

# Sweet carbon: An analysis of sugar industry carbon market opportunities under the clean development mechanism

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## ABSTRACT

Bagasse power generation projects provide a useful framework for evaluating several key aspects of the Clean Development Mechanism of the Kyoto Protocol. On the positive side, our analysis, which draws in part from a data set of 204 bagasse electricity generation projects at sugar mills, indicates that these projects provide Annex I country investors with a cost-effective means to achieve greenhouse gas emissions reductions. Our analysis also confirms that the marketplace for Clean Development Mechanism-derived offsets is robust and competitive. Moreover, bagasse projects appear to provide a positive example in a “new wave” of clean energy investment that has replaced the earlier industrial gas projects. At the same time, we also identify two aspects of the CDM that demand improvement. First, the additionality standard needs to be tightened and made more transparent and consistent. Financial additionality should be required for all projects; however, any financial additionality test applied by the Clean Development Mechanism’s Executive Board must be informed by the significant barriers faced by many projects. Second, the administrative processes for registration and verification of offsets need to be streamlined in order to prevent long registration time lags from chilling clean energy investment.

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## 1. Introduction

With the 2009 Copenhagen negotiations close at hand and the 2012 close of the Kyoto first commitment period not far behind, interest in evaluating the performance of the Clean Development Mechanism is increasing (EC, 2008). Has the CDM achieved the goals set out for it by Article 12 of the Kyoto protocol? That is to say, is it (1) “assist[ing] Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments, and (2) “assist[ing] Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention?” (UNFCCC, 2008a).<sup>1</sup>

In this paper, we start from the proposition that evaluation of the CDM’s performance must be informed in part by practical

experience in the CDM marketplace. Over the last 4 years, the CDM Executive Board has registered over a thousand projects accounting for over a billion tons of greenhouse gas reductions in dozens of industries (Capoor and Ambrosi, 2008). Given the diversity of CDM project types and the increasing interest in including sectoral approaches in the post-2012 climate framework, sector-specific investigations are often more valuable than generalizations about the CDM as a whole (EC, 2008). Moreover, the CDM marketplace is no longer just an idea—it has emerged as a \$12 billion industry with a complex “business ecosystem” encompassing project developers, brokers, investment banks, rating agencies, consultants, lobbyists, regulators, and the international trade shows that bring them all together.

With this in mind, we analyze the CDM’s performance with reference to a specific set of real-world CDM projects: bagasse electricity generation projects at sugar mills. We selected bagasse electricity projects because we think they are a good example of the “new wave” of clean energy projects that have emerged to dominate the CDM market in 2007–2008 (Wara and Victor, 2008). This new wave is made up of a large number of relatively small sub-sectors like the bagasse electricity sub-sector, no single one of which accounts for a majority.

Methodologically, our paper is based on three discrete research activities. First, we analyzed a data set of the 204 bagasse electricity projects that have been submitted for validation,

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<sup>1</sup> Article 12(5), Kyoto Convention. Often, the CDM is described as having an additional goal: “to accomplish the overarching goals of the Framework Convention.” (Wara, 2008) Invariably, authors struggle to define either the meaning of “sustainable development” or “accomplishing the overarching goals of the Framework Convention,” depending on whether they allocate the developing-country responsibilities to “sustainable development” (as we have) or to “accomplish[ing] the overarching goals of the Framework Convention.” For that reason, we suggest that the text of Article 12(5) is better read as setting out two goals, not three.

reporting project success rates, geographic distribution, and the major carbon market players involved in the projects. Second, we closely reviewed Project Design Documents (PDDs) from ten submitted projects in order to review the environmental soundness of CDM methodologies and understand their economics in more detail (see Table 8). In order to get a sense for the full range of projects included in the bagasse electricity category, we selected projects with diverse sizes, submission dates, technological improvements, and geographic locations. Third, we met with a large sugar producer in Southeast Asia in order to familiarize ourselves with the way a CDM project fits into a sugar mill's business and the motivations of potential project sponsors.

Based on our research, we argue that, at a high level, the evidence from bagasse electricity projects reveals the CDM to be a competitive, functional market that is performing well relative to some aspects of its two primary goals. With respect to its first goal, it is clear that the CDM is assisting Annex I parties in achieving Kyoto compliance. CDM performance relative to the second goal is more complicated in large part because the concept of sustainable development is both complex and contested. A full treatment of the broader debate about sustainable development is beyond the scope of this article, but we do note that the CDM has resulted in increased investment for clean energy projects in Non-Annex I countries. While it is problematic to say that CDM investment necessarily constitutes sustainable development and while concerns remain about a bias in the CDM towards large, centralized projects in a relatively small number of countries, in some cases CDM investments do appear to represent a potentially promising shift towards a set of more environmentally sound practices. Investments in increased power generation from bagasse fit within this trend.

Although the CDM has increased investment in clean energy, a close examination of the bagasse electricity projects also provides evidence of the seriousness of certain concerns about the CDM. Specifically, we argue that the project developers' incentives to "game the system" by submitting non-additional projects are a fundamental problem (Michaelowa and Purohit, 2007; Schneider, 2007). As a result, the system's "referee" – the Executive Board – must impose administrative hurdles such as the additionality requirement. Though well intentioned, the hurdles can have undesirable consequences: they are only partially effective in excluding unsound projects, unfairly exclude some sound projects, inequitably reward project developers with greater resources, and are expensive for all involved, reducing the efficiency of the mechanism as a whole.

The unexpectedly large number of projects passing through the Executive Board's hands has exacerbated these problems, making it particularly difficult for the Board to strike an effective balance between environmental credibility and administrative efficiency (Michaelowa and Purohit, 2007). In this sense, the CDM is the victim of its own success.

## 2. Bagasse power projects and clean energy in the CDM market

Since 2004, when the Brazilian "Vale do Rosario" project became the first bagasse project to be certified under the CDM, there have been 204 bagasse power projects submitted to CDM validators. As shown in Table 1, the majority of these projects are located in India, Brazil, and the rest of Latin America.

Numerically, these 204 projects account for only about 4% of the 4600 projects in the pipeline. As a share of total emissions reductions, they account for even less: 56 million tons of CO<sub>2</sub> between 2008 and 2012, or about 2% of the 2.9 billion tons of 2012 emissions reductions in the CDM pipeline as a whole. However, as

**Table 1**

Bagasse power projects: success rates and absolute numbers by country.

	Pending	Rejected/ withdrawn	Registered	Total	Success rate (%)
India	60	12	36	107	75
Brazil	30	3	26	59	90
Honduras	1	3	2	6	40
Thailand	1		3	4	100
Ecuador	2		1	3	100
Mexico	2	1		3	0
Colombia	1		1	2	100
El Salvador			2	2	100
Guatemala	1	1		2	0
Kenya	1		1	2	100
Philippines			2	2	100
Uganda	2			2	
China			1	1	100
Ecuador	1			1	
Guyana			1	1	100
Mauritius	1			1	
Morocco	1			1	
Nicaragua			1	1	100
Pakistan	1			1	
Peru		1		1	0
Swaziland	1			1	
Total	106	21	77	204	79

Source: authors' calculations based on data available at <http://cdmpipeline.org>, last accessed March 2009.

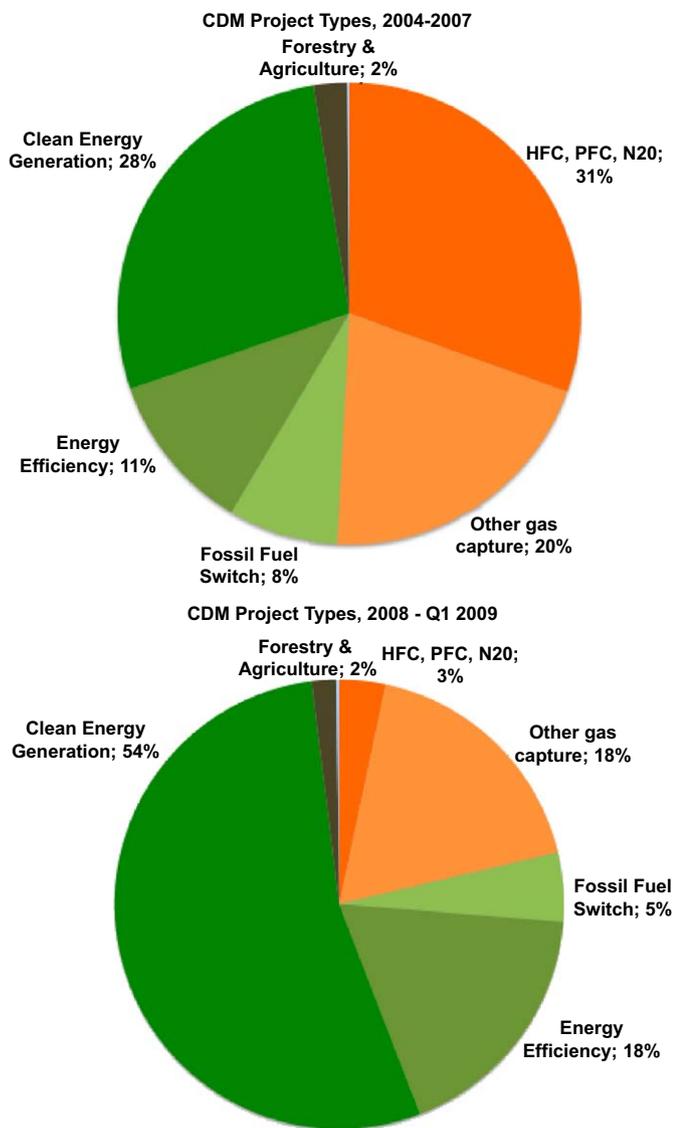
suggested in Section I above, this relatively small share is characteristic of the new wave of energy projects in the CDM: other biomass generation projects accounted for 7% of emissions reductions contracted in 2008 and the first quarter of 2009, wind projects accounted for 16%, hydroelectric for 21%, and energy efficiency projects of all types for 18%.

Taken together, the dominance of these clean energy projects represents a sharp change from the CDM's project mix during its first 3 years of operation. As shown in Fig. 1, through 2006 and the beginning of 2007 the largest share of CERs came from a handful of large projects based on the destruction of HFC-23, a greenhouse gas that is a by-product of the manufacture of HCFC-22, a refrigerant.

The early dominance of the HFC projects raised serious concerns about the CDM. The popular press derided the projects as a "scam" that exploited a "loophole" in the CDM (Bradsher, 2006). The destruction of HFC-23 that could have been achieved for about \$31 million per year by directly paying HFC-22 producers to install HFC-23 destruction equipment was contracted through the CDM at a cost of \$800 million per year (Bradsher, 2006). The project owners were now earning twice as much from the destruction of HFC-23 than they ever did from the production of HCFC-22.

CDM market participants countered that the CDM market was operating as a market should—channeling investment in climate change mitigation toward the projects that science showed would achieve the most climate change mitigation per dollar (IETA, 2007). Because the science had demonstrated that a ton of HFC-23 has 11,700 times the greenhouse potential of a ton of CO<sub>2</sub>, the CDM awarded 11,700 more credits for forgoing the emissions of a ton of HFC-23 reductions than for forgoing the emission of a ton of CO<sub>2</sub>. By virtue of controlling such a large amount of potential emissions reductions, the owners of the HFC-23 projects received a great deal of money from Annex I credit buyers, but that does not mean that the HFC projects exploited a "loophole." Their environmental benefit was real.

Whatever the respective merits of these arguments, the controversy was largely moot by late 2007. By then, most of the



**Fig. 1.** Sector shares of CDM emissions reduction by volume, 2004–2007 and 2008. Source: authors' calculations based on data available at <http://cdmpipeline.org>, last accessed March 2009.

HFC-23 destruction opportunities had been exhausted, and investment had begun flowing to projects with less spectacular returns (Wara, 2008; State of the CDM, 2008). The result was the dramatic shift in the breakdown of credits by project type shown in Fig. 1. The combined share of energy efficiency and clean energy generation projects grew from 39% of total emissions reductions up to 2007 to 72% in 2008, while industrial gas projects (HFC, PFC, and N<sub>2</sub>O) shrank from 31% to 3%. Moreover, because the energy projects tend to be smaller in size than the industrial gas projects, in numerical terms they account for 75% of all projects certified during 2008.

As shown in Table 2, developers of the new clean energy are not reaping the exorbitant returns that were characteristic of the HFC projects. On a yearly basis, €1 invested by an HFC project owner returned credit permitting the emission of 0.67 tons of CO<sub>2</sub>. At the current price of about €10 per ton, this right is worth about €6.70, implying a spectacular annual percentage yield (APY) of 670%. The wind and bagasse projects per 1, by contrast, return about 0.003 tons of CO<sub>2</sub> emissions credit per €1. This amount of credit is worth about €0.03 at current prices, implying an APY of only 3%. These low returns, of course, are incremental to the

returns from other project activities, such as electricity sales, suggesting that the CDM is now leveraging relatively small amounts of funding by coupling them to funding from other sources.

In conclusion, then, the CDM is currently delivering the types of emissions reductions contemplated by its architects. Moreover, it is doing so at a price that does not appear to be exorbitant relative to the cost of installation of the emissions-reducing technologies.

Alternative architectures – such as weighting the relative cost of emissions reductions of different greenhouse gases in addition to the greenhouse effects of those gases or “de-linking” the markets for emissions reductions of each type of gas – might have helped prevent the HFC-23 overpayment problem (Wara and Victor, 2008). However, now that the HFC-23 problem has largely disappeared, it is worth noting that it is one sense a success that the market has found clean energy projects like the bagasse electricity projects “on its own” and only after picking the low-hanging fruit of the HFC-23 projects. Specifically, the HFC-23 investments are evidence that the market is actively hunting the lowest-cost emissions reductions, and therefore performing well against its first goal—cost-effectiveness for Annex I countries.

### 3. CDM methodology: how a bagasse electricity project reduces emissions

Bagasse is the primary waste product from the processing of sugar cane—a fibrous, moist, cellulosic material with an appearance similar to dry grass cut by a lawnmower. Most sugar mills worldwide burn bagasse to power the machines in their factory. The bagasse is combusted in boilers, generating high-pressure steam. Some of the steam is generally run through turbines to generate electricity for electric-powered sugar processing crushing equipment. In many cases, a portion of the steam is also used to power mechanical-drive equipment. The remaining heat contained in the low-pressure steam exiting the power generation turbines and mechanical-drive equipment is frequently used for process heat requirements in the factory.

Currently, the majority of sugar factories worldwide do not generate significant electricity surpluses from the combustion of bagasse. Typically, just enough electricity is generated to power the sugar mill equipment, plus perhaps a little extra for “domestic consumption” at nearby company-owned houses or offices.

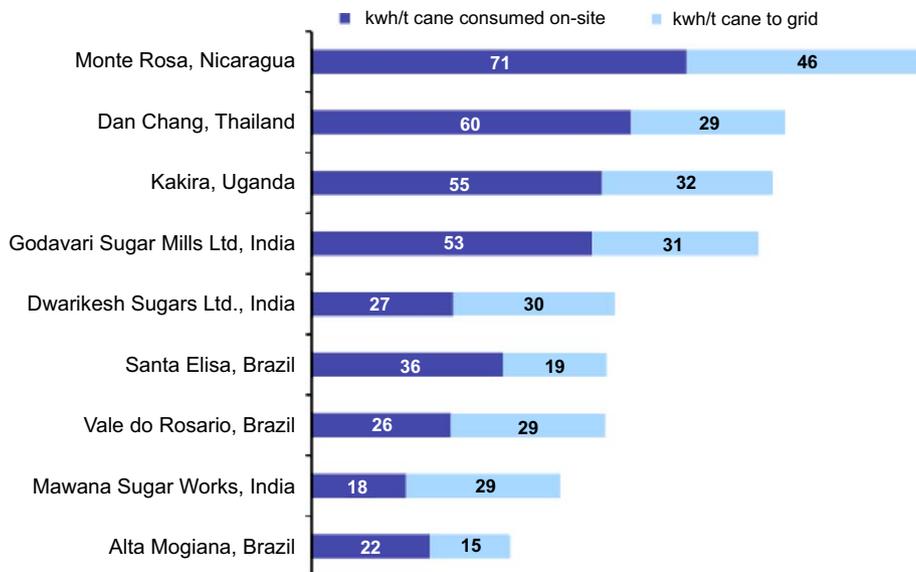
However, significant electricity surpluses are achievable at most sugar mills through simple efficiency improvements. At a fundamental level, there is an imbalance between the energy needed to crush a ton of sugar cane and the energy that can be captured by burning the quarter-ton of bagasse that is a by-product of crushing that ton of cane. Examination of sugar mills in actual commercial operation shows that that one-quarter-ton of bagasse can generate over 100 kWh of energy if it is combusted in a high-efficiency boiler, and if all the steam is passed through high-efficiency turbines rather than directed toward mechanical-drive equipment. Processing the ton of sugar cane from which the quarter-ton of bagasse originated with 100% electric-powered equipment takes only 30–50 kWh of energy. Therefore, it is feasible for high-efficiency sugar mills to generate 50–70 kWh of surplus electricity per ton cane crushed. Fig. 2 shows the electricity per ton of cane consumed on-site (dark blue bar segments) and surplus electricity achieved by efficiency improvements (light blue bar segments) at nine sugar mills that have applied for CDM certification. The total length of each bar corresponds to total electricity produced at the sugar mill.

Turning to the emissions reductions associated with these electricity surpluses, the “methodology” submitted by the project

**Table 2**  
CER returns to initial investment from selected projects.

Project name	Total project investment (× €1 M)	CERs/year	CERs/year returned per € invested	Annual revenue from CER Sales, €8 CER price (× €1 M)	Annual revenue from CER Sales, €13 CER price (× €1 M)	Annual percentage yield from CER Sales, €8–€13 CER price (× €1 M)
HFC destruction, Korea	€2.2	1,410,000	0.639	€11.3	€18.3	511–831%
Coal mine methane, China	€1.4	200,000	0.136	€1.6	€2.6	109–177%
Wind power, India	€19.1	104,000	0.005	€0.8	€1.4	4–7%
FFHC bagasse, Phillipines	€44.0	120,000	0.003	€1.0	€1.6	2–4%

Source: leftmost three columns reproduced from Ellis and Kamel (2007). Rightmost three columns are authors' calculations.



**Fig. 2.** Efficiency improvements at 9 sugar mills. Source: authors' review of project documentation for the 9 projects that appear in the figure, available at unfccc.com.

developer of the first bagasse electricity project, and subsequently refined and approved by the CDM for use by other projects, entitles sugar mills to claim credit for emissions reductions to the extent that the surplus electricity they generate displaces other, “dirtier” electricity.<sup>2</sup> In most (but not all)<sup>3</sup> projects, the sugar mill is already burning the same amount of bagasse before the efficiency-improvement project, and would have continued to burn the same amount if the project were not undertaken. Therefore, most mills assume no change in emissions at the project site as a result of the project, implying that the surplus electricity sent to the grid is “zero-carbon” electricity, comparable to electricity from other renewable projects, such as windmills or hydroelectric facilities. Because this zero-carbon electricity displaces electricity derived from combustion of fossil fuels, the project has caused the electricity sector as a whole to forgo some CO<sub>2</sub> emissions.

<sup>2</sup> The current methodology is “ACM0006” (UNFCCC). The original methodology was “AM0002,” which has been consolidated into ACM0006 along with several other similar methodologies (UNFCCCb).

<sup>3</sup> Where additional bagasse is purchased from off-site to support the project, the emissions change at the project site will be non-zero. The CDM methodology accounts for this possibility by demanding that projects measure the amount of bagasse consumed, and subtract any emissions increase associated with increased consumption from the emissions reduction associated with the efficiency improvements.

The specific number of CO<sub>2</sub> emissions forgone is directly proportional to two variables: the amount of power sold to the grid and the carbon intensity of the grid. Under the methodology, the amount of power is directly measured by an electric meter and reported annually to project validators and the CDM Executive Board. The carbon intensity is measured by an “emissions factor,” estimated using an algorithm which takes into account the current mix of power generation resources connected to the grid, the percent of electricity demand served by “low cost” or “must run” resources, and the type of power plants likely to be constructed in the future. As shown in Table 3, emissions factors vary widely between countries and between districts within countries. Brazilian bagasse projects typically report emissions factors of around 0.4 tCO<sub>2</sub>/MWh, whereas projects in India – where electric grids have relatively less hydropower and relatively more power from coal- or oil-fired plants – report emissions factors of 0.8 tCO<sub>2</sub>/MWh or more. This implies that a bagasse power project located in India would receive twice as many carbon offset credits as an equivalently-sized project located in Brazil.

Taking into account the bagasse electricity project features sketched out above, we suggest that both the basic emissions reductions theory behind these projects and the methodology by which those reductions are measured is sound. While any attempt to measure carbon savings down “to the last molecule” is doomed, it is commendable that the CDM treats the factors that most affect the quantity of emissions reductions as variables that must be

**Table 3**  
Average electricity generation mixes and emissions factors in selected countries.

	Brazil	Thailand	Indonesia	India
Fossil fuel (%)	7	92	78	76
Hydro (%)	83	5	9	14
Nuclear (%)	2	0	0	2
Other renewable (%)	5	3	7	2
Emissions factor (tCO <sub>2</sub> /MWh)	0.32	0.52	0.83	0.87

Source: electricity generation mixes from CARMA (<http://www.carma.org>). Emissions factors are approximate values based on factors documented by the projects listed in Table 8.

reported annually to the independent group charged with project validation. First, the number of offsets awarded depends on the amount of electricity actually sent to the grid, as measured by an electric meter. Second, while the carbon intensity of the grid is estimated, rather than measured at the smokestack, it is estimated using “granular” power plant-level data. Finally, allowance is made in the methodology for the possibility that transport of bagasse from off-site or an increase in the combustion of bagasse might increase on-site emissions. If it does, the emissions reductions awarded to the sugar mill as a consequence of displacing dirty grid electricity will be reduced accordingly.

At a higher level, the presence of bagasse projects in the CDM pipeline testifies to the effectiveness of the CDM’s “universal” approach. The alternate “categorical” approach suggested by Europe during the Kyoto negotiations (Trexler et al., 2006) and subsequently revived in various forms by some CDM critics (Wara and Victor, 2008) would have awarded credit only to projects that appeared on a list of specific technologies. Such a list might not have included electricity generation at sugar mills, a much less prominent emissions reduction strategy than solar, wind, or direct biomass generation. By instead adopting the universal approach, and allowing project developers to propose methodologies for the projects they found most attractive, the Kyoto protocol has created a decentralized market which, as noted in Section II above, has succeeded in ferreting out the most cost-effective emissions reductions, whether or not these emissions reductions were contemplated by the market’s designers.

**4. The “go/no-go” decision: additionality and the economics of a bagasse project**

Table 4 shows a simplified, illustrative cost and revenue model for full-scale bagasse power project. The project is hypothetical, but closely based on the cost information in the ten bagasse power PDDs we reviewed during our research. On the cost side, the project is characterized by a large up-front capital investment in boilers, turbines, and electric-powered equipment, but near-zero ongoing marginal cost. Very regular revenues come from a long-term fixed-price electricity sale agreement and a fixed-price CER sale agreement with a carbon buyer. Under the assumptions in the model, the CER sales account for about 20% of project revenues, and increase the rate of return on the project from 6% to 15%.

The relatively low importance of CER revenues raises the question of whether bagasse electricity projects are “additional.” Specifically, if the project’s return were attractive enough to justify investment even in the absence of the CDM, the project would not be additional. If not, an Annex I party would have no right to use emissions reductions purchased from the project to meet its Kyoto obligations, and the CDM Executive Board should not certify the project. The width of the left-most band on Fig. 3

**Table 4**  
Profitability model of a sugar-mill scale bagasse electricity generation project (all numbers × €1000)

	Year 1	Year 2–22
<b>Costs</b>		
Capital investment	(€18,165)	
CDM application	(€100)	
Administration		(€66)
Bagasse purchase (in shortfall years)		(€230)
<b>Total</b>	<b>(€18,265)</b>	<b>(€296)</b>
<b>Revenues</b>		
Electricity Sales (€33/MWh)		€2880
CER Sales (€10/CER)		€600
<b>Total</b>		<b>€3480</b>
<b>PBIT</b>		
Less tax		(€955)
Less debt service		(€1344)
<b>Profit Net of Tax and Debt Service</b>		<b>€885</b>
<b>IRR w/ CER Sales</b>		<b>15%</b>
<b>IRR w/o CER Sales</b>		<b>6%</b>

Project cost estimates and assumptions are based on cost information from the authors’ review of 10 bagasse power PDDs listed in Table 8. Cost and profitability analysis follows standard business accounting conventions, and relies on the following assumptions: MWh sold to grid per year = 87,000; CER price = €10; Emissions factor = 0.69; Electricity price = €33/MWh; Corporate income tax rate = 30%; Debt/equity ratio = 70/30; Interest rate on debt = 12%; Bagasse price = €9; 10% shortfall 1 in 4 years; Project has useful life of 21 years (3 7-year renewable periods).

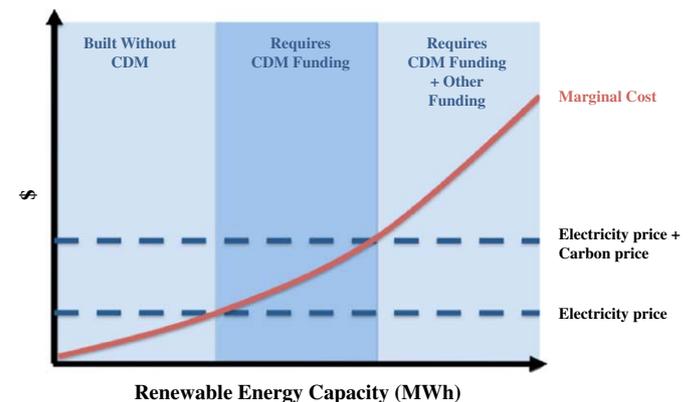


Fig. 3. Relationship between profitability and financial additionality in the CDM.

corresponds to the clean generation capacity that would be installed by these “non-additional” projects. The projects that the CDM wants to fund correspond to the darker blue band in the middle of Fig. 3; these “additional” projects were unviable at the prevailing electricity price, but are viable with revenue from both electricity sales and carbon offset sales. Some projects, of course, will be unviable even with the CDM. These projects correspond to the rightmost band on the figure, where the marginal cost of additional clean generation capacity is greater than both electricity and carbon revenues.

As discussed below in greater detail, the profitability of bagasse power generation projects depends largely on electricity (rather than carbon credit) sales. In addition, the decision to invest in efforts to increase bagasse-based power generation must typically be made before a project has been fully approved to receive certified emissions reductions credits under the CDM. Taken at face value, this appears to suggest that many bagasse power generation projects fall within the left-most column of

Fig. 3. However, to date the EB has rejected only seven bagasse electricity projects for failure to demonstrate additionality out of the 98 on which it has reached a decision.<sup>4</sup> This low rejection rate may be in part explained by the additionality rules developed by the CDM Executive Board. Under the rules, applicants may generally take either of two approaches: they can undertake an “Investment Analysis” or a “Barriers Analysis.”<sup>5</sup> An investment analysis requires a showing of financial additionality—that the project’s rate of return is low enough that in the absence of the CDM it would not have been financed. Barriers analysis requires only anecdotal evidence that the project faces obstacles to implementation which CDM revenue might help it to overcome. Most sugar mills have opted for a barriers analysis, as it allows them to argue that regulatory issues, lack of experience in negotiation of power purchase agreements, difficulties in accessing financing, and other “barriers” justify the inclusion of their project in the CDM.<sup>6</sup> In fact, some of the sugar mill decision-makers we spoke to seemed uncomfortable with the idea of financial additionality. The decision-makers typically want the project to be built on “solid” (i.e. non-regulatory) foundations. This means that they are likely to consider the CDM revenue “a nice bonus if it comes through,” but, due to the perceived high risk of that revenue actually materializing, they may resist making an investment if the success of the project depends on that revenue—which, of course, is exactly what the CDM additionality rule requires (Schneider, 2007). This issue interacts with the 2+ year time lags (described in Section V below) between project development and certification. In some cases, the project must stand on its own if it is to begin within a reasonable time period.

Should the EB tighten the CDM requirements in order to require that all projects make a showing of financial additionality? The EB is currently considering such a proposal, and may be imposing a *de facto* financial additionality requirement by rejecting projects that fail to provide a convincing investment analysis. Both of these developments have been opposed by IETA, an association of carbon traders and other major private-sector carbon markets participants (Derwent, 2008).

Our experience with bagasse projects leads us to believe that the additionality problem is very serious indeed.<sup>7</sup> Absent strong regulation of additionality by the CDM Executive Board, project developers and intermediaries will submit non-additional projects (Michaelowa and Purohit, 2007). Even projects like the bagasse electricity projects that look environmentally sound on their face could well be non-additional for financial reasons. For that reason, we applaud the Executive Board’s recent efforts to tighten the additionality requirement.

<sup>4</sup> Note that to date eight more bagasse power generation projects have been rejected for reasons not related to additionality (for a total of 15 rejected projects). Six projects have withdrawn their applications. Source: authors’ calculations based on data available at <http://cdmpipeline.org>, last accessed March 2009.

<sup>5</sup> The most concise articulation of the complex rules governing the use of barriers additionality is provided by the flow chart on p. 3 of the “Combined Tool to Measure Baseline and Additionality,” which is referenced in the ACM0006 methodology that governs bagasse electricity projects. Available at: [http://cdm.unfccc.int/methodologies/Tools/meth\\_tool02.pdf](http://cdm.unfccc.int/methodologies/Tools/meth_tool02.pdf).

<sup>6</sup> For an example of a sugar mill relying on a barriers analysis, see the Kakira Sugar Works project Project Design Document t, p. 13–16, available at <http://cdm.unfccc.int/>. For further discussion of additionality, barriers, and the sugar sector, see also Haya et al. (2009).

<sup>7</sup> Our conclusion echoes that of other CDM studies. Based on a 2005 sample of 19 projects, Sutter and Parreño (2007) give 11 out of 16 analyzed projects a “C” rating for additionality, corresponding to a judgment that additionality was “unlikely.” Based on a 2006 study of 52 Indian projects, Michaelowa and Purohit (2007) estimate that the additionality of a significant percentage of certified projects are questionable. Based on a 2007 analysis of 93 projects, Schneider (2007) estimates that 40% “unlikely or questionable,” though he notes that because of the smaller-than-average size of these projects, the projects account for 20% of total emissions reductions claimed by the CDM.

On the other hand, our research also indicates that projects can face real barriers to implementation, and we believe that these barriers should at least inform the EB’s additionality determination. The work of others has already provided a comprehensive list of the barriers that a bagasse power project may face, including technical barriers, institutional barriers, macroeconomic barriers, knowledge barriers, and barriers related to country risk (Restuti and Michaelowa, 2007). Our own research leads us to believe that three categories of barriers are particularly important. First, a regulatory infrastructure that incentivizes, or at the very least permits, independent power production is an absolute prerequisite to the implementation of a bagasse electricity project. If a sugar mill needs to overcome this barrier – say, by lobbying the government to make its project succeed, or by accepting an uncertain regulatory framework – it will need a higher-than-normal rate of return to make it willing to accept the risk it is taking on the project.

Second, and related to the first point, structural issues in the electricity industry can also be a problem. In order to get a loan for its project, a sugar mill typically needs to create a secure revenue stream by negotiating a long-term power purchase agreement with a utility. A firm considering a bagasse power project in Indonesia, for example, would have to contend with the fact that its contract partner – the national electric utility – may be financially unsound (Wu and Sulistiyanto, 2006). Trapped between rising prices for the electricity it buys in an unregulated wholesale sector and regulated retail prices for the electricity it sells to consumers, the utility has been losing money each year. In the past, it has been propped up with monies from the general fund, and has been able to sign contracts only when the national government agreed to guarantee its liabilities. However, the government recently gave notice that it planned to discontinue this practice. Without a creditworthy customer, a sugar mill would have little hope of getting a loan from a bank, and, given that it is in the sugar business and not the electricity business, even less desire to accept the full investment risk itself by becoming a “merchant” power plant.

Third, even if the regulatory infrastructure does exist and a creditworthy long-term power purchaser is available, a typical bagasse power project depends much more heavily on the wholesale electricity price the sugar mill is able to negotiate with the electric utility than on the price of CERs. For example, in the model described in Table 4 above, an electricity price of €50 per MWh would result in an internal rate of return to 35% while an electricity price of €25 per MWh would decrease the IRR to 5% (See Fig. 4).

Thus, the success of a project turns on the price that the sugar mill is able to negotiate with the power purchaser rather than on the availability of revenues from CERs. As a relatively small power provider that might want some flexibility in its requirement to account for outages or years with lower-than-average bagasse

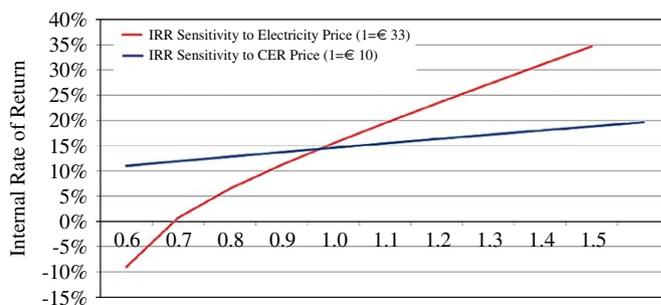


Fig. 4. Bagasse generation project profitability sensitivity to electricity and CER prices.

production, a sugar mill might not have a lot of leverage in such a negotiation. The fact that sugar mill management is unlikely to have expertise in negotiating long-term power purchase agreements compounds the problem. This, too, is a barrier that ought to be considered by the executive board in evaluating whether or not the project is additional from a financial perspective.

In brief, consideration of the obstacles faced by bagasse electricity projects leads us to the conclusion that financial additionality should be required for every project in order to ensure the environmental soundness of CDM emissions reductions, but that requirement should be informed by the industry- and country-specific barriers faced by the project. A rate of return alone will never be sufficient to prove or disprove additionality. A risk-free project might be non-additional with a 5% return, while a project facing serious barriers might be additional with a 50% return.

One of the most attractive aspects of the CDM as a funding mechanism is deeply entwined with the additionality problem. The fact that the CDM can use relatively small awards of CERs to leverage much larger investments in clean energy projects is a positive feature of the mechanism. For example, in the hypothetical bagasse electricity project described in Table 4, €600,000 per year in CER sales has leveraged an investment of nearly €20 million in clean energy capacity. This leverage means that every dollar of CDM investment drives several dollars of investment in clean energy. However, it is that same leverage that causes the low share of CDM revenue as a share of total project financial flows and calls into question the additionality of the project. Thus, caution is called for when rejecting projects for lack of additionality. The projects with the greatest doubts about additionality are also the projects that have the highest potential return in terms of total clean investment financing. Over-skepticism about additionality could risk limiting CDM access to projects like the HFC-23 projects, in which CDM revenues are 100% or close to 100% of total project revenue.

Therefore, we believe that in its application of the financial additionality requirement, the EB should not lose sight of the big picture. Awarding CDM credit to a handful of projects that do not deserve it is a small price to pay for inspiring huge investment flows which have the potential to change the carbon intensity of growth in the developing world.

## 5. Getting the credits to market: consultants, financial intermediaries, and the health of the CDM as a marketplace

When a sugar mill decides to go forward with a bagasse electricity project, it typically retains a consultant to help it prepare CDM-related documentation for submission to the Executive Board. The core task is the elaboration of a Project Design Document (PDD), which describes the project activity and estimates yearly emissions reductions using the approved methodology discussed in Section III above. As Table 5 shows, several firms have acted as consultants on a fairly large number of bagasse electricity projects. However, the large size of the “other” category testifies to the fact that smaller consultancies have assisted sugar mills in certain regions (especially India), and that some sugar mills may have prepared their documentation themselves.

Determining the purchasers of credits from bagasse electricity projects is more problematic than determining the names of the consultants that worked on the project, for three reasons. First, the majority of projects list “N.A.” in the purchaser field. Second, some of the listed “purchasers” are in fact consultancies that are paid in-kind with CERs. Third, the data record only the first purchaser of CERs. Typically, these “primary market” purchasers

**Table 5**

Project design consultants listed on bagasse power projects.

Consultants	No. of projects
Ecoenergy	38
Agrienergy	32
Ecoinvest	25
Ecosecurities	9
Care sustainability	5
Arquipélago Engenharia Ambiental	4
Bannari Amman Group	4
Core CarbonX Solutions	3
MITCON	3
Triveni Engineering and Industries	3
World Bank Carbon Fund	3
Other consultancies with 2 or fewer project listings	24
Project owner self-listed as consultant	40

Source: author's analysis of data available at <http://cdmpipeline.org>, last accessed March 2009.

**Table 6**

Top recipients of CERs generated by bagasse power projects.

	Number of projects	CERs expected by 2012
No recipient listed	106	26,162,000
Intermediary	67	18,298,000
Electric companies/industry	15	5,534,000
National Government	13	4,615,000
World Bank/IFC	2	757,000

Source: authors calculations based on data available at <http://cdmpipeline.org>, accessed May 2009.

are intermediaries or aggregators which package CERs into instruments like “guaranteed” CERs and then sell them to compliance buyers on the “secondary market.” (Capoor and Ambrosi, 2008).

Nevertheless, the purchaser data provided in Table 6 do support several basic conclusions. First, private-sector carbon trading firms tend to dominate the demand side of the market. Sixty-seven projects listed private-sector traders, compared to 15 that listed public-sector buyers and 15 that listed electric companies or other end users of credits.

Second, outside of Agrienergy, which was paid for its consultancy services with CERs on 35 out of 170 projects, the primary market for bagasse power project CERs does not appear to be concentrated. The majority of listed purchasers bought CERs from only one or two projects.

Finally, it is notable that two of the firms on the consultant list – Agrienergy and Ecosecurities – are also large primary market “buyers” of bagasse CERs, but that others – e.g. Ecoenergy and Ecoinvest Carbon – are not. While the data are not entirely reliable in this case, they do reflect the broader trend towards diversification of business models in the CDM intermediation and aggregation market. At a high level, there are at least four carbon market roles: project consulting, credit aggregation, intermediation, financing, and speculation. *Consultants* help with project design and lead PDD preparation and compliance with administrative procedures. *Financiers* help projects access funds, either by traditional means or by paying up-front for CERs or options to buy CERs in the future. *Intermediaries* “make the market” by matching up buyers and sellers. On some transactions, intermediaries act as brokers, matching up buyer and seller and taking a percentage of the sale. On other transactions, they actually buy the carbon assets on their own balance sheet, planning to later resell them at a profit. *Aggregators* pool together CERs from many different projects. They thereby reduce the risk of non-delivery

from any one project, allowing them to re-sell the CERs at a higher price as “guaranteed CERs.” *Speculators* take carbon market positions on their own balance sheets, hoping to profit from accurate predictions of price movements. In so doing, they increase the information, smoothing out price fluctuations.

These roles are not mutually exclusive, and are combined in different ways by different firms. For example, the data suggest that Ecoenergy’s bagasse project work has been limited to consulting only. On the other hand, Agrienergy’s receipt of CERs as “success payments” for its work as a consultant allows it to function as an intermediary or aggregator as well. Additionally, the contingent nature of the success payments builds some financing for the CDM project development into the transaction. A third firm, EcoSecurities, offers consulting, aggregation, and intermediation services, and also speculates on the price of CERs (MacCalister, 2007).

Taking a step back, the picture that emerges from an examination of the players in the bagasse electricity CDM sector is of a competitive, decentralized marketplace, one that is attractive not only to buyers and sellers, but also to intermediaries and consultants of various stripes. This is important. The consultants are part of the efficient division of labor that makes it possible for CDM projects to be developed as cheaply as possible. Consultancies develop expertise in certain kinds of projects, and are able to serve sellers and buyers by advising them on project development and elaboration of required documentation. The intermediaries are also critical. Because the CDM is a project-based system, and not an actual market with a trading floor, intermediaries are needed to “make the market.” Without them it would be very difficult for sellers and buyers to find one another, and costly to negotiate appropriate prices. Similarly, aggregation allocates risk to the party best positioned to bear it, allowing compliance buyers to purchase guaranteed CERs and giving intermediaries a chance to make a profit through aggregation and carbon market speculation.

Of course, in the aftermath of the recent financial crisis, it is also appropriate to wonder whether the regulatory framework within which this business ecosystem operates is adequate. Attracted by the fact that the value of carbon assets are “non-correlated” to economic performance, investment banks have already begun helping carbon market aggregators use carbon assets as the basis for financial derivatives (McCulloch, 2007). At least one investment bank has already created risk tranches from pooled projects, just as many financial-sector firms did with mortgages in the period preceding the financial crisis. In fact, the carbon market experienced its first mini-crisis in 2007, when the largest carbon trading firm, EcoSecurities, downgraded the value of its portfolio after finding that its CDM investments were not yielding as many credits as they had expected. The firm’s stock price fell by 47% (MacCalister, 2007).

Therefore, it is critical that as the CDM grows up, regulation grows up around it. For example, carbon traders might need to be subjected to reserve or reporting requirements. Additionally, it may be necessary to restrict their business activities to prevent the emergence of conflicts of interest and to check overly risky behavior.

## 6. The certification process: a barrier to wider implementation?

The rules governing the CDM were finalized in 2001, during the 7th Conference of the Kyoto parties. The CDM is governed by an Executive Board (EB), which is responsible for overseeing the registration of CDM projects, managing a registry of the Certified

Emissions Reductions (CERs) awarded to CDM projects, and certifying the project emissions reductions on an annual basis.

Development of a CDM project from the initial application to the actual issuance of credits can be thought of as a seven-step process:

1. *Project Design Document (PDD)*. The project developer and its consultants complete a project design document describing the project, making an argument that the project is additional, and applying an approved methodology to measure the emissions reductions from the project.
2. *Designated National Authority (DNA) Letter of Approval*. The project design document must be approved by the DNA, the governmental entity in the host country that is responsible for approving CDM projects.
3. *Designated Operational Entity (DOE) Validation*. The CDM requires that every project be independently validated by a UN-chartered “Designated Operational Entity.” Currently 19 DOEs have been accredited by the UN. Some are for-profit businesses, while others are non-profits or governmental organizations.
4. *Registration by the CDM Executive Board (EB)*. The Executive Board of the CDM certifies the validation and registers project. The Executive Board may request review of a project before registration. In the CDM’s first few years of operation, the EB rarely requested review, but as criticism of the non-additionality of many projects has picked up, both the rate of requests for review and the rate of actual review have increased. Currently, the EB reviews about 30–50% of DOE validated-projects.
5. *Monitoring*. When the project is complete, the project developer may begin implementing the monitoring plan as it is set out in the project design document. For a grid-connected electricity generation project, the most important monitoring task is the metering of power transmitted to the grid.
6. *Verification/certification*. On a periodic basis, the project submits a monitoring report to the DOE. The report is verified by the DOE, which certifies the credits and makes an issuance report to the EB.
7. *Issuance of CERs*. The EB is required to issue CERs within 15 days of the receipt of the DOE’s certification report. However, if the EB is not satisfied with the report, it can put the issuance under review.

All together, it can take a project developer up to 3 years to complete all of these steps. Using data from all submitted CDM projects, Table 7 breaks down the total delay into average wait times at each major stage of the process.

Preparation of the Project Design Document can often be completed within a few weeks, though it may take longer for some novel projects. The time required for the Designated National Authority approval varies by country. India’s DNA typically issues a letter of approval within 3 months. The Designated Operational Entity typically takes another 2–8 months to validate the project. Although CDM rules state that EB approval should come within 8 weeks of DOE validation, it often takes a longer in practice, and observers are concerned about the EB’s ability to keep up with its workload as more and more projects are submitted for approval (Capoor and Ambrosi, 2008). Finally, there is a time lag between project registration and the first issuance of CERs according to project monitoring. In effect, CDM administrative requirements create a bottleneck behind which a long pipeline of projects backs up. One hundred and six bagasse electricity projects, or about half of the 204 projects that have been submitted to date, sit in this pipeline.

**Table 7**  
Average number of days project spends at each stage in CDM pipeline

	Start comment—DOE validations <sup>a</sup>	DOE registration request—EB registration	Registration—first CER issuance <sup>b</sup>	Total
Mean # of days	276	130	373	779
Standard deviation	154	82	221	

Source: Authors' calculations based on data available at <http://cdmpipeline.org>, last accessed May 2009.

<sup>a</sup> Excludes 3 (of 1595) records that recorded a registration request (DOE validation) date earlier than the start comment date.

<sup>b</sup> Includes only projects to which CERs have been issued.

**Table 8**  
Results of survey of publicly-available documentation for 10 bagasse projects.

Project	Project description	Total MWh per year	Emissions reductions (tCO <sub>2</sub> e/year)	One-time investment cost	Ongoing O&M costs
Mawana Sugar Works, India	1.86 kg/cm <sup>2</sup> boiler; 1 extraction cum condensing turbo-generator of 19.1 MW	177,660	60,267		
Alta Mogiana, Brazil	3.42 bar boilers; 1.25 MW backpressure turbine	81,400	13,107		
Vale do Rosario, Brazil	1.65 bar boiler; 4 turbo-generators	247,500	31,775		
Dwarikesh Sugars, India	1 water tube bagasse fired traveling grate; 1.86 kg/cm <sup>2</sup> boiler; 1.24 MW double extraction cum condensing turbine	110,530	21,724	€1,701,711	€18,250
Santa Elisa, Brazil	1.65 bar boilers; several new backpressure turbines	330,000	57,823		
Godavari Sugar Mills Ltd., India	2 steam generators (2 × 100 TPH); turbo-generator of 30 MW	189,336	88,971		
Kakira, Uganda	2.45 bar boilers; 1 new 16 MW double extraction turbo-generator	204,255	57,348	€12,045,000	
Dan Chang, Thailand	2.70 bar boilers, 1.41 MW double casing turbine generator, 1 cooling tower	271,094	93,129	€34,288,100	
Monte Rosa, Nicaragua	1.62 bar boiler, 1.15 MW condensing type turbo-generator; 2.20 MW extraction type turbo-generators	199,134	56,020		
FFHC bagasse, Phillipines	Replacement of all boilers and turbines with high-efficiency equipment	210,000	120,000	€44,000,000	

Estimates of the total cost of certifying a CDM project vary widely and depend on project size (Michaelowa and Jotzo, 2007). Some of the apparent discrepancy between the estimates of different studies is actually due to disagreement over what costs should “count.” For example, does cost include the project developer's initial costs of finding a broker and negotiating a purchase agreement, or just the certification term in the Emissions Reductions Purchase Agreement? Are ongoing monitoring costs included? Moreover, costs depend on the nature of the project in addition to its size. A project that has to develop a new methodology and certify the methodology before certifying the project itself will be significantly more expensive than a project that makes use of a well-established methodology.

All that said, a reasonable ballpark estimate for the administrative costs of a medium-size project such as a bagasse electricity project is between €36,500 and €219,000 (Michaelowa and Jotzo, 2007). As other authors have noticed, high costs to access the CDM do raise a serious equity issue (Wara and Victor, 2008; Haya, 2007). For small, decentralized, or otherwise marginal projects outside of the corporate context, particularly in a LDC, figures in the hundreds of thousands of dollars merely to certify a project might well preclude implementation. In other words, the cost of certification and monitoring under the CDM, while important to ensure that claims about carbon emissions reductions are real, creates a *de facto* barrier to entry that may be enough to prevent small projects from seeking CDM registration.

This barrier to entry is not as serious for projects undertaken by Sugar mill-sized corporations as it is for a smaller project. Next to a €15–€45 million capital investment in sugar mill equipment and yearly revenues in the millions, €36,500–€219,000 is not a significant expense, and it is unlikely that administrative costs are preventing many sugar mills from implementing bagasse electricity projects.

In the context of the sugar industry, the long lag times between project submission and issuance of credits are a much more serious problem. From a sugar mill's perspective, it is bad enough that it has to rely on the international public sector not to extinguish the demand for carbon offsets for a period of 10–21 years. That they will not even receive the first year's share of assets for 3 years after the “go” decision on the project makes it even more unattractive, and tends to chill CDM investment.

Clearly, there is a trade-off between certification speed and the administrative procedures necessary to ensure that emissions reductions are additional and correctly quantified. We do not mean to suggest that the process should be streamlined at the expense of accuracy. However, there is reason to believe that certain delays are unnecessary. For example, currently the CDM Executive Board is re-reviewing many of the projects reviewed by the Designated Operational Entities (DOEs). Evidently, the Executive Board is dissatisfied with the quality of the DOEs' project evaluation. However, this begs the question of how much value the DOEs, on whose desks projects sit for an average of 276 days, currently add to the process. It seems that either DOE validation should be improved, or the Executive Board should hire the additional staff necessary to undertake all validation itself.

There is also room for improvement by the national governments. While DNA approval is critical in order to ensure that CDM projects are directed toward national priorities, it may be possible for the CDM to find a way to ensure that DNAs process project applications in a timely manner.

## 7. Conclusion

The CDM is working for bagasse power projects. It is both delivering low-cost emissions reductions to Annex 1 nations and

contributing to clean energy investment in non-Annex I nations. Thanks in part to the emergence of a robust and reticulated private sector around the CDM mechanism, investment is flowing toward the clean energy sector, and relatively small amounts of CDM revenue are inspiring large project decisions. The methodology approved by the CDM Executive Board is detailed and relatively confidence-inspiring.

That said, bagasse power projects reveal two opportunities for improvement. First, the additionality standard needs to be tightened and made more transparent and consistent. To be considered environmentally sound, a project must be financially additional. However, any financial additionality test applied by the CDM Executive Board must be informed by the significant barriers that many projects, and should not be applied in a way that loses sight of the CDM's big-picture goals. Second, the administrative process needs to be streamlined in order to prevent long registration time lags from chilling clean energy investment.

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