinese wind farms are higher than those for small hydro projects because of their higher

<sup>22</sup> As we have official Chinese data for prices actually paid by power stations only through 2006, for the later years we have estimated prices based on published data on spot price trends.

construction cost per kilowatt and because, in the Chinese context, they have a lower overall load factor (i.e. they are actually producing power for fewer hours per year).

- Even for the earlier years the MAC of many small hydro projects was below zero, indicating that the generation cost of electricity from these projects is lower than the generation cost of a new coal fired thermal power station in the same grid region. On the face of it, this indicates that these projects are not additional and should not be eligible for the CDM. In support of this view, we note that small hydro projects have historically accounted for a significant share of Chinese power generation. According to (Yi-Chong Xu 2002), the number of small hydro stations in China rose from 26,000 in 1970 to 90,000 in 1979 - clearly the Chinese government thought these stations were worth building even without the CDM subsidy. Our tentative conclusion is that many small hydro stations in China are not additional. This is not necessarily the case in India, where some project developers allege that complex bureaucracy and multiple licensing requirements constitute barriers to this type of investment that justify the inclusion of these projects in the CDM.<sup>23</sup> It may also be relevant that the construction cost per KW of small hydro stations in India is significantly higher than in China, possibly due to more difficult terrain or to a learning curve effect due to greater Chinese familiarity with the technology. More research is needed on this issue.
- For natural gas plants we are surprised by the sharp decline in MAC from 2007 to 2008. This may be due to the effect of the gas price. We have no information on Chinese domestic gas price formulae but we suspect that prices do not follow short term fluctuations in the international energy markets. LNG contract prices are typically linked to some basket of crude oil prices; the details of the price formulae are invariably commercially confidential, but we know that it is common for the price to be capped at some level that is only revised every few years: it may be that LNG prices paid by China did not reflect the 2008 price peak. It is also possible that our assumption that the gas price quoted in the PDD is valid for the year of application for registration is not correct. Our best explanation for the sharp fall in MAC in 2008 is that it reflects a sharp increase in the coal price paid by the baseline plant that was not accompanied by a similar increase in the gas price. The effect was exaggerated by the relatively low capital cost per unit of output of these plants. If we assume that the fall in MAC was due to out of phase movements in coal and gas prices, but in the long term prices of internationally traded forms of energy are closely correlated, we can tentatively conclude that NGCC projects in China are indeed additional (but only just so).
- Since April 2005 the market price of EUAs quoted on the European Climate Exchange (ECX) has ranged between €32.9 and €8.2, with a mean of €20.5 and a standard deviation of €4.4 (futures price for December 2009 settlement). All categories of CDM project analyzed here have mean MACs below the mean EUA price, though a significant number of projects (15 out of a total of 135 projects, or 11%) were above. This reinforces the key assumption underlying the CDM that MACs in developing countries are typically lower than in the developed world, assuming that the market price of EUAs is a reasonable proxy for MACs faced by European emitters of GHGs.

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<sup>23</sup> For example, the Managing Director of an Indian power company speaking at a conference on project risk management – see [http://www.re-indiafinance.org/summary\\_risks\\_hydro.htm](http://www.re-indiafinance.org/summary_risks_hydro.htm). We do not say that the government is to blame for all the problems encountered by small hydro projects in India: a report based on field research by TERI (The Energy and Resources Institute) mentions the bureaucracy problem but also lists a number of technical deficiencies on the part of the project developers themselves.

## *The effect of incorporating health benefits*

The benefit to the host country of cutting emissions of SO<sub>2</sub>, particulates and other pollutants that are known to be damaging to health is not a factor in the additionality calculation required by the UNFCCC and therefore not included in the MAC on table 6.1. However, the decision to propose a project for inclusion in the CDM rests with the host government, which would certainly consider the extent to which the project assists in meeting its policy objectives. In both India and China, the governments have stated their intention to reduce these emissions.

We believe that the government's key decision variable in deciding whether to support a CDM project is the net of MAC (the higher cost of electricity) and the value of the ancillary benefits of the project. We call this the adjusted MAC. If the adjusted MAC is less than the expected value to the country of the CER revenue stream from the project, then the project is economically beneficial to the host country<sup>24</sup>. We have estimated the monetary value of health benefits from these projects due to the reduction of coal consumption (see section 5 above), but this is one element only of this ancillary benefit to the host country - the estimates of adjusted MAC shown in the table below should therefore be seen as upper bounds to the true values. Other project benefits that clearly contribute to sustainable development but are hard to quantify include lower water consumption (particularly important in Northern China), enhanced opportunities for rural employment, the advancement of rural electrification and (for large gas-fired plants) more flexibility in adjusting power supply to the grid to actual demand.

Our results suggest that CDM projects in the grid connected generation category bring significant ancillary benefits to the host countries. The figures in table 6.2 below relate to 2007 as we feel that they are probably less distorted by energy price volatility than 2008 figures. It is worth pointing out that the calculations on which these adjusted MACs are based are specific to the region in which a project is located. Many wind farms and most gas-fired power stations are located in heavily populated coastal regions, while most hydro projects are in the more sparsely populated provinces such as Yunnan – we believe that the lower monetary value of health benefits from hydro projects is accounted for by the smaller number of people in the regions concerned.

**Table 6.2: MAC adjusted for health benefits of CDM projects (2007 data)**

€/tCO <sub>2</sub> e	Mean MAC	Mean Benefit	Benefit as % of MAC	Adjusted MAC
Wind	<b>18.6</b>	6.5	35%	12.1
Hydro	<b>(10.7)</b>	3.7	N/A	(14.4)
Natural Gas	<b>10.1</b>	6.1	60%	4.0

## *7: Conclusions and directions for future research*

In this paper we set out to evaluate the performance of the CDM program and to consider how to approach the design of a market-based or hybrid scheme that might meet the specification laid out by the Council on Foreign Relations as a “more robust” version of the CDM that focuses on “high-payoff areas”. In fact, we did not attempt to assess the performance of the CDM as a whole because our review of previous research

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<sup>24</sup> Strictly speaking, we can only say that it is economically beneficial. The division of the costs and benefits between the host country and other parties involved is presumably negotiated between them.

convinced us that this would not be helpful. The very broad range of projects that must be accommodated within the rules of the CDM, and the dominance of HFC reduction schemes in its early days lead inevitably to negative conclusions in any assessment of the CDM as a whole. We chose to focus on grid-connected electricity schemes in India and China. Our analysis of this very important sector led us to conclude that:

1. Wind farms and gas-fired thermal power stations generally meet the UNFCCC criteria for additionality. We tentatively concluded that small hydroelectric projects in China do not meet these criteria, which means that inclusion of these projects in the CDM leads to a net increase in global emissions of GHGs.
2. The majority of projects are economically rational in that they are profitable if the value of their CER revenue stream is taken into account. It also means, if we can assume that the CER price (or the EUA price) is a proxy measure for the MAC faced by power generation firms in the developed world, that the CDM does cut the global cost of emission reductions.
3. The public health benefits of cutting emissions of criteria pollutants such as SO<sub>2</sub> and particulates can be quantified and are significant. Many individual projects that do not seem to be rational based on the expected value of the CER revenue stream are likely to be economically justifiable if the value of these sustainability benefits is taken into account (particularly because there are other likely sources of benefits that we have not attempted to quantify).
4. Several of the researchers quoted in section 3 of this paper criticized the “quality” of GHG abatement achieved by CDM projects. This criticism is not valid for the projects we assessed: in fact, we believe that concern about the quality of GHG abatement is almost synonymous with concern about HFC/PFC/N<sub>2</sub>O projects in the CDM.<sup>25</sup>

It is not our intention in this paper to make detailed policy proposals, but in general we find the framework proposed by the Council on Foreign Relations (CFR) convincing. The CFR wants the US to focus on big countries, big projects and key technologies, and to work to modify the incentives faced by these countries. (Council on Foreign Relations 2008) The electricity generation sector is of vital importance to the development goals of countries such as China and India. There is surely scope in this sector for reaching an agreement that underpins the development goals of these countries by ensuring adequate supplies of electricity at the lowest possible cost while maximizing the use of zero or low carbon generation technologies.

In our view, the goal set by the CFR of working to modify the incentives faced by key developing countries would be advanced by a separate offset scheme for large scale power generation projects. Our research suggests a number of issues to be addressed in the detailed design of such a scheme, most of which would require further research and clarification:

- The minimum size of project eligible for the scheme: in principle there should be no maximum. The value of setting a minimum size is that more resources can be devoted to a thorough assessment of each project without adding disproportionately to the project cost.
- The permitted technologies: should large hydro schemes and nuclear power plants be included? If so, what safeguards are required?

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<sup>25</sup> There are also serious and justifiable concerns about forestry projects.

- Treatment of carbon capture and storage; should the new scheme be linked to a development aid fund that could provide subsidies for design features to ensure that new power stations can be modified at low cost when this technology is proved to be economically viable?
- Many coal-fired generation plants in both India and China are too old and too small to be efficient. Can a scheme be designed to include the (verifiable and permanent) closure of these plants?

Governance and the effectiveness of institutions are important considerations in the design of any such scheme. Research is needed on the nature of barriers to investment and whether these are, in part, created by domestic policies. Thought should be given to capacity building and the transfer of monitoring and related technologies. Beneficiary countries should aim for consistent monitoring of emissions (with the results to be made freely available), and should ensure compulsory fitting of antipollution measures such as flue gas desulfurization (with effective measures to ensure it is used). It is necessary to bear in mind that some of these proposals will have real constitutional implications – for example, the split of responsibilities and distribution of incentives between the central and regional governments in China. As regards project evaluation, a standardized version of our approach to the assessment of additionality based on generation cost differentials seems appropriate for large electricity generation projects, but some thought should be given to minimizing the distorting effects of short term energy price volatility.

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