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Barriers to sugar mill cogeneration in India: Insights into the structure of post-2012 climate financing instruments

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The Indian government has set the challenging goal of increasing its electricity capacity six- to eight-fold in the next 30 years in the context of significant capacity shortfalls and a financially ailing electricity sector. The central and state governments are subsidizing renewable energy because of energy security concerns, to promote domestic resources and a diversity of fuel supply. International funds made available through the international climate change regime could potentially provide much needed support to pay the higher costs that most renewable energy requires. This article performs a case study analysis of the history of the development of one renewable energy technology in India – cogeneration of sugarcane waste – focusing on the barriers this technology has faced in the past and now faces, and how well international and domestic efforts have worked to overcome these barriers. The goal of this work is to lend insight into the effective structure of future international support mechanisms being discussed for inclusion under the post-2012 climate change regime. This study finds that bagasse cogeneration has faced layers of informational, technical, regulatory and financial barriers that have changed over time, and differed significantly between the private and cooperative sugar sectors. Each of the programmes designed to support bagasse cogeneration had a role to play in enabling the bagasse cogeneration currently installed, and no single programme would have been successful on its own. Some barriers to the technology needed directed efforts designed to address the specific context of the sugar sector in India; simply subsidizing the technology or putting a price on carbon was not enough. Where climate (global) and development (local) priorities differ, projects that bring about international goals risk running into conflict with other more pressing domestic goals. Interviews at mills attempting to access carbon financing through the Kyoto Protocol's Clean Development Mechanism (CDM) indicate that additionality-testing is a challenge to the effectiveness of this mechanism. Any effort to exploit the remaining 86% of the estimated national potential for high efficiency bagasse cogeneration will need to address the special financial and political conditions facing cooperative mills.

Keywords: bagasse cogeneration; Clean Development Mechanism; CDM; climate change; post-2012; sugar cooperatives; USAID

1. Introduction

There is growing evidence that global greenhouse gas (GHG) emissions must be reduced by a daunting 45–80% below 1990 levels in the next 50 years for there to be a high likelihood of preventing dangerous disruption to the earth's climate (Baer and Mastrandrea, 2006, den Elzen and Meinshausen, 2006). These reductions must be made without constraining improvements in living standards in developing countries. Given how quickly global GHG emissions must be controlled, and the wide disparities among countries in levels of responsibility for causing climate change and capacity for mitigation, the post-2012 climate change regime will need to include substantial financial and technological support to help developing countries decarbonize their economies. Under discussion is the nature of the institutions through which such support will be provided.

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Proposals for the structure of these institutions largely fall into two categories: carbon trading-based mechanisms, such as the Kyoto Protocol's Clean Development Mechanism (CDM), and global funds, such as the Global Environment Facility's (GEF) climate change portfolio.

To lend insight into the design of such future support mechanisms, and the relative benefits and limitations of these two approaches, this article provides an in-depth look at the development of high efficiency bagasse cogeneration (the generation of electricity and steam from sugarcane waste) in India. It describes the development of this technology from its early projects through its current capacity, at 711 MW, 14% of its potential. It focuses on the barriers this technology has faced over time, and the effects of past international and domestic programmes, including the CDM and the GEF, in overcoming these barriers. This article examines why this cost-effective technology has not achieved greater deployment. The story of bagasse cogeneration, played out in a complex development context interlinked with multiple sectors of the Indian economy, offers a rich case study for exploring the potential benefits and challenges of international climate financing instruments as they are being discussed for inclusion under a post-2012 climate change regime. The major goals of the study are to provide: (1) a barrier analysis of high efficiency sugar mill cogeneration based on field study and literature review; (2) a review of the achievements, as well as oversights, of domestic and climate change funding programmes in supporting cogeneration to date; and (3) discussion of the structure of post-2012 financing instruments under the global climate change regime in light of this experience with bagasse cogeneration development in India.

Efficient bagasse cogeneration in India has been ranked among the highest for its potential for cost-effective emissions reductions and other development and environmental benefits (Banerjee, 2006; Smouse et al., 1998). India's sugar industry competes with Brazil for being the largest in the world and has the potential of contributing 5000 MW to the country's electricity grid (Ministry of New and Renewable Energy, 2008; Natu, 2005), which currently stands at a total capacity of 145,600 MW (Ministry of Power, 2008). More recent estimates have been slightly higher, indicating a potential of 5,575 MW (Purohit and Michaelowa, 2007). The technology improves the profitability of the sugar sector, which employs approximately 500,000 people (Natu and Zade, 2002), and on which 50 million sugarcane farmers depend (Department of Food and Public Distribution, 2003). We examine how it came to be that only 14% of India's estimated potential for bagasse cogeneration has actually been exploited to date, despite its cost-effectiveness, multiple purported benefits, and the numerous domestic and international programmes designed to support the technology. This study focuses on bagasse cogeneration development in Maharashtra and Tamil Nadu, two of the largest sugar producing states in India. In Maharashtra, sugar is predominantly owned by sugar cooperatives, whereas in Tamil Nadu the sugar sector is largely private. These divergent trends in agrarian development have important implications for the capacity of these two states to exploit their bagasse cogeneration potential.

The following section of this article provides background information on India's energy and sugar sectors, bagasse cogeneration development in the country, and previous government and international programmes supporting the technology. We then describe our research design and study sites in Maharashtra and Tamil Nadu. This is followed by a detailed analysis of the barriers that have faced bagasse cogeneration over the last decade in both the private and cooperative sectors, and the effects of support programmes in overcoming them. The following discussion examines the implication of these findings on the structure of financial instruments under the post-2012 climate regime.

2. Background

2.1. India's energy sector

The potential benefits of increasing the implementation of bagasse cogeneration can be understood in the context of India's rapidly growing, predominantly coal-based power supply. The combined impacts of urbanization, population growth and economic liberalization in the 1990s increased electricity consumption by five times from 1980 to 2003 (Energy Information Administration, 2007). There continues to be a considerable demand–supply gap as well as poor quality of supply (low voltage and grid instability), and substantial transmission and distribution losses and theft are estimated to be greater than 40% of power generation (Planning Commission of the Government of India, 2006). In order to bridge the supply–demand gap and to keep pace with its rapid growth in gross domestic product (GDP), India plans a rapid expansion of its power sector infrastructure. The government targeted an increase of 100,000 MW between 2002 and 2012 constituting a doubling in capacity (Ministry of Power, 2005) of which 10% is to come from renewable resources. Between 2002 and 2008 India has achieved an increase in capacity of approximately 40,000 MW (Ministry of Power, 2008, Planning Commission of the Government of India, 2002), 20% of which is from renewable energy.[1] In 2005, 69% of India's electricity was generated from coal (International Energy Agency, 2005).

In order to increase the diversity of its energy portfolio, India has made efforts to increase its renewable power capacity. Total grid-connected renewable energy capacity[2] stands at around 12,200 MW (Ministry of Power, 2008), of which wind and small hydro dominate (Ministry of New and Renewable Energy, 2008). This figure, however, is only a small proportion of India's total resource potential in renewable energy. Overseeing the various policy incentives for renewable energy is the Ministry for New and Renewable Energy (MNRE, and until recently called the Ministry for Non-Conventional Energy Sources or MNES). Its activities include, among other things, coordinating demonstration programmes, collecting and compiling resource data, and offering various tax, custom duty and capital and interest subsidy benefits.

India's power sector is severely financially constrained. Most state electricity boards (SEBs) are functioning at substantial losses, and have experienced a spiralling decline in their financial standing and the quality of electricity they provide. Since the 1970s, high industrial tariffs have cross-subsidized low tariffs paid by residential customers and in the agriculture sector and helped cover large transmission losses. Over time, industrial customers started to install dedicated generators which they found to be more reliable and cost-effective than grid electricity with its frequency fluctuations and brownouts and blackouts. As these customers left the grid, utilities saw their revenue base diminishing. This weakened the financial stability of the utilities, including their ability to build more capacity to keep up with increasing demand, which further compromised the quality of the power they produced. With the resulting decline in the reliability of the grid and electricity quality, industrial facilities continued to build captive plants to replace grid electricity and remaining customers became more resistant to tariff increases (Dubash and Rajan, 2002).

A number of reforms in the power sector have been underway since the late 1990s to tackle these inefficiencies with mixed results to date. In 2003, in an attempt to formalize various state-led initiatives, the central government passed the Electricity Act 2003, replacing all previous legislation in the sector. This electricity reform process involves the vertical debundling of generation, distribution and transmission, the establishment of independent electricity regulatory commissions in every state, and the implementation of competitive bidding for electricity contracts.

2.2. Sugar sector and cogeneration technology

India's sugar sector competes with Brazil's as the largest in the world, and is the second largest agriculture-based industry in India, after textiles (Natu and Zade, 2002). A majority of its production is destined for domestic markets (FAO, 2003 in WADE, 2004). India has over 500 sugar mills, 95% of which are located in nine states (Uttar Pradesh, Bihar, Punjab and Haryana in the north, Maharashtra and Gujarat in the west, and Andhra Pradesh, Tamil Nadu and Karnataka in the south). India's sugar sector is very heterogeneous. Mill size ranges from 500 to 10,000 tonnes crushed per day (TCD), with an average capacity of 3,300 TCD (Tuteja Committee, 2004). However, small mills with a capacity of less than 2,500 TCD are considered less efficient and less economically viable than larger mills. Recognizing this, the central government issued a mandate that only factories of above 2,500 TCD would receive new licences. The government also provided additional incentives for mills that undertook expansion projects (i.e. for those mills that wanted to expand from 1,250 TCD to 2,500 TCD and beyond). However, many mills established between 1950 and 1980 are smaller in size and use outdated technology.

Approximately 60% of India's sugar sector is owned and run by farmers through cooperatives, a situation that is unique to the country, while private sugar mills in India are the second largest producer. As with other agricultural cooperatives in the developed and developing world, in the sugar cooperative system in India individual landowning farmers are also shareholders in the sugar factory. Between 10,000 and 50,000 farmers belong to a single cooperative. Farmers deliver cane to the factory during the crushing season, and theoretically have a say in the functioning of the cooperative through their vote. Revenue earned from sugar sales are redistributed to farmer-members in the form of a sugarcane price (Ranganathan, 2005). The cooperative system generally suffers from poorer coordination and is therefore less efficient than the plantation system most common in other sugar-producing countries such as Brazil. This is because the timing for harvesting and crushing sugar cane is crucial, and should be done when the sucrose content in the cane is at peak maturity. Hence, there must be coordination among many small sugar farmers and the sugar mill so that the crop is harvested at its peak, while there is a steady and adequate supply of raw material to the factory (Attwood, 1992). Given its lesser efficiency, the reasons why the cooperative system is still dominant in sugar production in India are rooted in colonial history. Unlike colonial expansion in the New World, British policy did not involve expropriating large amounts of land from the Indian peasantry to cultivate sugar (Attwood, 1992).

As a means of meeting their factory needs for electricity and steam, and of disposing of the large quantities of bagasse (fibrous waste) left over after processing sugar cane, sugar mills all around the world burn bagasse in boilers to produce both steam and power. In the 1960s, efficient bagasse cogeneration was pioneered in Mauritius and Hawaii. The implementation of higher pressure (60 bar and higher) and higher temperature (450 °C and higher) boilers, and corresponding turbines allowed the more efficient burning of bagasse with export of electricity to the grid. Today, a minority of mills around the world export surplus power to the grid via more efficient, high temperature, high-pressure boilers. For instance, Mauritius, an island country with very little fossil fuel reserves, meets 8% of its electricity demand through sugar cane waste alone (Deepchand, 2001)

In order to maximize the use of steam for electricity generation, steam drives are replaced with electrical drives, ensuring more power from the same amount of bagasse. Bagasse cogeneration also creates incentives for increased mill efficiency to maximize the electricity available for export to the grid. Since most cooperative mills have outdated inefficient technology, a considerable amount of investment must be made.[3] Even though both the low efficiency and high efficiency cogeneration of bagasse can technically be considered bagasse cogeneration, in this paper the term 'bagasse cogeneration' refers to the high efficiency technology.

The sugar industry is well suited for cogeneration for several reasons: (1) the continuous manufacturing process of sugar (as opposed to a batch process) is useful for continuous electricity generation; (2) sugar processing requires only low-pressure steam, making higher pressure steam available for electricity generation; and (3) decentralized sources of electricity supply reduce efficiency losses on state grids. Bagasse cogeneration produces net zero emission of carbon dioxide, since the carbon released as CO_2 when bagasse is combusted, was taken out of the atmosphere through photosynthesis.

2.3. Support for bagasse cogeneration in India

In India, interest in high efficiency bagasse cogeneration started in the 1980s when the supply of electricity started falling short of demand. Since high efficiency bagasse cogeneration has been perceived as an attractive technology both in terms of its potential to produce carbon neutral electricity as well as its economic benefits to the sugar sector, a number of domestic and international programmes were launched to support the dissemination of this technology, the largest of which are listed in Table 1 and described below.

2.3.1. Ministry of Non-Conventional Energy Sources (MNES)

The national programme on Promotion of Biomass Power/Bagasse Based Cogeneration was launched in 1992. It involved demonstration projects specifically in the cooperative/state sugar sector, as well as biomass resource assessment studies, training and assistance to states in formulating their power purchase policies. In 1994, MNES expanded its bagasse programme by offering capital and interest subsidies, research and development support, accelerated depreciation of equipment (e.g. boilers, turbines, waste heat recovery systems), a five-year income tax holiday and excise and sales tax exemptions. Capital subsidy for cogeneration projects in the cooperative/public sector sugar mills were Rs. 3.5–4.5 million/MW ($0.87–1.1 million/MW) depending on the level of pressure of the boiler. Interest subsidies for commercial biomass power projects were 1–3% depending on the pressure of the boiler. MNES also offered a range of other services, such as biomass resource assessments and funding for bagasse cogeneration workshops and prefeasibility studies. Jawahar SSK, a cooperative sugar factory in Maharashtra and one of the nine mills visited for this study, was one of MNES's pilot projects.

TABLE 1 Summary of largest programmes that have supported bagasse cogeneration in India

Funding institution	Type of support provided
Ministry of Non-Conventional Energy Sources (MNES)	Interest subsidy, capital subsidy, tax benefits, workshops, pilot projects in the cooperative sector and lower customs duty for importing technologies
US Agency for International Development (USAID)	Up to 10% equity contribution for nine demonstration projects, trainings, workshops, newsletter and outreach activities
Indian Renewable Energy Development Agency (IREDA)	Multilateral lines of credit for renewable energy development provided through IREDA from international and bilateral finance institutions. The Asian Development Bank (ADB) provided funds dedicated for bagasse cogeneration
Clean Development Mechanism (CDM)	A project-based carbon offsetting programme established under the Kyoto Protocol
Global Environmental Facility (GEF)	Project under preparation to provide creative financing to cooperative mills

2.3.2. USAID Alternative Bagasse Cogeneration Project

A major source of international funding for bagasse cogeneration has been the United States Agency for International Development (USAID). Complementing the Indian government's efforts through the 1990s, USAID carried out an initiative from

1994–2003 called the Greenhouse Gas Pollution Project (GEP) with a special component for bagasse cogeneration (the Alternative Bagasse Cogeneration or ABC component). This project built on prior work by the USAID in the late 1980s in which a series of feasibility studies assessing the potential for bagasse cogeneration were carried out. Nine mills were chosen as demonstration projects and were screened for their financial viability. The criteria were that the mills had to have a capacity above 2500 TCD, and had to install boilers that were 60 bar and 480 °C or above. The chosen mills were required to operate for 270 days per year only on biomass. In order to elicit participation by sugar mills, USAID issued a request for proposals inviting mills to apply for the grant assistance. The nine chosen mills received grant assistance of $1 million per project (or 10–20% of the project cost). Another component of this project involved a series of trainings and workshops, a quarterly newsletter and outreach efforts to inform Indian sugar mills of the possibility of exporting electricity to the grid. Two mills visited in this study, TA Sugars and EID Parry, were USAID demonstration projects.

2.3.3. Asian Development Bank (ADB)

ADB is one of several international finance institutions that extend lines of credit to the Indian Renewable Energy Development Agency (IREDA) for loans for biomass cogeneration, some with portions reserved for bagasse cogeneration. A loan to IREDA from ADB contains a portion specifically dedicated to supporting bagasse cogeneration projects, and in 2004 had supported 130 MW of the technology.

2.3.4. Clean Development Mechanism (CDM)

Under the Kyoto Protocol the primary mechanism involving developing countries in emissions reducing activities is the CDM. The CDM is a project-based emissions trading mechanism that allows industrialized countries to fund emissions reducing projects in developing countries and use the resulting carbon credits towards their own domestic targets. The CDM is one of several ‘flexibility mechanisms’ established under the Kyoto Protocol, creating flexibility in how industrialized countries can meet their Kyoto targets. A project that is successfully registered under the CDM is allowed to generate carbon credits periodically according to a defined methodology for estimating emissions reductions from that project type. In September 2008, India hosted 356 registered CDM projects, just under one-third of the global total, with an additional 690 projects in the process of applying for inclusion in the CDM (Fenhann, 2008). Of these, 33 are bagasse cogeneration projects totalling 534 MW capacity. During September 2008, 55 more bagasse cogeneration projects were in the CDM pipeline seeking approval for registration, amounting to 1,050 additional megawatts if all are built.

2.3.5. Global environment facility (GEF)

The GEF was established in 1992 to support activities in developing countries that have positive benefits on global environmental problems. The GEF funds the ‘incremental costs’ of activities with global environmental benefits, that is, the additional costs of performing a sustainable activity over the costs of a convention project. The GEF also provides technical assistance grants (for instance, it has provided $5 million to IREDA). Country or state governments apply for GEF funds by submitting project proposals. The GEF has initiated a project, entitled ‘Removing Barriers to Biomass Power Generation in India’, part of which is aimed at developing a model for overcoming the financial barriers specific to bagasse cogeneration in cooperative mills in India. During the time this study was conducted this GEF project was still in its planning stages.

3. Study design and methods

This research, primarily conducted in 2004, involved visits to nine sugar mills in Maharashtra and Tamil Nadu (see Table 2), review of project documentation from the support programmes

TABLE 2 Sugar mills visited

Name of mill and location	Ownership type	Installed capacity in 2004 (MW)	External funding source(s) in 2004
Maharashtra			
Ajinkyatara	Cooperative	–	–
Baramati	Cooperative	–	–
Hutatma	Cooperative	–	–
Jawahar	Cooperative	25.5	MNES
Pravara	Cooperative	–	–
Tamil Nadu			
Chengalryan	State-owned	–	–
EID Parry	Private	24.5	USAID, MNES/ IREDA
Rajshree Sugars	Private	15	None
TA Sugars	Private	110	USAID, MNES/ IREDA, proposed CDM

analysed, and interviews with individuals involved in various aspects of the development of efficient bagasse cogeneration projects. The nine sugar mills chosen comprised five cooperative mills in Maharashtra, three private mills in Tamil Nadu and one state-owned mill in Tamil Nadu. We selected mills with varying situations in terms of stage of implementing bagasse cogeneration, financial standing and size. In Maharashtra, we interviewed one mill that had successfully upgraded its boilers to enable high efficiency cogeneration through financial support from MNES, and five mills that had not yet done so. In Tamil Nadu, we visited three private mills – all of which had installed cogeneration – and one state-owned mill that had not as yet. We visited several highly profitable mills and loss-making mills running for only a fraction of the crushing season. In each of these sites, we conducted interviews with senior management and engineers, and technicians in charge of the mill's everyday operations.

We interviewed individuals working on bagasse cogeneration from the Indian government, non-governmental organizations (NGOs), multilateral agencies that were in charge of implementing renewable energy and/or climate change funding programmes, energy consulting firms and research institutions in New Delhi, Pune, Chennai and Bangalore.

4. Barrier analysis and evaluation of support programmes

When high efficiency bagasse cogeneration was first introduced in India in the early 1990s, several informational, technical and regulatory barriers prevented the rapid uptake of the new technology. Mill owners and managers were largely unaware of the technology, and did not have the technical expertise needed to implement it. Also, the lack of regulatory structures ensuring evacuation of the electricity from the mill and payment for it was a major obstacle to the technology (Smouse et al., 1998). By the time this study was conducted in 2004, mill owners and managers knew about the technology and its benefits, and had access to the substantial technical expertise that had been gained in the country. However, regulatory uncertainties were still a substantial barrier, and the poor financial conditions that had overcome both the sugar and power sectors made the high capital costs required to implement the technology even harder to access. Moreover, the cooperative sugar sector, comprising 60% of the total sugar production in India, faced additional financial problems due to their institutional structure, and today these problems present the most significant challenge to scaling up bagasse cogeneration. In the following sections we trace these shifts and discuss how well various international and domestic programmes have addressed these barriers.

4.1. Informational and technical barriers

Prominent early barriers to the use of highly efficient bagasse cogeneration were informational and technical. Sugar mill owners and managers were largely unaware of the technology. Nor did they have experience working with high-pressure boilers, which involve a higher level of expertise and skill to run than do low-pressure boilers. The demonstration projects, trainings, workshops, newsletters and outreach from both the USAID and the MNES programmes are considered highly successful at overcoming the informational barriers and lessening the technical barriers. A decade after the USAID project started in 1995, mill owners in India were widely aware of the practice of cogeneration with export to the grid. Demonstration projects proved that the technology was cost-effective, and technical information was available to mills considering implementing the technology.

One problem with the USAID programme was that its knowledge transfer component (e.g. newsletters such as Cane Cogen India, other publications, workshops, etc.) did not sufficiently reach out to cooperatives. Published materials were predominantly in English, but most cooperative leaders are not educated in English. Many of the study tours (e.g. to Mauritius) also required hefty participation fees that cooperatives could not pay.[4] In addition, though many mills in India expressed interest in being a USAID demonstration project in response to calls for applications, not one of the applicants was a cooperative mill.

4.2. Regulatory barriers

A persistent barrier to the dissemination of bagasse cogeneration was regulatory uncertainty. At the time that the technology was first being introduced in India, regulations had not yet been put in place ensuring that excess electricity produced by sugar mills would be purchased by state electric utilities or defining the terms and tariffs under which it would be purchased. In 1994, MNES issued guidelines to state electric utilities to purchase power from local generators at avoided costs, plus a 50% contribution to grid connection costs (WADE, 2004). The tariff prescribed by MNES was \$0.049/kWh for 1994–1995 with a 5% compounding escalation per year thereafter, making it \$0.067/kWh in 2002. MNES also issued guidelines for wheeling and banking of power from distributed generators. Based on this, several states independently announced policies for electricity purchase from bagasse cogenerators.

Several sugar mill owners report that state electricity boards have historically not been creditworthy, which makes project developers and lenders cautious about investing in bagasse cogeneration. Many interviewees for this study recalled stories that state electricity boards in various states lowered the tariffs to bagasse cogeneration facilities mid-contract, failed to make payments for six months to a year, or reneged on contracts altogether. For instance, the tariff guidelines for cogenerated power issued by the Maharashtra electricity regulatory commission, faced considerable resistance by the state utility on the grounds that they did not strictly 'need' the power from sugar mills. They insisted on compensation by the government for the higher tariffs they were being required to pay (Deo, 2004). This initial resistance on the part of the Maharashtra State Electricity Board resulted in the delaying of the first cooperative bagasse cogeneration project in Maharashtra,[5] and in turn dissuaded other cooperatives from installing bagasse cogeneration since they believed that they would not be guaranteed a buyer for the electricity they generated. It was generally understood that the reason for these regulatory problems was that state electricity boards, already functioning at substantial losses, resisted purchasing power from independent power generators, especially at supportive rates they deemed excessively high. Experiences with broken contracts, lowered tariffs and delayed payments added substantially to the perceived risk of bagasse cogeneration by mill owners and lending banks.

The prospects of overcoming regulatory barriers are favourable. The Maharashtra electricity regulatory commission, established in the process of power sector restructuring, has made the state electricity board more accountable. Due to this, state electricity boards are less likely to rescind their power purchase agreements with bagasse cogeneration mills. Furthermore, the Electricity Act 2003 allows for open access to the grid. At least one private company (Indal Ltd) has been allowed open access to the Karnataka state grid. This would give sugar mills the opportunity to sell power to customers directly, while they would only pay wheeling charges to the state electricity board.

4.3. Financial barriers

In 2003–2004, drought in major sugar producing states led to low capacity utilization in sugar mills. In the same year, the price of sugar reached a low point in part due to low global sugar prices. These conditions together led to a serious financial crunch in the sugar industry for both private and cooperative mills.

Early implementers of bagasse cogeneration, including the nine mills participating in USAID's pilot programme, had proved bagasse cogeneration to be a profitable technology – especially in that it provided benefits beyond the sale of sugar alone. At EID Parry and TA Sugars, two of the USAID pilot projects, the sale of electricity to the grid provided a steady flow of revenue. Electricity production is viewed as a major revenue source at these mills, and a more stable revenue source than sugar production whose price and yield fluctuates. Electricity is treated as one of their primary businesses. In the context of low sugar prices and drought, electricity production for sale to the grid has provided enough additional revenue to keep some mills out of bankruptcy.

Despite the cost-effectiveness of the technology, mills that had not implemented bagasse cogeneration typically faced a range of difficulties accessing the necessary investment capital – a major on-going barrier to the widespread use of this technology. Financial institutions were hesitant to lend to sugar mills to implement bagasse cogeneration because of the high risk involved. Bagasse cogeneration projects conventionally require investment of Rs. 1 billion (around $25 million), while smaller allied projects, e.g. alcohol distilleries and ethanol producing plants, require an investment of only 10 million rupees.[6] Sugar mills are often successful at attracting the requisite finance for these small projects, but bagasse cogeneration requires an order of magnitude investment that banks are not willing to risk in this industry.[7]

In 2004, most of the mills that had implemented bagasse cogeneration were large private sector mills. Some were owned by large multifaceted companies such as EID Parry, a well-known company that produces a range of known products of which sugar was only one. Banks are likely to fund a bagasse cogeneration plant at such a company because of the financial standing of the company, even if they are not familiar with the sugar sector or the technology. Smaller lesser known mills had a much harder time finding debt. By 2004, the poor condition of the sugar sector, compounded by the poor condition of the electricity sector and the increased regulatory uncertainty this brought, made the sugar sector an even riskier investment, and made it even more challenging for mills to access financing.

Each of the support programmes discussed in this article had a role to play in helping some mills gain access to the investment capital needed to implement bagasse cogeneration. MNES's guidance to states to implement preferential tariffs, and various tax and other benefits, supported the cost-effectiveness of the technology. However, these policies were not always carried out by states or the federal government, introducing substantial risk that undermined the incentives these programme were designed to create. In addition to the problems with power purchasing contracts discussed above, MNES has been criticized for failing to deliver the subsidy payment for implementing the technology as per MNES policy.[8]

The IREDA multilateral lines of credit enabled some mills to acquire loans that otherwise would not have had access to debt, though at high interest rates. High interest rates charged by ADB and other lenders translate into high lending rates to mills by IREDA of around 13%, compared with 7–8% from local banks.[9] IREDA's positive appraisals were commonly used by local banks in their own lending decisions, and as such helped developers to refinance IREDA loans through local banks at much lower interest rates.

Similarly, USAID demonstration projects not only received a subsidy from USAID, but also benefited from the USAID 'stamp of approval' from being chosen as a demonstration project, that enabled them to receive better loan terms. It is also interesting to note that by choosing mills with the strongest financial standing and which were most likely to successfully implement bagasse cogeneration as their demonstration project, USAID was also choosing those mills which were most likely and able to implement the technology without USAID support. For example, TA Sugars had already invested in a bagasse cogeneration plant in one of its mills before the USAID project, and was preparing to shift two other plants to bagasse cogeneration without USAID support. Still, the USAID project was praised because of its success in supporting projects that were successful, and thus demonstrating the successful implementation of the technology.

The GEF project was specifically designed to address the financial barriers of cooperative sector mills. The CDM was designed to improve the financial returns from low emissions projects. Both of these programmes are described in more detail below. Despite all of these programmes, substantial financial barriers still exist, especially in the cooperative sector, as described in more detail in the following section.

4.4. Barriers particular to the cooperative sugar sector

In 1998, 55% of sugar mills in India were in the cooperative sector accounting for 60% of total sugar production in India (Godbole, 2000). Almost half of these mills are in Maharashtra, and 99% of sugar produced in Maharashtra is in the cooperative sector. The cooperative sector has certain political and financial characteristics that make it difficult for them to stay financially solvent; as a result, more than one-third of the cooperative sugar factories in Maharashtra have been loss-making for the past three years, or are running at less than 75% of their capacity.

There are a number of reasons for the poor performance of cooperative mills and for the perception that they are more risky investments than private sector mills. Their institutional structure creates yet additional financial barriers to implementing the technology. First, cooperative mills have historically been smaller than private mills, commonly 2,500 TCD or less. Lower crushing capacity mills are less efficient than higher capacity ones, and it is costly to undertake mill expansion in order to install bagasse cogeneration. Second, as stockholders in the mill, farmers also own a share of the mill profits. These profits are paid to the farmers in the price paid for sugarcane. Therefore mills hold little capital that they can use for investments (Natu and Zade, 2002), and certainly not enough to cover the level of equity needed to invest in cogeneration. Collecting the equity needed would involve a political process whereby farmers would agree to pay for the cost of the equity portion of the investment, such as through receiving a lower price for their sugar cane. Third, because cooperative mills are democratically run, with typical election cycles of five years for board members, there is a high chance of policy change if a new management board is elected. The perception that cooperative mills are less creditworthy expresses itself in state guarantees and collateral requirements by banks (UNDP, 2005), that also, cooperatives are unable to meet. Fourth, some interviewees described the mills as lacking professionalism and not being well managed (also described in Natu and Zade, 2002). The 'un-corporate' culture of cooperatives is something international agencies are not used to, which is one reason they have focused on the more profitable private mills. The cooperative sector's poor financial health, perception by banks and the central and state governments as not creditworthy, and their lack of equity holdings all make it difficult for cooperative mills to access the equity and debt needed to invest in cogeneration.

Support programmes to date have done little to help the majority of cooperative mills implement cogeneration. In 2006, only 50 MW from eight sugar mills were in the cooperative sector (Purohit and Michaelowa, 2007), compared to approximately 600 MW in the private and public sectors. This is despite the higher subsidies cooperatives receive from MNES, and early MNES demonstration projects specifically in the cooperative sector. At the time of this study, the GEF project was being developed specifically to develop a creative financing programme to address the specific barriers facing the cooperative mills.

5. Discussion

Over the last decade, bagasse cogeneration faced a dynamic and varied set of substantial informational, technical, regulatory and financial barriers. These barriers changed over time, and differed between the private and cooperative sectors. Each of the programmes designed to support bagasse cogeneration had a role to play in supporting the 711 MW of bagasse cogeneration currently installed, and no single programme would have been successful on its own. MNES promotional policies, including capital and interest subsidies, a variety of tax benefits and guidelines to states to implement preferential tariffs made bagasse cogeneration cost-effective to implement in India. The USAID programme is considered especially effective in increasing experience in a country with the technology, bringing awareness of the technology to sugar mills throughout the country and offering technical resources and support to mills considering implementing it. Various multilateral lines of credit offered through IREDA offered loans to some mills unable to access debt through other institutions. Still, to date, support programmes have done little to address the unique financial barriers facing the cooperative mills due to the institutional structure of these mills, currently the most pressing barriers facing the technology.

Against this story of bagasse cogeneration development in India, we explore the effectiveness and limitations of the CDM and the GEF, and carbon trading and fund-based instruments more generally, as they are being discussed for inclusion in the post-2012 climate change regime.

5.1. Financial instruments currently being debated for the post-2012 regime

Under negotiations over the post-2012 climate change regime, proposals for structuring mechanisms which will support climate change mitigation in developing countries largely fall into two categories in country submissions and the research literature. One category comprises various credit trading mechanisms that create tradable carbon credits by comparing actual emissions to specified baselines. The Kyoto Protocol's CDM is a project-based credit trading mechanism, generating credits from projects in developing countries that supposedly reduce emissions. Proposals for the CDM post-2012 vary widely, from replacing it to expanding it. Another set of proposals involves implementing a sector-based crediting trading mechanism such as 'no-lose' sector-based targets (e.g. Schmidt et al., 2006). Sectoral targets are targets applied to specific sectors rather than to the whole economy, and can be absolute (a defined figure covering the whole sector) or intensity-based (such as a target per kWh produced or per ton of steel produced). No-lose targets are targets for which the country can sell credits if their emissions are lower than their target, but do not need to purchase credits if their actual emissions exceed their target.

A second category of proposals involves various types of global funds. There are various ways that the funds could be generated. Contributions from each country can be calculated based on principles of responsibility and capability (Mexico, 2008), auction (Norway, 2008) or taxes (Switzerland, 2008). These funds would then be administered through an international body to support specific policies, programmes and projects in developing countries.

5.2. The CDM: the additionality problem

It is interesting to note that not one of the interviewees for this study mentioned the CDM as a factor influencing their decision to invest in the technology, or as an influence on the dissemination so far of bagasse cogeneration in India. This is true even though 173 MW out of the 433 MW of bagasse cogeneration already commissioned or about to be commissioned at the time of the interviews, are in the CDM pipeline.[10] Most of these are currently registered. By the end of 2007, 502 MW out of 711 MW of commissioned bagasse cogeneration were registered CDM projects.[11]

An important reason why the CDM would not likely have had much influence on the technology despite the number of projects in the pipeline relates to the difficulties associated with testing project 'additionality'. The CDM allows industrialized countries to invest in projects in developing countries that reduce emissions and use the carbon credits generated by these projects to meet their Kyoto emissions targets. A challenge to the CDM is estimating the amount of emissions that are actually reduced by the CDM project, and in fact, whether any emissions are reduced at all. Fundamental to the CDM is the need to screen each proposed CDM project, allowing only 'additional' projects to register. The idea of 'additionality' is that if the CDM project would have been built anyway, without the additional revenues from the generation of CDM carbon credits, then the CDM is not actually enabling a project to go forward and therefore is not actually reducing emissions. A project that is 'additional' required the revenue stream generated by the CDM to go forward. Credits generated by non-additional projects, projects that would have gone ahead without the CDM, would allow an industrialized country that purchased the resulting credits to emit more than their Kyoto targets, without reducing emissions in a developing country.

Surprisingly, interviewees involved with four different sugar mills clearly stated that they were planning to implement bagasse cogeneration without the CDM, but were still submitting their projects for CDM approval. At least one of these projects has been successfully registered under the CDM. These CDM project developers seem to view the CDM as a potential additional source of profits for projects they were already planning to build, and the additionality test as a hoop they must jump through to access those funds.

These interviews support concerns raised about the CDM regarding whether it is possible to accurately test whether projects are 'additional'. Various studies describe the poor quality of the evidence provided for the additionality of proposed CDM projects (Michaelowa and Purohit, 2007) and that the subjectivity involved in project development and lending decisions makes it very difficult to accurately test whether individual projects would have gone forward without the CDM (Haya, 2007; Schneider 2007). As a result large numbers of non-additional projects are registering under the CDM (Haya, 2007; McCully, 2008; Wara and Victor, 2008). Without the ability to test with reasonable confidence whether a project would have gone ahead without the CDM, the CDM can be understood as a subsidy for the activities allowed under it, with large uncertainties and transaction costs, rather than a working offsetting programme.

5.3. The CDM: limitations on the barriers it addresses

It is useful to ask how well a carbon trading mechanism like the CDM would address the past and current barriers to bagasse cogeneration if the additionality problem were solved. For example, we can ask if bagasse cogeneration in India would be an appropriate project type for the CDM if the CDM were limited to a defined set of project types (sometimes referred to as a 'positive list'), foregoing the project-by-project additionality test.

The barrier analysis carried out in this study indicates that bagasse cogeneration in India should probably not be included in such a positive list. The CDM supports projects by improving their anticipated financial returns, adding an additional revenue source through the generation of tradable carbon credits. These additional revenues can make a marginally viable project viable (reflected in the investment analysis option of the standard CDM additionality-testing tool). Alternatively, additional revenues from the

CDM can overcome project barriers by compensating for high financial, regulatory or other risks or by otherwise convincing actors to take action to reduce project barriers (reflected in the barrier analysis option of the standard CDM additionality-testing tool).

While bagasse cogeneration is already cost-effective in India, with the help of MNES incentives, it is unclear how the CDM would overcome the other barriers facing the technology. The additional revenues from the CDM would not address the many reasons banks perceive that bagasse cogeneration, especially in the cooperative sector, is a risky investment. Also in most cases, it does not directly help cooperative mills access the equity needed to invest in the technology. While the CDM involves a new set of entities in the project development process, including CDM consultants, carbon credit purchasers and auditors, none of these entities generally involve themselves in the details of project development and planning, and therefore do not engage directly in activities that overcome informational, technical or regulatory barriers. The CDM would not directly incentivize the outreach, workshops and newsletters that were so important when the technology was first being introduced in India, since those performing such activities would not be eligible for CDM credits.

An underlying rationale for the CDM, and market mechanisms more generally, is to put a price on emissions reductions and let the market find cost-effective reductions. Certainly it is positive to change the relative prices of low and high emitting technologies. The CDM could potentially help mills access equity capital if their contract with a credit buyer involves up-front payments in addition to, or rather than, payment for credits once they are generated. Some credit purchasing agreements are already structured in this way. Also, we can envisage that if CDM revenues were guaranteed for any new bagasse cogeneration plant in India, this could allow for lower tariffs, relieving the burden on ailing utilities and possibly the regulatory barriers.

In sum, even if the CDM were recognized as a subsidy for project types allowed under it, and the additionality problem was thus solved, the direct effects of the CDM are still limited and would not address many of the barriers that face this technology now, or have faced it in the past. Other mechanisms would still be needed to address a wider range of barriers.

5.4. Acknowledging competing (global) climate and (local) development goals

One debate in discussions about future financial transfer under international climate agreements is how climate and development benefits are to be weighed against one another. Within the climate policy literature, some argue that climate projects have the potential to have significant synergies with other domestic development goals (Davidson et al., 2003), and are more likely to be successful if they also address these other goals (Swart et al., 2003).

This study of bagasse cogeneration suggests that where priorities differ across scale (international, national and local) these priorities can compete with one another. This is an inherent problem with climate aid. Projects funded based on the international priority of climate change mitigation, run a risk of conflict with other more pressing local goals.

In areas of Tamil Nadu, due to drought and the resulting high price of biomass, paper mills are paying high prices for bagasse. Several sugar mills that have implemented high pressure boilers for bagasse cogeneration have chosen to sell their bagasse to paper mills and burn coal in their new boilers instead, which would not be economically feasible with the old low pressure boilers. Many mills are choosing this option because the current high prices offered for bagasse make it economic to do so. Therefore, projects meant to support bagasse cogeneration for climate change purposes, might actually lead to an increase in emissions by enabling mills to replace bagasse with coal throughout the year. This situation exists as long as the price of biomass remains high, and for mills located relatively close to paper mills.

A second example of a conflict between goals across scale is the interest of electricity companies to remain solvent on the one hand, and the national goal of increasing the renewable energy share on the other. In both Tamil Nadu and Maharashtra the state electricity boards went back on contracts they signed with bagasse cogeneration and wind power plants, rejecting MNES guidelines to offer preferential tariffs for renewable energy while they were running at losses. This conflict produces regulatory uncertainties that are a substantial barrier to investments in renewable energy.

5.5. Discussion of an alternative to credit trading mechanisms: international funds

The variety of barriers that have faced bagasse cogeneration over the last decade and the range of programmes that have been important in enabling its implementation to date, imply that for this technology several support instruments working together would likely be more effective than a single instrument. While the CDM creates a price for carbon emissions reductions, treating all projects uniformly, according to the amount of emissions reduced, international funds like USAID and the GEF are able to customize their projects to address the specific barriers and conditions of the technology they are promoting.

One reason the USAID programme was so successful is because it was developed by individuals who had been working on renewable energy, and bagasse cogeneration specifically, in India for many years. They were familiar with the barriers to the technology and the local conditions under which the programmes would be implemented and could design their programme so that it is suited to these needs and conditions. While the GEF project was still in its planning stages at the time of this study, its intention of developing creative financing strategies for the cooperative sector directly addresses the most pressing barriers currently facing the technology. Such a programme can only be successfully developed with in-depth understanding of the cooperative sugar sector in India.

Still, bridging the global/local gap is a challenge for international funds. Several GEF projects in India supporting renewable energy technologies have been criticized by individuals familiar with them for the lack of transparency regarding how decisions are made as to what GEF proposals are funded, the amount of time it takes to go through the GEF approval process and the lack of accountability and oversight the GEF has to assure positive project results.

6. Conclusions

This study finds that bagasse cogeneration has faced layers of informational, technical, regulatory and financial barriers that have changed over time, and differed significantly between the private and cooperative sugar sectors. Each of the programmes designed to support bagasse cogeneration had a role to play in enabling the bagasse cogeneration currently installed, and no single programme would have been successful on its own. Some barriers to the technology needed directed efforts designed for the specific context in which they were implemented; simply subsidizing the technology or putting a price on carbon was not enough. This, along with the fact that bagasse cogeneration is already cost-effective in India, implies a limitation to the effects carbon trading mechanisms like the Kyoto Protocol's CDM could have in supporting the technology, even if the additionality problem were solved. Interviews at mills attempting to access carbon financing through the CDM indicate that additionality testing is a serious challenge to the effectiveness of this mechanism. Where climate (global) and development (local) priorities differ, projects that bring about international goals risk running into conflict with other more pressing domestic goals. Any effort to exploit the remaining 86% of the estimated national potential for high efficiency bagasse cogeneration will need to address the special financial and political conditions facing cooperative mills.

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Notes

1. Figures taken from Ministry of New and Renewable Energy Annual Reports.
2. Including small hydropower plants, defined as hydropower plants below 25 MW.
3. Interview with sugar engineer, July 2004.
4. Interview with engineer at cooperative sugar mill, June 2004.
5. Interview with engineer at cooperative sugar mill, June 2004.
6. Interview at cooperative sugar mill, July 2004.
7. Interview with cooperative sugar mill owner, July 2004.
8. Interview with manager at private sugar mill, July 2004, who was still waiting to receive the MNES subsidy long after the bagasse cogeneration plant was installed.
9. Interview with IREDA employee, June 2004.
10. This analysis is based on data from Fenhann J. 2008. CDM Pipeline Overview. UNEP Risø Centre. http://www.cdmpipeline.org/. It is assumed that projects are commissioned by their *credit start date* listed in the database.
11. It is assumed that projects are commissioned by their *credit start date* listed in the database. This figure includes CDM projects which will be registered pending corrections made to the Project Design Document.

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