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# Kyoto Flexibility Mechanisms

*Clean Development Mechanism and  
Joint Implementation*

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# Kyoto Flexibility Mechanisms: Clean Development Mechanism and Joint Implementation

Juha Siikamäki, Jeffrey Ferris, and Clayton Munnings \*

## I. Overview

The international agreements that attempt to control greenhouse gas (GHG) emissions are hierarchically structured (Wara 2006). The highest-level agreement—the U.N. Framework Convention on Climate Change (UNFCCC, or Convention)—adopts a goal of stabilizing “greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system” (United Nations 1992, 4). All major emitters and most other countries have ratified the UNFCCC. However, the Convention does not contain provisions that compel countries to take action. Rather, it lays out a process for negotiating protocols that might contain such provisions (Wara 2006). The first of these protocols was negotiated in Kyoto in 1997 (Wara 2006).

The Kyoto Protocol (KP) requires Annex B countries<sup>1</sup> to reduce their aggregate GHG emissions by 4.2 percent on average for the period 2008-2012 relative to emissions in the base year, which in most cases is 1990 (Olivier et al. 2011). The target for the KP can be reached by reducing six GHGs—carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride—in any

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This backgrounder is one in a series prepared for the project “Planning for the Ex Post Analysis of U.S. Climate Policy” to inform discussions and assessments of U.S. climate policy. The backgrounders summarize research on the following topics: (i) competitiveness impacts of climate policy; (ii) climate policy, international trade, and emissions leakage; (iii) Kyoto flexibility mechanisms: the Clean Development Mechanism and joint implementation; (iv) land use, land-use change, and forestry; (v) EU Emissions Trading System, and (vi) the U.S. Environmental Protection Agency’s Acid Rain Program. Taken together, these backgrounders summarize research on several key aspects of climate policy. In addition to helping inform discussions and assessments of climate policy, the backgrounders are intended to provide informative overviews of each topic to anybody interested in conducting or better understanding climate policy assessment, including researchers, students, and experts in academia, government, nongovernmental organizations, and industry. Funding for this project has been provided by the Alfred P. Sloan Foundation. The authors thank Ray Kopp for comments and suggestions on this backgrounder.

<sup>1</sup> Annex B countries include industrialized countries and countries in transition, with the exception of countries that neglected to ratify the UNFCCC—namely, Turkey—and countries that did not ratify the KP (the United States).

combination (UNFCCC 1998).<sup>2</sup> In addition, the KP allows participating countries to meet their targets through the use of three flexibility mechanisms: (a) purchasing assigned amount units (AAUs)—that is, emissions allowances under the KP—from other countries participating in the KP; (b) contributing to emissions-reducing projects in other Kyoto-participating countries and acquiring emissions reduction units (ERUs) through Joint Implementation (JI); and (c) contributing to emissions-reducing projects in countries not participating in the KP and acquiring certified emissions reductions (CERs) from the Clean Development Mechanism (CDM) (Lecocq and Ambrosi 2007).

This backgrounder focuses on the CDM and JI mechanisms, which provide the flexibility to purchase carbon offsets. Section II provides background on the CDM and JI mechanisms. Section III describes the data available for the CDM and JI. Section IV describes current research on the CDM and JI and Section V provides tables summarizing this research. Section VI concludes and Section VII is a list of references.

## II. Introduction

The E.U. Emissions Trading System (E.U. ETS) accepts only those carbon offsets that result in CERs and ERUs (Lecocq and Ambrosi 2007). Although any Kyoto-participating country or emitter can purchase CERs and ERUs, demand is largely determined by emitters regulated by the E.U. ETS (Lecocq and Ambrosi 2007).<sup>3</sup>

### ***A. The Clean Development Mechanism***

The CDM has two purposes. First, it aims to help Kyoto-participating countries reach their commitments by providing the flexibility to purchase relatively inexpensive carbon offsets. Generally speaking, investing in emissions reductions in developing countries is less expensive than reducing emissions in developed countries. Second, the CDM aims to aid countries not participating in Kyoto develop sustainably through technology transfer and development.

CDM projects encompass a wide variety of development activities that reduce emissions, including the capture and incineration of HFC-23 gas; capture and destruction of CH<sub>4</sub> from

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<sup>2</sup> All reductions are converted to CO<sub>2</sub>-equivalents based on their global warming potential relative to CO<sub>2</sub>. For example, HFC-23 has a global warming potential of 11,700. Therefore, reducing 1 ton of HFC-23 emissions is equivalent to reducing 11,700 tons of CO<sub>2</sub> emissions.

<sup>3</sup> In 2005, for example, the E.U. ETS accounted for 75 percent of the value of the CDM market (Lecocq and Ambrosi 2007).

landfills, livestock, oil fields, coal mines, and wastewater; reduction of N<sub>2</sub>O emissions from the creation of adipic acid; increased use of biomass; installation of wind and hydrological power projects; and energy efficiency (Wara 2006). As of 2012, the CDM executive board (EB) had registered 1,651 CDM projects in 91 countries and issued 973 million CERs. Although wind (28 percent of projects) and hydro (26 percent of projects) are most popular, they produced only 20 percent of issued CERs. In contrast, most CERs (65 percent) result from a small number (0.3 percent of all projects) of HFC-23 projects. China dominates the supply of CERs.<sup>4</sup>

Negotiations leading to the KP outlined processes and restrictions for CDM projects, which were intended to ensure the environmental integrity of the CDM. First, negotiators decided that additionality—whether the project and emissions reductions would have occurred without the CDM—would be determined on a project-by-project basis. Second, negotiators tasked the CDM EB to very conservatively assess the validation of each CDM project. Third, the E.U. ETS disallowed CDM projects involving nuclear power or avoided deforestation (Lecocq and Ambrosi 2007).

To earn CERs, each potential CDM project goes through a process that reflects the two purposes of the CDM. First, the project proponent creates a project description, known as a project design document (PDD). Among other things, the PDD compares the baseline and expected emissions projections to estimate the quantity of additional emissions reductions—reductions that would not have occurred if not for the extra carbon offsets revenue—that the project will create. The PDD also includes estimates of emissions leakage from the project. This consideration of additionality and leakage helps guarantee that CERs are as environmentally credible as E.U. emissions allowances. Next, the buyer(s) and seller must each get a letter of approval (LoA) from their respective governments stating that the country approves participation in the project; the host country must also approve that the project contributes to domestic sustainable development (Lecocq and Ambrosi 2007). Then, a third-party accredited by the CDM EB—known as the designated operational entity (DOE)—validates the PDD and LoA (Lecocq and Ambrosi 2007). The DOE then submits the validation report to the CDM EB for registration. Finally, a second DOE is tasked with reviewing and certifying emissions reductions from the project (Lecocq and Ambrosi 2007). The CDM EB issues and transfers CERs to the

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<sup>4</sup> United Nations Environment Program Risoe Center, CDM/JI Pipeline Analysis and Database: <http://cdmpipeline.org/>.

project participants' accounts via the International Transaction Log.<sup>5</sup> Each CER is equivalent to an AAU or ERU—representing a 1-metric-ton reduction or sequestration of CO<sub>2</sub>-equivalent emissions—and can be used to comply with the E.U. ETS and/or the KP.

### ***B. The Joint Implementation Mechanism***

The process for creating ERUs is roughly analogous to that of creating CERs; the main difference is that ERUs take place in countries participating in the KP. In addition, unlike the CDM, the JI allows offsets from the forestry sector. Because ERUs originate from more developed countries—relative to countries hosting CDM projects—opportunities for cheap emissions reductions are comparatively limited. Consequently, the purchase of ERUs occurs less often than that of CERs. In 2012, for example, 586 projects have been registered and 174 million ERUs have been issued.<sup>6</sup>

## **III. Available Data**

Researchers interested in the CDM and JI primarily rely on three sources of data: the UNFCCC's CDM Project Cycle Search database, the UNFCCC's JI Project Overview database, and the U.N. Environment Programme (UNEP) Risoe Center's (URC) CDM/JI Pipeline database. Whereas the two databases maintained by UNFCCC provide detailed project-level information, the URC database provides excellent summary-level information on the CDM and JI.

### ***A. United Framework Convention on Climate Change Clean Development Mechanism Databases***

The UNFCCC maintains an online, queryable database—called the Project Cycle Search—of all CDM projects, including approved, registered, rejected, and withdrawn projects.<sup>7</sup> Each project's PDD is available, meaning that researchers can access detailed documentation on the methodologies used to determine project additionality and to estimate emissions leakage resulting from the project. A complete list of available data follows:

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<sup>5</sup> United Nations Framework Convention on Climate Change, International Transaction Log: [http://unfccc.int/kyoto\\_protocol/registry\\_systems/itl/items/4065.php](http://unfccc.int/kyoto_protocol/registry_systems/itl/items/4065.php)

<sup>6</sup> United Nations Environment Program Risoe Center, CDM/JI Pipeline Analysis and Database: <http://cdmpipeline.org/>.

<sup>7</sup> United Nations Framework Convention on Climate Change, Project Search: <https://cdm.unfccc.int/Projects/projsearch.html>.

- project title
- project type
- PDD
- monitoring plans, validated monitoring plans and LoA from each proponent's government
- sectoral scope: describes the industry within which the project takes place
- activity scale: qualification of the scope of the CDM project (e.g., small, medium, or large)
- methodologies used: methodology used by the DOE in determining the amount of CERs for which the program is eligible
- number of reductions: total number of CERs for which the program is eligible, typically denoted on a yearly basis
- fee level: application fee
- host party: country of project origin, authorized participants, and other host parties, including those involved in the approval process
- other parties: sponsoring nations (i.e., credit buyers)
- validation report: complete documentation of the approval process, registration, and other publically available information
- registration date: date the project is registered by the CDM EB
- crediting period: the period over which credits are granted
- requests for issuance and related documentation: includes updated monitoring reports
- bilateral and multilateral funds: other involved financial banking institutions

### ***B. United Nations Framework Convention on Climate Change: Joint Implementation Databases***

The UNFCCC also maintains an online, queryable database—called the JI Project Overview—of all JI projects.<sup>8</sup> Much of the information available in this database is similar to that available in the CDM database. However, two methods are acceptable for JI approval: a project approved under “Track 1” meets all eligibility criteria, whereas, a project approved under “Track 2” does not meet all eligibility criteria and is subject to further review from a supervisory committee. UNFCCC collects different data for each track. Compared to Track 2, much more data are available for Track 1 projects. These data include the following:

- project title
- project type
- location: city, state (province), and country
- host party: project country
- other party: country of the entity buying the ERU
- sectoral scope(s): industrial sectors impacted by JI project
- LULUCF project: whether the project is classified as a land use, land-use change, and forestry (LULUCF) project
- total emissions reductions expected: total anticipated emissions reductions (per metric ton of CO<sub>2</sub>-equivalent)
- crediting period: period during which ERUs can be issued for the project
- project information provided by host party: PDD, LoAs, and approval and verification documents
- current status of the project: whether the project is operational
- total verified emissions reductions: reported in metric tons of CO<sub>2</sub>-equivalent
- additional information (as appropriate): any other supporting documents or information not included in the report

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<sup>8</sup> United Nations Environment Program Risoe Center, CDM/JI Pipeline Analysis and Database: <http://cdmpipeline.org/>.

### ***C. United Nations Environment Program Risoe Center: Clean Development Mechanism / Joint Implementation Pipeline Analysis and Database***

URC is a collaboration among the Ministry of Foreign Affairs of Denmark, Risoe National Laboratory for Sustainable Energy at the Technical University of Denmark, and UNEP. URC is an international research and advisory center that focuses on energy, environment, climate, and sustainable development in developing nations. URC publishes guidebooks and reports on the CDM and JI<sup>9</sup> and maintains an online database on CDM and JI projects.<sup>10</sup> Available data include the number of CDM and JI projects, country of origin and partner countries for CDM and JI projects, status of CDM and JI projects, number of issued CERs and ERUs, and information on buyers of ERUs and CERs. In addition, data are collected on the frequency at which DOEs are used.

### ***D. Limitations of Available Data***

Although substantial data are available for the CDM and JI, the lack of transaction-level data for CERs and ERUs—including contemporaneous information on the buyer, seller, and future and spot prices—constitutes a significant gap in publicly available data.<sup>11</sup> These data are available, for a price, through third-party exchanges like Thomson Reuters Point Carbon and Inter-Continental Exchange.<sup>12, 13</sup>

## **IV. Research**

Researchers predominately focus on the CDM, given that JI provides a comparatively small number of offsets. Regarding CDM research, a strong focus is on potential CDM projects in China and India. Researchers also focus on estimating transaction costs associated with both CDM and JI projects.

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<sup>9</sup> Capacity Development for the Clean Development Mechanism, CDM Guidebooks:  
<http://cd4cdm.org/Guidebooks.htm>.

<sup>10</sup> United Nations Environment Program Risoe Center, CDM/JI Pipeline Analysis and Database:  
<http://cdmpipeline.org/>.

<sup>11</sup> The E.U. ETS does have a queriable database for transactions here, but it is not possible to filter by CDM and JI credits. European Commission, European Union Transaction Log:  
<http://ec.europa.eu/environment/ets/transaction.do?languageCode=en>.

<sup>12</sup> Thomson Reuters Point Carbon, Carbon Market Research:  
<http://www.pointcarbon.com/research/promo/research/>.

<sup>13</sup> Inter-continental Exchange, Emissions:  
<https://www.theice.com/productguide/ProductGroupHierarchy.shtml?groupDetail=&group.groupId=19>.

## ***A. The Clean Development Mechanism***

Generally speaking, research on CDM has been divided into two camps: ex ante and ex post assessments of CDM potential at the country level. However, some economists have attempted to estimate the potential global market for CDM.

### **1. Ex Ante Estimates of Total Clean Development Mechanism Potential and Associated Carbon Quota Prices**

An earlier study—Jotzo and Michaelowa (2002)—provides ex ante estimates for many aspects of the CDM market, including offset price; number, type, and geographical distribution of CERs; and total CER revenue. To calculate their estimates, the authors use a recalibrated version of the Pelangi Emissions Trading (PET) model and the Massachusetts Institute of Technology's (MIT) Emissions Prediction and Policy Analysis (EPPA) model. Importantly, the authors consider only projects that reduce CO<sub>2</sub> emissions and, therefore, ignore two important, low-cost offset supplies: the capture and destruction of HFC-23 and N<sub>2</sub>O. Because the authors do not consider these types of offsets, the estimates of offset prices in this study are probably higher than they would otherwise be.

In their central case, Jotzo and Michaelowa (2002) find an equilibrium CER price of \$3.78. At this price, the authors estimate that offset suppliers will sell 372 million tonnes of CO<sub>2</sub> per year and earn \$7 billion in revenue over the first commitment period of the KP, 2008–2012. Nearly half of this offset supply originates in China; India, the Middle East, and Africa each contribute roughly 10 percent to the total supply. Sensitivity analysis reveals that these estimates are most sensitive to assumptions regarding the portion of “hot-air” credits, which are allowances allocated in excess of a country's baseline emissions, injected into the market by economies in transition. A large portion of these credits competes against and strongly crowds out the supply of CERs. However, estimates are nearly as sensitive to assumptions regarding the business-as-usual (BAU) emissions of countries buying CERs.

Another early study (Chen 2003) uses a computational meta-model, the Carbon Emissions Reduction Trading (CERT) model, to produce ex ante estimates of carbon quota price and CDM potential. To do this, the CERT model first imputes BAU emissions projections from the EPPA model, the Center for International Climate and Environmental Research, the Royal Institute of International Affairs, and the Global Trade and Environment model (from the Global Trade Analysis Project database). In addition, both top-down and bottom-up marginal abatement

curves (MACs) are used.<sup>14</sup> Assuming U.S. participation, the author estimates a carbon price of \$3.69–\$26.95 and a supply of 113.6–613.1 MtC from the CDM. Using bottom-up MACs, the estimated carbon supply falls by nearly half (with a range of 102.8–362.9 MtC), whereas the maximum carbon quota price estimate nearly doubles, to a carbon price \$50.10. As in Jotzo and Michaelowa (2003), two variables predominantly account for the large range of estimates by Chen (2003): BAU emissions projections and the assumed quantity of available hot-air credits. Each model within CERT contains a significantly different assumption and/or estimate regarding these two variables. All else being equal, higher BAU emissions and lower availability of hot-air credits leads to higher prices. Finally, the authors find that the assumed implementation rate—the rate at which projects successfully complete the CDM project cycle and create CERs—more significantly impacts estimates than do assumptions regarding transaction costs. Without U.S. participation, all models other than the EPPA model estimate a carbon price of less than \$10 and a supply of carbon offsets of 70–160 MtC.

## 2. Ex Ante, Country-Level Estimates of the Clean Development Mechanism

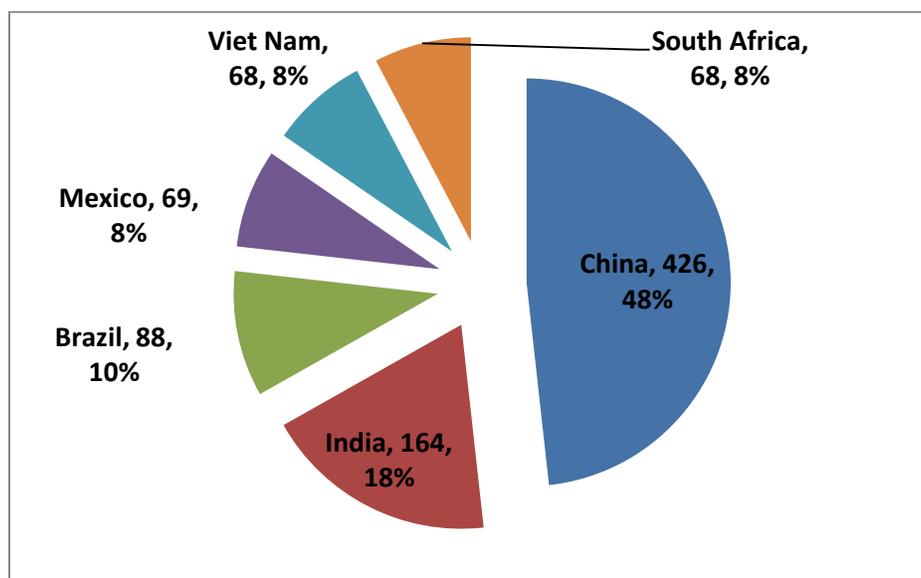
Researchers have estimated, at a country level, the price of supply of CERs for different projects. A country-level focus arguably allows for more accurate estimates. Because of the unequally distributed supply potential of CERs, researchers have focused on a narrow subset of countries. In a broad search of the ScienceDirect.com literature database, we conducted a general survey of the literature currently available on CDM at the country level.<sup>15</sup> Figure 1 represents a breakdown of the CDM literature by country. In this backgrounder, we focus on estimates of projects in China and India, as these countries are the most heavily researched.

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<sup>14</sup> The authors compare top-down and bottom-up MACs, the latter of which are project-level estimates of the cost of creating carbon offsets, to consider the argument that top-down MACs ignore constraints on energy substitution (among other things) and, therefore, overestimate abatement potential from CDM projects (Chen 2003).

<sup>15</sup> Studies that reference more than one country may be double counted, as search terms could not be excluded. Additionally, not all studies focused strictly on CDM, studies may be included which make reference to CDM, or make policy recommendations, but do not study CDM in detail.

Figure 1. ScienceDirect.com Literature Search for the Clean Development Mechanism



#### *Estimates for Clean Development Mechanism Potential in China*

Researchers have employed a variety of methodologies to study the CDM in China. Resnier et al. (2007) and Liu (2010) provide ex ante estimates of the benefits of CDM reform. Several studies estimate reduction potential and costs: Zhao and Michaelowa (2006) propose three unique CDM projects, and Kaneko et al. (2006) conduct a case study on a Chinese steel plant. Wang (2010) offers an ex post survey that analyzes the CDM's impact on technology transfer. Most of these studies use government data and build on preexisting models. However, Kaneko et al. (2006) conducted their own survey of Chinese and Japanese iron and steel manufacturers. Table 1 summarizes studies on the CDM in China.

The mixture of CDM projects in China is dominated by HFC-23 and N<sub>2</sub>O projects.<sup>16</sup> These large, low-cost projects create impressive amounts of reductions in CO<sub>2</sub>-equivalents but do not contribute greatly to sustainable development in the host country. Generally, high-cost projects make a greater contribution toward sustainable development (Liu 2010). Therefore, some authors—including Resnier et al. (2007) and Liu (2010)—have focused on strategies to shift the mix of CDM projects in China toward renewable energy projects, aiming to achieve a better balance between sustainability and profitability of CDM projects.

<sup>16</sup> For example, as of April 2009, nearly 80 percent of the total number of CERs issued for projects in China were for HFC-23 and N<sub>2</sub>O projects (Liu 2010).

Resnier et al. (2007) rank the sustainability of CDM project types and develop the CDM Tax/Subsidy Optimization model to optimize the environmental benefits of the CDM through a tax and subsidy scheme. At a discount rate of 9 percent, this optimal scheme allows the following “better”—or more sustainable—CDM projects to supply offsets: hydropower (16 MtCO<sub>2</sub>, wind (10 MtCO<sub>2</sub>), and natural gas combined-cycle (10 MtCO<sub>2</sub>) projects. However, at a discount rate of 7 percent, the scheme allows only natural gas combined-cycle projects to supply offsets. The authors’ findings suggest that China could improve the sustainability of its CER supply by placing taxes on “worse” projects and subsidies on “better” projects.

Liu (2010) builds on the work of Resnier et al. (2007), detailing a tax and subsidy plan that outlines how tax revenue might be recycled. In addition, the author considers the preexisting taxes China places on CDM projects.<sup>17</sup> Assuming a carbon price of €5, opportunity costs of \$1.5 per CER, and using marginal costs derived from the PET, the author finds that current CDM policies result in a 119 MtC supply of offsets and \$301 million in government revenue. Under current policies, the mix of CDM projects is dominated by low-cost (53 MtC) and middle-cost (57 MtC) projects. Under the author’s proposed tax and subsidy plan, the offset supply and government revenue increase, respectively, to 155 MtC and \$424 million. In addition, this plan significantly increases the portion of high-cost projects. An additional 98 MtC can be generated if this revenue is used to invest in economically unviable projects.

Wang (2009) conducts a survey that assesses technology transfer in China under the CDM, an important aspect in achieving the CDM’s goal of promoting sustainable development in developing countries. The author finds that, in the CDM, technology transfer—the adoption of developed country technologies in developing countries—occurs at a higher rate for different projects. The degree of technology transfer is high in projects where a large proportion of total income is derived from CER revenue and access to local technological options is low or nonexistent. For example, technology is transferred for 91 percent of HFC-23 projects and 100 percent of N<sub>2</sub>O projects. In contrast, technology is transferred to a lesser extent in projects related to coal mine CH<sub>4</sub> utilization (29 percent), wind power (27 percent), and cement heat waste recovery (7 percent).

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<sup>17</sup> In 2005, China placed taxes on the following CDM projects: HFC-23 and PFC projects (65 percent tax); N<sub>2</sub>O projects (30 percent tax); and, for many other projects, a 2 percent tax. China states that the revenue will be used to support activities related to climate change.

Kaneko et al. (2006) conduct a case study on the potential CO<sub>2</sub> reductions achieved by a Chinese steel firm from adopting Japanese energy-saving technology through the CDM. The authors consider several combinations of energy-saving technology under a range of CER and energy prices. They find a significant difference between the technological and economic potential of reducing CO<sub>2</sub> emissions. Although technically, emissions can be reduced 24 percent from baseline projections, the possible range of economically viable reductions is between 13 and 22 percent. To reach a 22 percent reduction from BAU, a higher CER price of \$10/ and a higher energy price are required. In addition, the authors find an average cost of reducing emissions of \$24.6 per ton of carbon. Finally, the authors conclude that the CDM complements foreign direct investment and technology transfer.

Zhoa and Michaelowa (2006) outline the costs and reduction potential of three distinct projects in an area of China that is rapidly transitioning into an urban center. The authors estimate that (a) a project that installs 200,000 solar water heaters would provide a 1.3-MtC reduction over 15 years at a carbon price of \$1.3/, (b) a project that installs 100,000 air conditioners would provide 818,000 tons of reductions over 15 years at a carbon price of \$4, and (c) a project that installs 200,000 compact fluorescent light bulbs would produce 106,000 tons of reductions over 10 years at a carbon price of \$3.

**Table 1. Clean Development Mechanism Studies in China**

Author	Data sources	Estimates of JI transaction costs
Zhoa and Michaelowa (2006)	Institute of Rural Planning of Zhejiang University; Yinzhou County Statistic Yearbook; Transportation Bureau of Yinzhou; ChangAn University; China Statistical Yearbook; China National Information Center for Resource Conservation and Comprehensive Using; International Energy Agency; World Bank	At a variety of scales, potential CDM projects can create CERs at the following rates: 1.3 MtCO <sub>2</sub> over 15 years at a carbon price of \$1.3 for residential solar water heaters; 0.054 MtCO <sub>2</sub> over 15 years at a carbon price of \$4/residential air conditioners; and 0.1 MtCO <sub>2</sub> over 10 years at a carbon price of \$3/.
Resnier et al. (2007)	UNEP	A tax/subsidy scheme that favors higher-cost, smaller CDM projects allows for natural gas, wind, and hydropower projects to create CERs.
Liu (2010)	China CDM; PET Model	A tax/subsidy scheme that favors higher-cost, smaller CDM projects increases CDM offset supply and

		revenue. If this revenue is used to further subsidize economically unviable, small, high-cost projects, offset supply increases an additional 98 MtC—a roughly 66% increase in offset supply.
Wang (2010)	PDDs for UNFCCC CDM	Technology is transferred in 100% of N <sub>2</sub> O projects, 91% of HFC-23 projects, 26% of wind power projects, 8% of CMM utilization projects, and 6.7% of CWHR projects.
Kaneko (2006)	Field study in 2002; Committee on Iron and Steel Statistics	A Chinese steel firm adopting multiple Japanese technologies could reduce emissions 13%–22% from baseline at an average carbon price of \$24.6.

*Notes:* CMM, Coal Mine Methane; CWHR, Cement Waste Heat Recovery.

### *Estimates for Clean Development Mechanism Potential in India*

Research on the CDM in India is dominated by a team of researchers led by Pallav Purohit. This team focuses on producing ex ante assessments on the potential offset supply of a variety of CDM projects, with an emphasis on renewable energy. For each paper, the authors develop a theoretical model of CDM adoption for a given technology and then estimate a baseline level of adoption using government- and industry-specific data. The authors then apply expected financial returns and CDM adoption criteria—for example, additionality tests—to their model to estimate the number of CERs a technology might produce. Table 2, in the appendix, summarizes studies on the CDM in India.

Purohit and Michaelowa (2007) assess the potential CDM offset supply of bagasse cogeneration in India. The authors find a theoretical maximum annual availability of 28 million CERs. However, under realistic assumptions based on past experience with government-run programs, the authors also estimate a realistic annual volume of CERs of 20 to 26 million tons by 2012. The authors assert that the CDM would help achieve maximum utilization potential of bagasse cogeneration more rapidly compared to the current rate of adoption in India, which will not reach its maximum potential for another 20 years.

Purohit (2008) assesses the potential CDM offset supply of small hydropower projects in India. The author finds a theoretical maximum annual potential of these projects at 24 million

CERs. However, under realistic assumptions based on past experience with government-run programs, the author also estimates a realistic annual volume of CERs of 7–20 million in 2012 and 13–24 million CERs in 2020. The author asserts that the CDM would help achieve maximum utilization potential of small hydropower projects more rapidly compared to the current rate of adoption in India.

Purohit and Michaelowa (2008a) assess the potential CDM offset supply of solar water heating systems in India. When the authors wrote this paper, CERs had been issued for only three solar water heating systems. The authors estimate a theoretical maximum annual availability of 27 million CERs. However, under realistic assumptions based on past experience with government-run programs, the authors also estimate realistic annual volumes of CERs of 4–9 million in 2012 and 15–22 million in 2012. These levels of deployment would require the government to set a subsidy level that allows solar water heaters to become viable with extra CER revenue.

Purohit and Michaelowa (2008b) assess the potential CDM offset supply of solar photovoltaic pumps in India. When the authors wrote this paper, CERs has been issued for only one solar photovoltaic pump project. The authors estimate a theoretical maximum availability of 214 million CERs. However, with very high mitigation costs of €24–€242 per ton of carbon, the authors estimate a drastically lower realistic availability of CERs—50,000 to 100,000 in 2012 and 250,000 to 750,000 in 2020. However, even this level of deployment would require the government of India to set a subsidy at a level that allows solar photovoltaic pumps to become viable with extra CER revenue.

Purohit (2009) assesses the potential CDM offset supply of biomass gasification projects in India. When the author wrote this paper, CERs had been issued for only one biomass gasification project. The author estimates a theoretical maximum annual availability of 58 million CERs. However, under more realistic assumptions based on past experience with government-run programs, the author also estimates a realistic annual supply of 0.4 to 1.0 million CERs in 2012 and 1.0 to 3.0 million CERs in 2020. The CDM could help achieve deployment of biomass gasification programs more rapidly than the current trend in India, which requires another 50 years to reach maximum utilization potential.

Table 2. Clean Development Mechanism Studies in India

Author	Project type	Data sources	Estimates
Purohit (2009)	Biomass gasification	India Ministry of Power; India Ministry of New and Renewable Energy; India National Productivity Council; India Ministry of Agriculture.	Theoretical potential: 58 million tonnes of CERs annually. Practical Potential: 0.4–1 million tonnes by 2012 and 1–3 million tonnes by 2020.
Purohit (2008)	Small hydro	India Ministry of Power; International Energy Agency; India Ministry of Non-conventional Energy Sources; India Ministry of New and Renewable Energy.	Theoretical potential: 24 million tonnes of CERs annually. Practical potential: 7–20 million tonnes by 2012 and 13–24 million tonnes by 2020.
Purohit and Michaelowa (2008a)	Solar water heating	India Ministry of Power; India Meteorological Department; India Ministry of Non-conventional Energy Sources; India Ministry of New and Renewable Energy; Tata Energy Research Institute; India Ministry of Power.	Theoretical potential: 27 million tonnes of CERs annually. Practical potential: 4–9 million tonnes by 2012 and 15–22 million tonnes by 2020.
Purohit and Michaelowa (2008b)	Solar photovoltaic pumps	India Ministry of Water Resources; Tata Energy Research Institute; India Ministry of Power; India Ministry of Non-conventional Energy Sources; Fertilizer Association of India; India Ministry of Agriculture; India Ministry of Science and Technology.	Theoretical potential: 214 million tonnes of CERs annually. Practical potential: 0.05–0.1 M tonnes by 2012 and 0.25–0.75 million tonnes by 2020.
Purohit and Michaelowa (2007)	Bagasse cogeneration	U.N. Economic and Social Commission for Asia and the Pacific; Food and Agriculture Organization of the United Nations; Information Credit Rating Agency; India Renewable Energy Development Agency Limited; India Ministry of Food and Consumer Affairs; India Ministry of Non-conventional Energy Sources; World Resources Institute.	Theoretical potential: 28 million tonnes of CERs annually. Practical potential: 20–26 million tonnes by 2012.

## ***B. Joint Implementation***

Research in JI has been limited because CDM has dominated the offset supply. One study—Frankhauser and Lavric (2003)—identifies some drivers of this outcome. Another study, Jackson (1995), conducts an ex ante estimate of the cost-effectiveness of the JI.

Frankhauser and Lavric (2003) provide ex ante estimates of the potential JI offset supply in 13 potential host countries: Russia, Ukraine, Bulgaria, Romania, Poland, Lithuania, Czech Republic, Estonia, Slovak Republic, Latvia, Hungary, Croatia, and Slovenia. The authors develop a framework that includes qualitative and quantitative indicators that assess each country's carbon intensity, JI institutional capacity, and general investment climate. To construct the carbon intensity indicator, the authors rely on data from the UNFCCC and the European Bank for Reconstruction and Development (EBRD). To construct the JI institutional capacity indicator, the authors performed a survey of each country's environment ministries as well as UNFCCC and EBRD data. To construct the general investment climate indicator, the authors use data from the World Economic Forum and the EBRD. None of the countries scores well in all three categories. For example, although Ukraine has the highest carbon intensity indicator—and therefore has a large reduction potential under the JI—it also ranks lowest for the JI institutional capacity and general investment climate indicators. Overall, the authors find that JI investors face a clear trade-off between cheap JI reductions and the quality of JI institutions and general investment climate. The authors recommend that JI countries push ahead with reform to improve the business environment, clarify their JI policies, and build JI capacity to attract JI investors.

Jackson (1995) tests the argument that JI results in cost savings. The author uses national GHG abatement costing studies from the United Kingdom, Denmark, Poland, and Zimbabwe to assess several linking scenarios. Abatement cost data for Denmark and Zimbabwe is from the UNEP Greenhouse Gas Abatement Costing Study; data for Poland is from Sitnicki et al. (1990, 1991); and data for the United Kingdom is from Jackson (1989, 1991). Without trade among countries, the author finds that Denmark and the United Kingdom can meet their Kyoto obligations with substantial net savings of \$380 million and \$2,130, respectively. These net savings are the result of abatement projects with negative costs. In contrast, Poland would incur a net positive cost of \$120 million. Zimbabwe does not have a Kyoto obligation. Countries benefit from linking in all of the scenarios considered by the author. For example, a partnership between the United Kingdom and Poland results in hypothetical savings of 7.5 percent, and a partnership between Denmark and Zimbabwe results in a hypothetical savings of 13.5 percent. In both of these examples, reductions in the less-developed countries increase relative to the case without trading. Therefore, these examples are evidence for the claim that cost-effective reductions might

be sourced from developing countries. However, the direction of reductions could change if developing nations take on Kyoto obligations. For example, if Zimbabwe committed to reducing emissions to 20 percent below 1998 levels by 2010 and partnered with Denmark, Denmark would further reduce emissions (compared to a case without trading) to sell reductions to Zimbabwe. The author uses this example to show that one should view with skepticism the assumption that trading with developing countries will decrease costs. Overall, the author asserts that benefits from some forms of linking might be outweighed by transaction costs.

### **C. Transaction Costs**

Since the inception of the CDM and JI, researchers have focused on quantifying the transaction costs associated with offset projects. These costs might originate from: searching for projects; negotiating the terms of the project; registering the project, which could include establishing a baseline, proving additionality, and estimating leakage; monitoring and verifying emissions; and achieving certification of CERs or AAUs to the offset project. To estimate these transaction costs, authors use models and conduct surveys and case studies. Generally, transaction costs for the CDM are expected to be higher than those for JI because of the detailed CDM project cycle (Krey 2005. Table 3, in the appendix, summarizes the studies discussed below and the data sources used in each study.

Michaelowa et al. (2003) conduct an ex post review of a precursor to the CDM—the Prototype Carbon Fund (PCF)—and estimate transaction costs for certain project types. They find transaction costs of €0.19–€0.71 per ton of carbon for PCF projects, €0.3–€0.7 per ton of carbon for a gas plant project, and transaction costs of €0.4–€1.1 per ton of carbon for biomass plants. The authors conclude that projects with emissions reductions smaller than 0.20 million tons of CO<sub>2</sub> are not economically viable at the, then current, CER prices.

Michaelowa and Jotzo (2005) estimate transaction costs of the CDM in India. Using the PET model—with data provided primarily by the World Bank and the Food and Agriculture Organization of the United Nations—the authors estimate that transaction costs would represent 14 percent of CDM revenue. The authors conclude that—although demand from developed countries remains the crucial factor—the size of the CDM will significantly depend on transaction costs in host countries.

Krey (2004) conducts a survey to estimate transaction costs of non-sink CDM projects in India. The author administered the survey to CDM project developers, CDM consultants, financial institutions, and government representatives. In total, transaction cost data were

collected from 15 projects—with complete transaction cost data for 7 projects. The author finds a range of transaction costs of \$0.07–\$0.47 per ton of carbon.

Ahonen and Hämekoski (2005) analyze the transaction costs of four JI projects and six small-scale CDM projects. They find the total costs of these projects to range from €62,000 to €303,000. Regarding average costs, the authors find a price of €0.37–€1.89 to €0.22–€3.38 per ton of carbon for JI and CDM projects, respectively.

Chadwick (2006) conducts a case study on a potential CDM project in Ghana that involves substituting liquefied petroleum gas for wood and charcoal for home cooking. The author finds that the project is economically unviable until CER prices are \$16 or \$35; the higher cost applies if a methodology has not been created for the project. The author asserts that the supply of offsets depends critically on the expected quantity of CERs, anticipated CER prices, and the size of transaction costs.

**Table 3. Estimates of Clean Development Mechanism and Joint Implementation Transaction Costs**

Author	Data sources	Estimates of JI transaction costs	Estimates of CDM transaction costs
Michaelowa et al. (2003)	Organisation for Economic Co-operation and Development; EcoSecurities; Federal Ministry of Research; KPMG; PriceWaterhouseCoopers; Prototype Carbon Fund (2002); UNFCCC.	Gas plants have transaction costs of €0.3–€0.7 per ton of carbon; biomass plants have transaction costs of €0.4–€1.1 per ton of carbon.	PFC projects have transaction costs of €0.19–€0.71 per ton of carbon.
Michaelowa and Jotzo (2005)	PET model, with data provided primarily by the World Bank and the Food and Agriculture Organization of the United Nations; MIT EPPA.	N/A	Transactions costs are estimated to be 14% of CDM revenue, given carbon prices of €3.66 and total CER sales of 363 Mt CO <sub>2</sub> .
Krey (2005)	Empirical survey of 15 CDM projects in India conducted by the author.	N/A	Transaction costs of \$0.07–\$.47 per ton of CO <sub>2</sub> , strongly dependent on economies of scale.
Ahonen and Hämekoski (2005)	Finish Environmental Institute.	€0.37–€1.89/ton of CO <sub>2</sub> .	€0.22–€3.38 per ton of carbon.
Chadwick (2006)	EcoSecurities; McKloskey (2005); UNFCCC; World Bank	N/A	Case study project is not profitable unless CER prices are \$16 or \$35; the higher cost holds if a new methodology must be created.

## V. Conclusion

To date, CDM can be viewed as a success in that it has supplied a significant amount of carbon offsets. Trust in the additionality of CERs has negatively impacted the CDM. Specifically, CDM projects involving the capture and destruction of HFC-23 gases have been suspected of supplying nonadditional offsets. These offsets constitute 42 percent of the CERs ever issued (UNEP Risoe 2012). Wara (2008) calculates that revenue from reducing HFC-23 emissions can dwarf that of HCFC-22 production and argues this incentivizes firms to produce HCFC-22 only to abate the resulting HFC-23 emissions for offset credits. Schneider (2011) finds that the choice of participating projects to produce HFC-23 is influenced by CDM rules; the author concludes that some projects were probably credited for nonadditional reductions. Seemingly, these studies have contributed to the European Commission's decision to ban the use of HFC-23 carbon offsets after April 30, 2013 (Europa 2011). Although these offsets have been banned, they have undermined trust in the CDM and continue to provide a challenge to further CDM use. In addition to addressing issues surrounding additionality, the research highlighted in this backgrounder shows that changes to the CDM could better prioritize projects that promote sustainable development.

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