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Can the Clean Development Mechanism attain both cost-effectiveness and sustainable development objectives?

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Sammendrag: Den grønne utviklingsmekanismen (CDM) er definert i Kyotoprotokollen, og har to målsetninger: å fremme bærekraftig utvikling i utviklingsland, og forbedre global kostnadseffektivitet ved å bistå de utviklede landene i å nå sine Kyotoforpliktelser. Målsetningen med denne artikkelen er å utforske bakgrunnen for CDM og diskutere til hvilken grad dens nåværende design åpner for innfrielse av begge målsetningene. Den første delen er en litteraturgjennomgang som inkluderer beskrivelse av Kyotomekanismene, CDMs markedspotensiale, og temaene kostnadseffektivitet og bærekraftig utvikling. Artikkelens andre del består av en diskusjon av hvorvidt det er en konflikt mellom kostnadseffektivitet og bærekraftig utvikling, og hvorvidt begge målsetningene kan oppnås samtidig. Vi utvikler et sett av indikatorer for å evaluere tilleggseffekter av CDM prosjekter m.h.t. miljø, utvikling og likhet, og viser hvordan disse indikatorene kan brukes i praksis ved å analysere potensielle CDM prosjekter i Brasils og Kinas energisektor. Vi demonstrerer at det for enkelte CDM prosjekter vil være en avveining mellom kostnadseffektivitet (i form av lav kvotepris) og et godt resultat på indikatorene for bærekraftig utvikling. Vi har grunn til å tro at størrelsen på CDM markedet i enkelte studier er overestimert siden transaksjonskostnader og utfordringen med å fremme bærekraftig utvikling ikke er tilstrekkelig inkludert. Et sett med indikatorer kan være et nødvendig redskap for å sikre at CDM prosjekters innvirkning på bærekraftig utvikling blir tilfredsstillende tatt med i betraktning.

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Abstract: The Clean Development Mechanism (CDM), as defined in the Kyoto Protocol, has two objectives: to promote sustainable development in host developing countries, and to improve global cost-effectiveness by assisting developed countries in meeting their Kyoto targets. The aim of this paper is to explore the background of the CDM and discuss to what extent its current design allows it to achieve its dual objective. The first part of the paper is a literature review that includes descriptions of the flexibility mechanisms under the Kyoto Protocol, the CDM's market potential, and the issues of cost-effectiveness and sustainable development. In the second part of the paper, we discuss to what extent there is a conflict between cost-effectiveness and sustainability, and whether the two objectives of the CDM can be achieved simultaneously. We develop a set of indicators to evaluate non-carbon benefits of CDM projects on the environment, development, and equity, and show how these indicators can be used in practice by looking at case studies of CDM project candidates in the energy sector from Brazil and China. We demonstrate that for some CDM projects there is a trade-off between cost-effectiveness, in terms of a low quota price, and a high score on sustainability indicators. We have reason to believe that the size of the CDM market in some studies is over-estimated since transaction costs and the challenge of promoting sustainable development are not fully accounted for. Also, we find that the proposed set of indicators can be a necessary tool to assure that sustainability impacts of CDM projects are taken into consideration.

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1 Introduction

The Kyoto Protocol was adopted at the third Conference of the Parties (COP-3) to the United Nations Framework Convention on Climate Change (UNFCCC) in December 1997. Developed countries (Annex I countries) are through this protocol committed to reducing their emissions of six gases or groups of gases.[1,2] The Kyoto Protocol allows for some flexibility in fulfilling these commitments through the use of the flexibility mechanisms *emissions trading* (ET), *Joint Implementation* (JI), and the *Clean Development Mechanism* (CDM). The CDM is one of the most interesting components of the Kyoto Protocol since it is the only direct manner in which non-Annex I countries (developing countries) can be involved in emissions abatement measures. It is also highly relevant since certified emissions reductions (CERs) were to be obtained from the year 2000 to achieve compliance for the first commitment period (2008-2012). Article 12 of the Kyoto Protocol defines the CDM's purpose as follows:

> *The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3 (UNEP, 1998, p. 16).*

The CDM therefore has the dual objective of promoting sustainable development in developing countries and ensuring international cost-effectiveness in reducing greenhouse gas (GHG) emissions. The idea is to assist the developing countries onto a more sustainable path through, for instance, technology transfer, capacity building, and financial resources. At the same time, these activities are to bring about reductions in GHG emissions. The benefits will therefore not only be reductions in global GHG emissions, but most likely also local and regional improvements. An example of such a case is when energy-savings programs make the building of a new fossil-fuelled power plant superfluous. This not only reduces emissions of CO_2, but also of nitrogen oxides (NO_x), sulphur dioxide (SO_2) and particles. The reductions of these other emissions could have positive effects on health conditions and building materials, and reduce acidification and vegetation damage at a regional level (Seip et al., 2000).

The CDM therefore appears to be a mechanism from which both investors and host countries may benefit. However, there is a tendency both in the literature and in general to focus almost exclusively on the issue of assisting Annex I countries in fulfilling their commitments. Estimates of the GHG abatement potential of the CDM are common. However, there is hardly any focus on how the CDM can be used to promote sustainable development, and to what degree. There seems to be a general assumption that projects that are attractive in terms of GHG abatement also promote sustainable development in developing countries. While this may be true for many projects, there will probably also be projects that are more attractive from a GHG abatement perspective than from a sustainable development perspective (WRI, 1999).

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[1] 'Annex I countries' refers to the industrialized countries that have special commitments under the UNFCCC. These countries are with minor exceptions identical to the countries listed in the Annex B to the Kyoto Protocol (so-called Annex B countries) where the countries' specific emissions reduction targets are specified. To avoid any confusion, we hereafter use the term 'Annex I countries.'

[2] The six gases or groups of gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorcarbons (PFCs), and sulphur hexafluoride (SF_6).

The aim of this paper is to explore the background of the CDM and discuss to what extent its current design allows it to achieve its dual objective. The paper consists of two parts. The first part comprises a literature review that starts with a short historical presentation of all three flexibility mechanisms. The review then continues with an assessment of the CDM market's potential followed by a description of key issues that will determine the cost-effectiveness of CDM projects. The focus is then turned to the issue of sustainable development, its context with regards to the CDM and the Kyoto Protocol, and general criteria for sustainable development in a CDM project. In the second part of the paper, we discuss to what extent there is a conflict between cost-effectiveness and sustainability, and whether the two objectives of the CDM can be achieved simultaneously by analyzing two case studies from Brazil and China. Finally, we discuss the lessons learned and the future prospects of the CDM.

2 Background

The flexibility mechanisms will enable Annex I countries to reduce their overall costs of fulfilling their commitments, as the mechanisms are likely to promote the cheapest measures across countries. The regulatory framework and set-up of the flexibility mechanisms are, however, yet to be determined, and there are several unresolved issues that need to be clarified. One such issue is supplementarity, that is, the requirement that Annex I countries use the flexibility instruments to meet only part of their commitments. The European Union has been strongly in favor of a quantified limit, and has proposed a cap on the use of the flexibility mechanisms.[3] This is likely to reduce the cost-effectiveness of meeting the Annex I countries' emissions reductions, but would most likely increase the incentives to develop more efficient technologies in Annex I countries. The Buenos Aires Plan of Action that was agreed upon at COP-4 in 1998 called for agreement on rules for the flexibility mechanisms at COP-6 in The Hague in November 2000. However, the Parties failed to agree, and key issues of the Kyoto Protocol therefore remain unsolved. The recent statement from President Bush that the USA does not intend to ratify the Kyoto Protocol has in fact made the implementation of the Kyoto Protocol itself more uncertain.

Flexibility instruments were first discussed in 1989 within the framework of international climate policy negotiations. It was Norway that actively introduced the ideas of flexibility instruments into the negotiations at the end of 1991 under the title 'Joint Implementation' (Michaelowa and Dutschke, 2000).[4] Norway proposed that cost-effectiveness could be increased by separating the emissions targets from the method of abatement – in other words, that countries could choose to implement measures domestically or jointly on a bilateral or regional basis. The Norwegian proposal can be regarded as a practical first step towards a system of tradable emissions rights (Hanisch, 1991). Not all countries involved in the climate negotiations supported the idea of joint implementation. The opposition was based partly on non-economic, moral arguments. Many developing countries and non-governmental organizations (NGOs) saw joint implementation as an opportunity for developed countries to maintain their lifestyles through cheap emission reductions in developing countries. They therefore proposed that joint implementation be used only among developed countries. At

[3] The EU has suggested introducing a cap on the use of the Kyoto mechanisms. The cap is meant to be applied to both the supply side and buyer side in order to secure that the Parties implement domestic strategies to abate emissions, to stimulate the development of green technology, and to limit the sale of so-called 'hot-air' from Russia and Ukraine. This cap implies that half or more of the required emissions abatement must be carried out domestically. However, the EU has recently taken a step away from this proposal. The EU's comment to Mr. Pronk's (The President of COP-6) paper is: "*Each Annex I Party shall meet its commitments primarily through domestic action since 1990.*"

[4] This concept has since been adapted and is known as 'Joint Implementation,' one of the three flexibility mechanisms in the Kyoto Protocol.

Kyoto, the EU backed down on its opposition to flexibility instruments, and the Kyoto Protocol therefore includes all the instruments proposed by the USA: emissions trading, JI and the CDM (Michaelowa and Dutschke, 2000). Table 2.1 summarizes the main features of these mechanisms as defined in the Kyoto Protocol (where 'Annex I Parties' are industrialized countries).

Table 2.1 Features of the Kyoto mechanisms as defined in the Kyoto Protocol.

Article	*Mechanism*	*Units*	*Participants*	*Requirements*
17	Emissions trading (ET)	Assigned amounts units (AAU)	Annex I Parties	Any trading shall be supplemental to domestic actions.
6	Transfer or acquire emissions reduction units resulting from projects (JI)	Emissions reduction units (ERU)	Annex I Parties and legal entities authorized by Parties	Emissions reductions must be: Approved by the Parties involved; additional to measures that would have otherwise been implemented; acquired only by Parties that comply with their reporting obligations; and supplemental to domestic action.
12	Acquire certified emission reductions from projects in non-Annex I Parties from 2000 and onwards (CDM)	Certified emissions reductions (CER)	Annex I Parties buy, non-Annex I Parties sell	Supervised by an executive board; emissions reductions will be certified by operational entities designated by the COP/MOP. [5]
			Private and/or public entities	A share of the proceeds of certified project activities shall cover administrative costs as well as assist particularly vulnerable developing countries with adaptation.

(Source: OECD, 1998).

Emissions trading represents an efficient way of meeting a certain level of emissions. The price per ton of emissions is determined by the market as governments trade with their allocated emissions. Countries that have undertaken abatement measures so that their actual emissions fall below their allocated emissions can sell surplus quotas to countries that would otherwise not meet their emissions targets. The units in emissions trading are called 'assigned amount units' (AAU) and can only be traded among Annex I countries. The only experience of tradable, limited-period emissions permits over a relatively long time period is from the USA. Michaelowa and Dutschke (2000) argue that the experience with SO_2 in the USA has confirmed the feasibility of emissions trading and has demonstrated a great potential for increasing efficiency. Kerr (1998) is more reserved and sees an emissions trading system as just one factor in the overall flexibility of the SO_2 program. Trading has saved money, and although on the increase, trading has been small in volume and largely limited to swaps between plants within the same company.

Joint Implementation under the Kyoto Protocol involves co-operation between Annex I countries only. One country (the investor country) funds, and possibly also conducts emission reduction projects in another (the host country). JI will draw on the experience from the pilot phase for JI, "Activities Implemented Jointly" (AIJ), which was adopted at the Berlin Conference in 1995. AIJ did not result in carbon credits, and operated with relatively open criteria. Under JI, the host country transfers emission reduction units (ERUs) to the investor

[5] MOP = Meeting of the Parties to the Kyoto Protocol

country based on an agreed upon estimate of the ERUs resulting from the JI-project. Under emissions trading, quotas are transferred based on an agreed upon price (Holtsmark and Alfsen, 1998).

The CDM came as a relatively late proposal, submitted just days before the deadline of June 1, 1997, when proposals for possible features of the Kyoto Protocol had to be communicated to all Parties. The concept of a fund for sustainable development was first raised jointly by Argentina and Brazil during preparations for the 1992 UN Conference on Environment and Development (Estrada-Eyuela, 1998). The original proposal of Brazil, which eventually led to the CDM, envisaged a ‘Clean Development Fund’ as a new element of the financial mechanism established by the UNFCCC. The fund’s financing was to come from non-compliance fees from Annex I countries that exceeded their assigned amounts of greenhouse gas emissions in a given budget period. It was also linked to historical emissions of Annex I countries. The proposal was modified after intense negotiations involving many delegations, and the term ‘fund’ was changed to ‘mechanism.’

The CDM requires the establishment of an executive board whose powers, composition and relation to COP/MOP will be determined by COP. One of the main responsibilities of the exectutive board will be to define acceptance criteria for the CDM projects (Goldemberg, 1998). The CDM allows for the participation of both private and public entities, in either an investor or host capacity, in project activities that result in CERs and their acquisition. A share of the proceeds from project activities is to be used to cover administrative expenses and to assist developing countries that are particularly vulnerable to climate change to meet adaptation costs (Dessus, 1998). CERs can be obtained as early as 2000 and onwards.

3 The CDM market

The creation of a new mechanism has led to speculation about the degree of potential emissions reductions and the accompanying financial flows. The developed countries want to know how many CERs will be available, and at what cost. Countries need this information to be able to design the most cost-effective combination of domestic reductions, CDM projects, and the two other flexibility mechanisms. A large CDM market will generally mean greater sustainable development benefits in developing countries and lower costs for developed countries in meeting their targets (WRI, 1999).

Given that all three flexibility mechanisms can be used to meet the emissions reduction requirements, there will be competition among the mechanisms. Market forces will, unless the COP decides on a quantified limit, determine the total shares of emissions reductions obtained through the Kyoto mechanisms. They will also determine the importance of each mechanism relative to the others. Investments through the CDM may have an advantage in that CERs can be counted from 2000 and onwards. However, the CDM will be burdened by the fees covering the costs of administration and adaptation, making it less attractive (Goldemberg, 1998). The note by the COP-6 president that came towards the end of the negotiations in The Hague suggests that 2% of the CERs generated by a project should finance the adaptation fund (Pronk, 2000). During the negotiations, the developing countries have signaled that also some share of the proceeds from emissions trading and JI should be channeled towards adaptation for developing countries. This is, however, unlikely to happen since no such indications can be found in the Kyoto Protocol and there is strong opposition from industrialized countries.

AAUs, ERUs and CERs are all defined as tons of CO_2-equivalent emission reduction. The views on whether this automatically implies that they are fully fungible, or exchangeable, differs. It is argued that since the origin of emissions reduction does not matter, the three mechanisms are fully fungible. For an investor, the effect of an AAU or ERU is no different from the effect of a CER. However, a reason for distinguishing could be that Article 12 states that a CER can only be transferred when the project generating the CER has proved to be in line with sustainable development criteria. No such criteria exist for AAUs and ERUs. The extent to which the sustainable development criteria are enforced will naturally be a significant factor in determining the size of the CDM market. There can be risk corrections to the price, e.g. highest for CERs and lowest for AAUs. Given the number of uncertainties concerning the CDM, is difficult to predict just how large a mechanism the CDM will become (Austin and Faeth, 2000). Table 3.1 indicates the potential size of the CDM market from several studies.

Table 3.1 Estimates of the size of the CDM market in 2010

Study	*Size of the CDM Market (MtC)*	*Total emissions reductions required to meet the Kyoto targets of Annex I countries (MtC)*[6]	*Contribution of the CDM (% of total emissions reductions)*
EPPA	723	1,312	55
Haites	265–575	1,000	27–58
G-Cubed	495	1,102	45
GREEN	397	1,298	31
SGM	454	1,053	43
Vrolijk	67–141	669	10–21
Zhang	132–358	621	21–58

(Sources: Zhang, 2000, and Austin and Faeth, 2000.)

Haites (1998) makes assumptions about the contributions from domestic abatement measures and hot air, and divides the remaining demand among emissions trading, JI and CDM in proportion to the estimated potential supply. The estimated size of the CDM market in 2010 ranges from 265 MtC in the 50% reduction from BAU emissions scenario to 575 MtC under no limits scenario.[7] The estimates by Vrolijk (1999) are at the lower end of the estimated CDM market. The estimated 67–141 MtC still account for 10–21 % of the required emissions reductions in Annex I countries. The potential size of the CDM market is also analyzed in a paper by Zhang (2000) that aims to estimate the size of the potential market for all three flexibility mechanisms under the Kyoto Protocol. Using a model based on the marginal abatement costs of twelve regions, the paper estimates the contributions of three flexibility mechanisms under four trading scenarios. The results show that the CDM market could cover 132–358 MtC in 2010, or from USD 456.9 million to USD 4512.8 million. The lowest estimate assumes a EU ceiling while the highest estimate assumes no hot air.

Austin and Faeth (2000) analyze the results from several economic models; EPPA (Ellerman et al., 1998), G-Cubed (McKibbin et al., 1999), GREEN (Van der Mensbrugghe, 1998), and SGM (Edmonds et al., 1998). The models have been used to explore “global trading” scenarios that focus on the relative cost of abatement in different regions. It is assumed that the world as a whole makes sufficient reductions to meet the Kyoto targets by choosing the most cost-effective pattern of abatement. They ignore high transaction costs that

[6] Given the differences in the model structures and the baseline emissions paths, the estimates of the total emissions required will differ. The study by Zhang (2000) is based on compilation of national communications and is lower than those from economic modeling studies. This is partly because Zhang covers all six GHG gases, whereas other economic modeling studies (except Edmonds et al. (1998) focus only on CO_2.

[7] The 50% reduction from the BAU emissions scenario assumes that the maximum allowed acquisitions from all three flexibility mechanisms are limited to 50% of the difference between projected baseline emissions and the Kyoto targets in 2010.

may arise from the CDM, potential limits to CDM activity, and the need to raise funds for adaptation. The models make different assumptions about central aspects, so the estimated size of the CDM market will naturally vary. Table 3.1 shows that the estimated size ranges from 397 to 723 MtC and that it could account for 33 to 55% of the total emissions reductions in Annex I countries. The model results discussed in the study indicate that the quota price may vary between USD 13 and USD 26. The total quota value to developed countries of investing in abatement in developing countries could in 2010 be between USD 5.2 billion and USD 17.4 billion.

But can the CDM actually produce the amount of CERs that the various studies estimate? The experience from AIJ might give some indications. As of June 30, 1998, 95 projects were listed as AIJ projects. If all these projects were fully implemented and operating as designed, they would generate a combined annual GHG offset of 2.7 MtC. The projected CERs from CDM projects imply as much as a 100-fold increase in this type of project based activity. Lack of adequate incentives for private sector participation in AIJ project financing has probably limited the role of AIJ. However, such a large expansion poses a great institutional challenge for developing countries, as most of them have no experience from AIJ within their own countries (Zhang, 2000). Baron (1999) states that the size of reductions may only be theoretical. He finds that the macro-economic models are too optimistic in their assessment of the CDM's contribution to emissions reductions. The realism of the estimates can be questioned, as assumptions of full market (and policy) efficiency and the absence of transaction costs in trading are not realistic. Baron also finds it necessary to consider what it would take, in terms of institutional arrangements and domestic policies, to fully benefit from the CDM. The concerns about 'over-use' of the mechanisms may thus be unfounded, and time might be better spent seeking practical ways to realize the potential that the CDM theoretically provides.

4 Achieving cost-effectiveness

Since its inception, a major issue in climate policy has been how abatement could be implemented cost-effectively in a world where not all countries have emission reduction targets. Cost-effective measures ensure that a goal (emissions reduction) is reached by using as few resources as possible. Different marginal abatement costs across countries is the driving force. The United Nations Framework Convention on Climate Change (UNFCCC) that was adopted at Rio de Janeiro in 1992 explicitly addresses the importance of cost-effectiveness in Article 3.3: *"...policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost."* (UNEP, 1999, p. 6). This implies that even though only a certain group of countries have emission reduction targets, the cost variation among countries means that measures can be taken outside these participating countries.

The CDM can become an important mechanism for achieving cost-effectiveness in reducing global GHG emissions because developing countries have prevailing high emission intensities and low abatement costs. The theoretical efficiency of using less costly measures abroad to achieve domestic reduction targets is widely accepted. The resources required for reducing a ton of carbon in a developed country could typically offset more emissions in a developing country. However, the CDM's potential efficiency can be distorted if its design does not take into account incentives for cheating, leakage, and uncertainties. It is essential to define mechanisms with low transaction costs that lead to real and measurable emissions reductions (Michaelowa & Dutschke, 1999). Important issues in this respect are project validation, monitoring, and certification.

4.1 Validation

Project validation is an assessment of whether the project meets the requirements of the CDM with respect to additionality. Article 12.5(c) of the Kyoto Protocol states that emission reductions must be: *"additional to any that would occur in the absence of the certified project activity"* (UNEP, 1998, p. 16). One of the key tools for both determining a project's additionality and measuring its GHG benefits is an emission baseline. A baseline is the stream of net GHG emissions that would be expected to occur in the absence of the project. If the emissions reductions stemming from the project result in emissions levels falling below those that would normally occur in the absence of the project, then the project would be considered additional. The difference between the two emission streams would count as CERs (Kelly et al., 2000). In this respect, one challenge is to avoid the acceptance of no-regrets projects as CDM projects. No-regrets projects are not additional since these are projects that are already profitable without greenhouse gas emission abatement benefits and associated non-carbon benefits, and thus should be undertaken in any case. On the other hand, projects that are almost no-regrets are the cheapest projects in terms of cost per ton of carbon, and are thus likely to be the most attractive projects for investors from developed countries. A further complication is posed by the lack of a generally accepted method for calculating the profitability of projects (e.g. in terms of which interest rate and time horizon to employ). Due to country-specific circumstances, a CDM project that seems to be 'no-regrets' for an outside observer, might not be considered profitable by a company in the developing country given e.g. a high interest rate and credit-rationing. The key question is whether the project would be realized without the additional CDM-funding, which, as we can see, is a difficult question to answer – particularly given the incentive for the host to overestimate the project cost to sell a no-regrets project as a (cheap) CDM project. This shows the importance of establishing a system to approve CDM project candidates and verify CDM projects, particularly with respect to identifying and excluding likely no-regrets projects.

The AIJ pilot phase has given useful results in identifying key baseline issues. Financial and environmental additionality were determined at the national level, leading to a variety of methodologies and definitions. The process of determining project emission baselines has therefore been time and resource-intensive, with a lack of consistency across projects (Hargrave et al., 1998), and the results from AIJ pilot projects have been patchy (Michaelowa & Dutschke, 1999). CCAP (1999) finds that project baseline setting and additionality has occurred on an ad hoc, case-by-case basis because the formal rules are lacking. This 'bottom-up' approach means that project preparation requires a significant amount of time and resources.

A number of practical approaches for baseline calculations have been proposed and used by researchers, project developers, national AIJ programs and the Subsidiary Body for Scientific and Technical Advice (SBSTA). These approaches are often classified in three categories: method-based, comparison-based, and simulation-based approaches (OECD, 1999). Method-based approaches generate generally applicable guidelines that are independent from an individual project's specific conditions. These approaches include benchmarking, top-down baselines, technology matrix, and default baselines. The comparison-based methods seek to identify a 'real-world' reference project instead of constructing an artificial 'without project.' This requires finding a valid reference project and measuring the GHG emissions in that concrete project. The simulation-based approaches aim to determine which projects would have been implemented in the absence of the proposed activity. Methods include barrier removal, commercial tests and multiple baselines (OECD, 1999).

Michaelowa & Dutschke (1999) recommend, given current insights, that project-specific baseline scenarios be used as a basis for the CDM. They recommend that different approaches for defining project-related baselines should not only be tolerated, but also encouraged. Meyers (1999) also favors a project-level approach because this type of approach considers each case separately, better ensuring that emissions reductions are likely to be additional. CCAP (2000) recommends that guidelines be designed to ensure that project baselines adhere to the principles of reliability, transparency, consistency, completeness, and verifiability and preserve the environmental integrity of the Kyoto Protocol. Bosi (1999) examines examples of hypothetical multi-project emissions baselines for new electricity generation projects. He finds that multi-project baselines, through their simple design, are useful in estimating 'what would occur in the absence of' a particular CDM project in the electricity sector. Another result is that multi-project baselines, in sectors with homogeneous output, offer greater transparency and lower transaction costs compared to more complex baseline approaches for a potential investor. In another study, Bosi (2000) examines the implications of developing multi-project or standardized baselines in the electricity generation sector. Less aggregated multi-project baselines are likely to provide a better reflection of what would happen without CDM/JI projects in the electricity sector.

Lax methodologies can hinder accurate quantification, and over-crediting projects will introduce "paper tons" into the emissions trading system. Overly stringent definitions of additionality could, on the other hand, discourage project implementation, drive up project costs, and cause legitimate GHG-reducing projects to be left out. Practical experience has shown that current definitions of additionality do not provide sufficient guidance for determining project baselines. Several difficulties remain in determining project baselines that are politically feasible, environmentally sound, and with minimal transaction-cost implications. The design of the respective mechanisms should also allow the incorporation of modifications at a later stage (OECD, 1999).

4.2 Monitoring and certification

The operators of a CDM project will, once the project is implemented, need to monitor the relevant aspects of the project. Emissions and absorptions of all greenhouse gases resulting from the project activity must be measured in addition to more general project performance indicators (Baumert and Petkova, 2000). A monitoring plan will normally include selecting relevant parameters of concern, determining the method of collecting and handling of samples, determining how the samples will be analyzed, and specifying a format for reporting the results. One of the most important factors in establishing a monitoring system is to first reach agreement on the objectives of the system, and then design the system so that it addresses these objectives. It is also essential to be confident that the measurements reflect the existing situation. In other words, the data must be clearly defined and well documented (World Bank, 1997).

There are several technical questions regarding how to measure and monitor the outcome of individual projects. Both carbon sequestration and emissions reduction projects have their own measurement and monitoring challenges (Kopp et al., 1998). Measuring changes in carbon stored in the biosphere is not as straightforward as measuring emissions reductions from combustion of fossil fuels. The main problems are resolution (recognizing small changes in large numbers) and maintaining the infrastructure needed to regularly measure changes in carbon stocks. Estimates show that changes in carbon stocks stored in tree stems can over a ten-year period be approximated within +/- 10% for a specific project. The uncertainty of measuring carbon in roots and soil will usually be greater (Schlamadinger and Marland, 2000). The accuracy of the monitoring should be sufficient enough to distinguish the anticipated changes. However, establishing and maintaining monitoring systems is time-consuming and expensive. It therefore becomes important to focus resources and priorities on those areas where information is most needed and useful (World Bank, 1997).

When a project has been implemented and in operation for a period of time, the quantity of emissions claimed by project operators has to be verified. This process could include periodic reviews and full audits of monitoring data, project documentation and project operations (Baumert and Petkova, 2000). Calculating the amount of CERs to be issued requires an assessment of the emission reductions the project generates relative to its baseline. There is some concern about the differences between after-the-fact and before-the-fact project performance due to e.g., unanticipated deviations in technical performance and issues related to project implementation. An illustration would be a power plant that achieves the promised energy efficiency but only operates at 50% of expected capacity (Toman, 2000). A static baseline implies that it is set for the life of the project. An advantage of a static baseline is that the investor is assured that it will continue to receive credits as long as the project continues to meet the criteria upon which its approval was based. The problem is that static baselines become more and more out of date as market, economic, and regulatory conditions change over time. The reference case is likely to prove wrong because future events may turn out different than expected. As circumstances change and new information becomes available, regulators may be tempted to 'true-up' the baseline. Performance evaluations will be seen as customary and legitimate, but revision of the baseline is likely to be seen as changing the rules of the game. Some analysts suggest that a middle-ground option is a possible solution. They argue that the interests of investors must be balanced against the benefit to the environment of updating baselines to avoid over-crediting (UNCTAD, 1998).

5 Achieving sustainable development

Section 1 pointed out that one of the aims of the CDM is to assist developing countries in achieving sustainable development. But what is sustainable development? The UN's World Commission on Environment and Development (WCED) put the idea of sustainable development on the political agenda with their report *Our Common Future* (WCED, 1987). The concept *sustainable development* was not new, but was given a new and broader definition by the WCED than its former, more narrow environmental interpretation (Langhelle, 1999, p. 10). The WCED emphasized *solidarity* both within and between the generations by defining sustainable development as the ability *"to meet the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987, p. 43). WCED tried to strike a balance between environment and development, North and South, and between the future and the present. The concept emphasized in particular *"the essential needs of the world's poor, to which overriding priority should be given,"* but also *"the environment's ability to meet present and future needs"* (ibid.).

There has been a lot of discussion around the concept of sustainable development and how it should be enacted through policy. A vital issue has been the aim of economic growth, which the WCED encourages in both developed and developing countries. According to the WCED, developed economies can also become sustainable by reducing resource- and energy-intensive activities and by generally using resources and energy more efficiently (WCED, 1987). In that regard, *Our Common Future* promotes a strong redistribution policy (Langhelle, 1999).[8] The main challenges for the industrialized countries are, according to the WCED, to change production and consumption patterns – particularly by reducing the use of energy and emissions of CO_2 to allow development in the developing countries – and to develop and transfer environmental technology to ease the transition to sustainable development both in the North and the South (WCED, 1987; Langhelle, 1999).

The goals of the CDM are clearly in line with the WCED's main challenges for developed countries. By transferring technology, the use of energy and CO_2 emissions could be reduced while permitting economic and social development that also benefits the environment. However, the absence of an exact definition of sustainable development in Article 12 of the Kyoto Protocol presents some difficulty. In fact, there is no such definition in the Kyoto Protocol at all. Throughout the text of the Kyoto Protocol, the term 'sustainable development' can only be found three times. This could reflect what Austin and Faeth (2000,

[8] Principle 8 of the *Rio Declaration On Environment And Development*: "To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies."

p. 2) call an 'unwritten assumption' in the Kyoto Protocol *"that projects that are good for carbon abatement must also be good for sustainable development in developing countries."* This will surely be the case for many projects, but not for all.

There are many examples of potential positive side effects. CDM projects can, for example, improve air quality through many alternative power generation and cogeneration options that lead to reductions in SO_2, CO, particulates, smoke dust and NO_x. Improved forest management can protect against water depletion, runoff problems, and loss of biodiversity. CDM projects can also have social and developmental benefits. For example, there are options that offer increased employment opportunities and promote local energy self-sufficiency through renewable energy sources in rural or remote areas (Austin and Faeth, 2000). However, projects that are favorable from a climate perspective can also have less desirable environmental and social impacts that conflict with the concept of sustainable development – for example, reduced water quality and availability, increased social inequalities, and loss of biodiversity.

Environment-related development projects can accrue added value through the CDM market, whereas there will be no similar price tag on the project's impacts on biodiversity, water quality, and so forth. This could lead to projects considered economically or ecologically unsustainable to become operative. For instance, several dam projects in Africa and Asia have not received funding from the World Bank because they are considered neither profitable nor ecologically sustainable. With the extra-funding from CDM-projects, several new dams might be built since the aim of combating climate change is an additional value.

It is clear that not all potential CDM projects may be considered to be in line with sustainable development. There are several steps that may be taken to ensure that the sustainable development aspect of the dual objective is fulfilled. One could be to establish more formal guidelines and an explicit evaluation system. This approach could help control not only the carbon dimension of each CDM project, but also its broader sustainability impact. This would require the development specific indicators to measure and evaluate how each project could contribute to sustainable development. [9]

Sustainability can be promoted at the approval stage by ensuring that approval criteria includes a requirement that the CDM project comply with other international agreements, such as the UN Convention on Biological Diversity. However, the Commission for Sustainable Development (CSD) emphasizes four dimensions of sustainable development for approval criteria: social, economic, environmental and institutional. The CSD has developed criteria for the indicators that are to assess the CDM project's impact on sustainable development, and suggests that they be:

- primarily national in scale or scope (although countries may also wish to use indicators at state and provincial levels);
- relevant to the main objective of assessing progress towards sustainable development;
- understandable, that is to say, clear, transparent and unambiguous;
- realizable within the capacities of national governments, given their logistic, time, technical and other constraints;
- limited in number, remaining open-ended and adaptable to future developments;
- broad in coverage of Agenda 21 and all aspects of sustainable development;
- representative of an international consensus, to the greatest extent possible; and

[9] CICERO has, in cooperation with Det Norske Veritas and ICF Incorporated, developed a pilot verification and certification method for auditing GHG reductions where a set of sustainable development indicators was developed (Telnes et al., 1999).

- dependent on data that are readily available or available at a reasonable cost to benefit ratio, adequately documented, of known quality and updated at regular intervals (CSD, 2000).

But what about the actual indicators? Article 10 of the Kyoto Protocol states that national and regional development priorities, objectives and circumstances are to be determined by the Parties themselves. The participation in CDM projects will be voluntary and approved by each Party involved, giving the host country a high degree of influence on the type of projects, and hence the type of side effects. The costs of verifying sustainable development can make the CDM less attractive if measures are not taken to avoid an extensive and complex process.

Table 5.1 Criteria for evaluating non-carbon benefits

Non-carbon benefits	*Explanation*
Environmental impacts	
Water resources availability	Impact on relative water scarcity
Water resources quality	Impact on water pollution or water assimilative capacity
Air quality	Impact on air pollution or air assimilative capacity
Soil erosion	Impact on soil erosion or land protection capabilities
Soil contamination*	Impact on soil quality
Noise level	Impact on noise level
Ozone depleting substances*	Impact on the ozone layer and UV-radiation
Biodiversity	Impact on biodiversity
Land use*	Impact on land's alternative use, scenery or recreation value
Development impacts	
Economic effects	Income and economic growth generated
Effects on trade balance	Import and export effects
Effects on regional economy	Assessment of proportion of income generated that stays at regional level
Output foregone	Opportunity cost of activities foregone
Human capital*	Effects on human knowledge and skills
Institutional capacity*	Effects on the local or regional institutional knowledge and capacity
Equity impacts	
Income distribution effects	Assessment of impact on relative demand for unskilled labor as a way to address income inequality
Poverty reduction*	Impact on number of people below the poverty line
Distribution of environmental benefits by income classes	Assessment of appropriation by income class of project's environmental effects

(Source: Based on Seroa de Motta et al. (2000:27), the indicators marked with * are new.)

An attractive approach can then be to evaluate CDM projects against some qualitative indicators. Based on a study by Seroa de Motta et al. (2000), we propose 18 criteria for evaluating non-carbon benefits that cover environmental, development, and equity issues as shown in table 5.1.[10] The list of criteria is not exhaustive, but covers the most relevant and easily identified benefits. The magnitude of the benefits is ranked, ranging from low negative impact to very positive impact. The questions of whether a limit should be set on the number of allowable negative impacts, or whether positive impacts can offset negative impacts, are

[10] The CSD's fourth institutional dimension is not addressed directly by Seroa de Motta. However, we have included an institutional capacity indicator as a non-carbon development benefit.

not addressed here. The indicators are on an ordinal scale, which means that a project's aggregate scores of pros and cons cannot be directly calculated. There is need for a more qualitative assessment and evaluation of whether some projects have a distinctive negative impact on core indicators. We suggest that some core indicators must have a neutral or positive impact if the project is to be considered to contribute to sustainable development. One such core indicator could be a requirement that the project does not increase poverty. However, each case must be assessed in accordance with local conditions, and even one single local negative factor may outweigh other positive impacts. For instance, if water shortage is a pervasive problem in a region, a project that has a negative impact on water availability cannot be regarded as contributing to sustainable development, no matter how large the CO_2 reduction may be.

6 Can sustainable development and cost-effectiveness be achieved simultaneously?

Various types of projects may qualify for credits within the framework of CDM. *Energy efficiency* programs and fuel switching to *renewable energy* or other more environmentally sound energy sources or fuels have the largest carbon potential (see figure 6.1). These two options were the ones that Mr. Pronk, the president of COP6 in The Hague, proposed *"should be given priority"* (Pronk, 2000, p. 6). However, the most sustainable solutions are not necessarily the most cost-effective since they often require new and more expensive technologies. Storage of carbon in various reservoirs may also represent viable alternatives, but they are not addressed in this paper mainly because it is uncertain whether such projects are acceptable under the Kyoto Protocol. A fundamental problem with respect to both types of carbon storage measures – biomass sinks as well as reservoirs – is that their impacts on a long time scale are highly uncertain. It is also still uncertain whether biomass sinks will be accepted under Article 12.

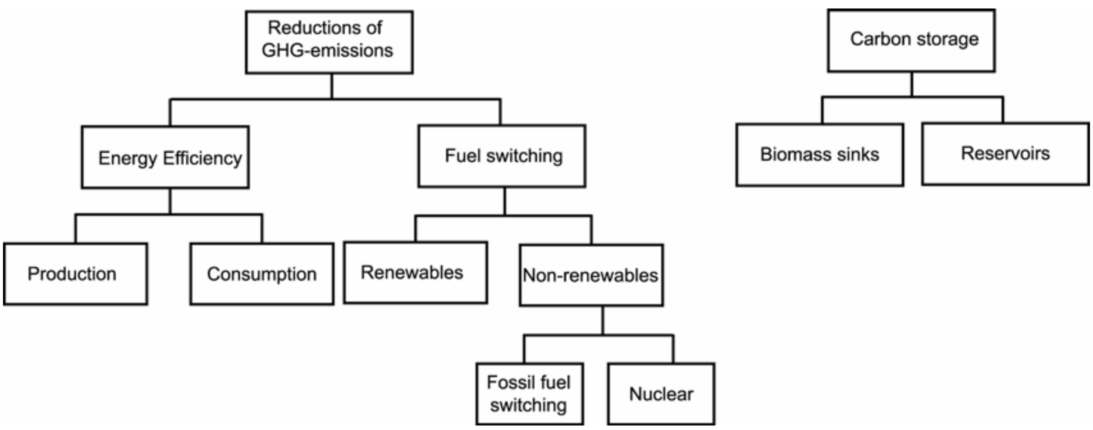

Figure 6.1 Ways of reducing the emissions of greenhouse gases.

We have in chapters 4 and 5 discussed both sides of the CDM's dual objective. We will now, by analyzing two case studies, discuss whether the two objectives can actually be achieved simultaneously. Two potential CDM-projects, representing the two most likely categories, energy efficiency and fuel switching, are assessed. First, we analyze some potential CDM projects in Brazil that aim to switch to other energy sources/options. Second, we look at a selection of energy efficiency and clean coal options in Shanxi. These options were analyzed according to their capacity to simultaneously reduce CO_2 emissions and health-threatening air pollution in the province.

6.1 The Brazilian case

Hydroelectricity dominates Brazil's present energy sector, but fossil fuels are likely to help meet the growing energy demands. Table 6.1 shows some abatement options in the Brazilian energy sector as found in a study by Seroa et al. (2000).

Table 6.1 Energy response options in Brazil

Project type	*Ethanol (with bagasse cogeneration)*	*Cogeneration from refineries*	*Biomass thermoelectricity (gasification of wood)*	*Wind energy*
Average carbon benefit [11] tC/ha	203	-	102	-
tC/MWh	-	0.180	0.197	0.180
Implied carbon price (US$/t C)[12]	19.70	-17.70	2.40	14.60

(Source: Seroa da Motta et al., 2000:24.)

Ethanol has been an alternative clean fuel for vehicle use, but its advantage over conventional gasoline with respect to air pollutants has been eroded by the introduction of catalyst technology. Low oil prices have made ethanol production dependent on subsidies. Using sugar-cane residues (bagasse) to produce steam or electricity, or both, can reduce ethanol production costs. Cogeneration can be a profitable activity if residues are available as a costless byproduct that is gasified for use in high performance gas turbines. It can also reduce some of the expected increase in natural gas or fuel oil consumption and reduce the aggregate costs of ethanol production. However, a carbon price of US$ 19.70/t C is required for cogeneration to be profitable (Seroa da Motta et al., 2000). The non-carbon effects of this option are varied. For certain low-income groups, the ethanol program has been an important source of employment, and this option could also have positive impacts on other development indicators (see table 6.2). The use of ethanol has also a positive impact on the trade balance since it reduces the demand for import of the relatively expensive oil. The use of ethanol in place of gasoline keeps carbon emissions down, despite some negative environmental effects such as discharge of water pollutants. Increased production of ethanol made from sugar cane requires huge land areas, which might lead to rising land prices and may endorse deforestation. Paixao (1997) identifies *"soil compacting and intensive chemical consumption"* as additional environmental problems (referred to in Seroa de Motta et al.).

The use of cogeneration has grown in sectors such as the chemical and petrochemical industries, the pulp and paper industry, and metallurgy. Using data from an ongoing project in Cubatão, we estimate a refinery's cogeneration potential and non-carbon effects. Cogeneration improves the use of inputs that would be consumed anyway, and represents a no-regrets option (and generates few externalities) (Seroa da Motta at al., 2000). Even more

[11] The carbon benefits, in tons of carbon (tC) per hectare, for ethanol and cogeneration and gasification options are the difference between the carbon stock of plantations and the carbon stock of degraded land as measured by Fearnside (1995) plus fuel substitution from COPPE (1998). Carbon benefits from electricity from oil refinery and wind sources are measured from oil substitution from COPPE (1998).
[12] Figures indicate the carbon price that will be required to bring the project's internal rate of return to 12 percent annual average. A negative value indicates that the investment is already profitable at 12 percent rate of return. All MWh revenues were assumed to be the current price paid in the Brazilian electric sector of US$35/MWh. All values are in 1998 US$. The estimates are based on low oil prices as seen for Brazilian imports, at about US$18.

importantly, heat power plants that generate electricity may have a positive effect on urban air pollution since the demand for other new polluting power plants is reduced (see table 6.2).

The technology of biomass energy systems is being improved, and there are clear indications that commercial units will perform reasonably well in economic terms. The project under consideration here is the development of a wood biomass commercial unit, and it is assumed that half of the raw materials would come from residues from the pulp industry. The project requires a carbon price of US$ 2.40/t C. Gasification of wood projects would certainly increase the energy efficiency and make use of residues from the pulp industry. However, biomass thermoelectricity might increase the air emissions and the use of water and higher demand for land may promote/contribute to deforestation. Despite the negative environmental effects of such biomass projects, positive impacts are expected in terms of job creation and economic development for rural communities close to the project (see table 6.2).

Wind power appears to be the most promising ‘clean’ energy technology for Brazil. It has lower costs than solar energy, the main competing energy source particularly in remote areas. It does, however, require a relatively high degree of technical expertise. The data used here is based on a commercial unit in the state of Ceará. This option requires a carbon price of US$ 14.60/t C (Seroa da Motta et al., 2000). Wind energy is a renewable ‘clean’ energy technology and will have few negative environmental impacts. Noise pollution might be a problem, as well as use of land, but such projects would not generate any urban air pollution. Wind energy projects do not have the same local economic and development effects as the other energy options discussed by Seroa de Motta et al. However, the relatively high degree of technical expertise required may have positive impacts on the economy and contribute to the development of human capital.

While the costs of these different options vary quite substantially, the non-carbon impacts of all these carbon-reducing projects are, except for the environmental effects of biomass and ethanol, predominantly positive or neutral. From a pure sustainable development-perspective, it seems like cogeneration from refineries is particularly beneficial since there are several positive impacts and not a single negative. This type of project also seems profitable (see table 6.1). From a cost-benefit viewpoint, cogeneration seemed most viable, and there are no negative impacts that should disqualify such projects from the CDM, even though they are economically viable without any payment for the carbon credits. Fuel wood gasification, which is beneficial also with very low carbon quota prices, has positive effects on the development indicators but negative impacts on most environmental indicators – except for biodiversity protection. The most environmentally sustainable project with a neutral rating on many indicators, wind power, requires high carbon quota prices. The ethanol option, which requires the highest carbon quota price, also has the strongest positive impacts on the development and equity indicators. However, the ethanol option has several negative environmental impacts.

The environmental non-carbon benefits of the ethanol and biomass thermoelectricity options are mostly negative, while the development and equity impacts of these projects are very positive (see table 6.2). The wind energy option also has overall clear positive or neutral impacts. In fact, both the wind energy and cogeneration from refineries options have positive impacts on all three dimensions, while the other two options have negative environmental but stronger positive impact on development and equity. It is difficult to weigh the projects against each other, but the clear negative environmental impact of the ethanol and biomass thermoelectricity makes these options less attractive from a sustainability point of view. However, the biomass thermoelectricity option requires such low quota-prices that if there are no clear sustainability constraints, such projects are very likely to be promoted as CDM-projects despite the clear environmental negative impacts.

Table 6.2 Non-carbon effects of energy options in Brazil

Non-carbon benefits	Impacts of the different projects[13]			
	Ethanol (with bagasse cogeneration)	*Cogeneration from refineries*	*Biomass thermoelectriccity (gasification of wood)*	*Wind energy*
Environmental impacts				
Water resources availability	-	Neutral	-	Neutral
Water resources quality	-	Neutral	-	Neutral
Air quality	+	++	-	++
Soil erosion	-	Neutral	-	Neutral
Soil contamination*	Neutral	Neutral	Neutral	Neutral
Noise level*	-?	Neutral	Neutral	-?
Ozone depleting substances*	Neutral	Neutral	Neutral	Neutral
Biodiversity protection		Neutral	+	+
Land use*	-?	Neutral	Neutral	-?
Development impacts				
Economic effects	++	+	+	+
Trade balance	++	++	++	+
Regional economy	++	+	++	+
Output foregone	+	Neutral	+	Neutral
Human capital*				+?
Institutional capacity*				+?
Equity impacts				
Income distributions	++	Neutral	+	Neutral
Poverty reduction*	+			
Distribution of environmental benefits by income classes	++	+	+	+

(Source: Based on Seroa de Motta et.al. (2000:28))
We operate with negative, neutral, positive (+) and very positive (++). A blank space indicates that the effect is unknown.

From this discussion it is clear that an assessment of the projects' non-carbon benefits are needed. While biomass thermoelectricity is appealing from a cost-benefit perspective, it is not as attractive from an environmental sustainability perspective. The negative environmental impacts of the ethanol program coupled with the high implied carbon price makes this kind of project the least attractive among these four options discussed here. Even though wind power is expensive, the positive overall non-carbon impacts could make it more attractive (than biomass thermoelectricity. Cogeneration is the most cost-effective option and has also neutral or positive secondary benefits. It is therefore the most likely to be certified and implemented as a CDM project.

6.2 The Chinese case

A study by Aunan et al. (2001) examines abatement options in Shanxi, one of China's major energy bases with rich coal deposits. The coal industry is the province’s most important industry, and coal production in Shanxi represents about a quarter of the total production in

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[13] The impacts have been slightly modified from the study by Seroa de Motta et al. (2000) by reducing the number of categories for impact. The two categories positive (+) and very positive (++) are equivalent to (+, ++) and (+++, ++++), respectively, in Seroa de Motta et al. We have made some assumptions of the projects' non-carbon effects on the *new* indicators (indicated by an asterisk). A blank space indicates that the effect is unknown.

China. Six different abatement options for the industry sector, the power sector, and rural households, all designed to reduce emissions related to use of coal, were analyzed. The abatement options, their costs, and emissions reduction potential are listed in table 6.3.

Table 6.3. Costs per ton CO2, and emissions reduction potential.

	Cogeneration	*Modified boiler design*	*Boiler replacement*	*Improved boiler management*	*Coal washing*	*Briquetting*
Abatement costs (US$/ton CO_2)	-30.00	-6.23	-2.74	9.20	22.73	27.27
CO_2 (Mill. tons)	0.3	12.8	12.3	3.7	11.8	6.8

(Source: Aunan et al. (2001))

Three of the abatement options are no-regrets options: cogeneration, modified boiler design, and boiler replacement. Cogeneration of heat and electricity is an extremely low-cost option when the conditions are right, i.e. when no infrastructure investments are needed to utilize the heat. These conditions are met in plants in the paper and textile industries. To assess the cost of cogeneration in these industries, an average based on two estimates from London et al. (1998), and an estimate from Aarhus et al. (1999) were used. The potential for improvement is from Aarhus et al. (1999). Modified boiler design amounts to a multilayer combustion system. The purpose of such a system is to sort the coal that goes into the boiler. This allows more efficient operation of the boiler. The multilayer combustion system is a potential option for chain stoker boilers (60 percent of Shanxi boilers). Boiler replacement amounts to exchanging old, inefficient industrial boilers with state-of-the-art boilers. Still, the new boilers are not extravagant, but rather medium size, indigenous boilers. Assuming that an existing boiler has an efficiency of 60 percent (Fang et al., 1999), the annual fuel savings amounts to more than the annualized cost. The savings would be even greater had not the price of coal in Shanxi been so low (around 15 $ per ton).

Improved boiler management includes simple changes in management practice, maintenance etc., and small investments. The cost of improvements ranges from negative to positive. The cost estimate and potential for improvements are adapted to Shanxi conditions from Fang et al. (1999). Coal washing removes coal dust as well as impurities in the coal. Washed coal in Shanxi is roughly 30 percent more expensive than unwashed coal ($ 5 per ton coal). The cost lies in the operation, the water, plus the loss of some useful coal. The benefit is more efficient operation and approximately 10 percent lower CO_2 emissions. The high quota price that is required for this option to be feasible significantly reduces its attractiveness, despite its huge potential for reducing CO_2 emissions (see table 6.3).

Briquetting binds the coal together, which results in more efficient operation and the elimination of coal dust, similar to washing. The cost (approximately $ 6 per ton coal) is related to the process and the lime that is added to the briquettes.

Table 6.4 shows that all of these abatement measures contribute to improving urban air pollution, and most of them have few negative secondary/non-carbon impacts. All options contribute to development, but we have had little basis for assessing the equity impacts. Tentatively, one may assume a positive impact on equity from briquetting, because this first and foremost will improve the indoor air quality in poorer, rural households. The measures' non-carbon benefits as measured by their health effects, on the other hand, differ substantially and have decisive effects on the ranking of the options with respect to cost-effectiveness. Measures that from a pure CO_2 abatement perspective are not cost-effective turn out to be so when the socio-economic benefit of reduced local air pollution is included in the calculation. For example, briquetting is one of the most expensive options for reducing emissions of CO_2, but is one of the most cost-effective options for providing local benefits. Figure 6.2 shows how the marginal cost curve for the six abatement measures is changed when local health benefits are taken into account.

Table 6.4 Non-carbon effects of the Shanxi-projects

Non-carbon benefits	*Impacts of the different projects*			
	Cogeneration	*Boiler modifications*[1]	*Coal washing*	*Briquetting*
Environmental impacts				
Water resources availability	Neutral	Neutral	-	Neutral
Water resources quality	Neutral	Neutral	-	Neutral
Air quality	++	++	++	++
Soil erosion	Neutral	Neutral	Neutral	Neutral
Soil contamination	Neutral	Neutral	-?	Neutral
Noise level	Neutral	Neutral	Neutral	-?
Ozone depleting substances	Neutral	Neutral	Neutral	Neutral?
Biodiversity protection	Neutral	Neutral	Neutral	Neutral
Land use	Neutral	Neutral	Neutral	Neutral
Development impacts				
Economic effects	+	+	++	++
Trade balance	+	+	+	+
Regional economy	+	+	+	+
Output foregone	?	?	+[2]	+[2]
Human capital	+	+	Neutral	Neutral
Equity impacts				
Income distributions effects				+[3]
Distribution of environmental benefits by income classes				
Poverty reduction				+[3]

(Source: Aunan et al. 2001)
[1] Includes three measures related to coal-fired boilers: Modified boiler design, boiler replacement, and improved boiler management.
[2] Investment costs are negative due to the energy savings obtained by implementing the measure.
[3] Resulting from the potentially lower costs for heating and cooking in the rural households.

In contrast to the other abatement measures, coal washing does have substantial negative environmental impacts because of the vast water resources that are required, which will have negative consequences for the availability and quality of water in the region. Water shortages and water pollution are major problems in Shanxi and are likely to be exacerbated by this option. Coincidentally, this measure is in our case the option considered least attractive in a CDM context due to the high abatement cost. Hence, in this case the most cost-effective options probably should have first priority, at least under a strong dual-objective CDM regime where all important sustainability indicators are considered.

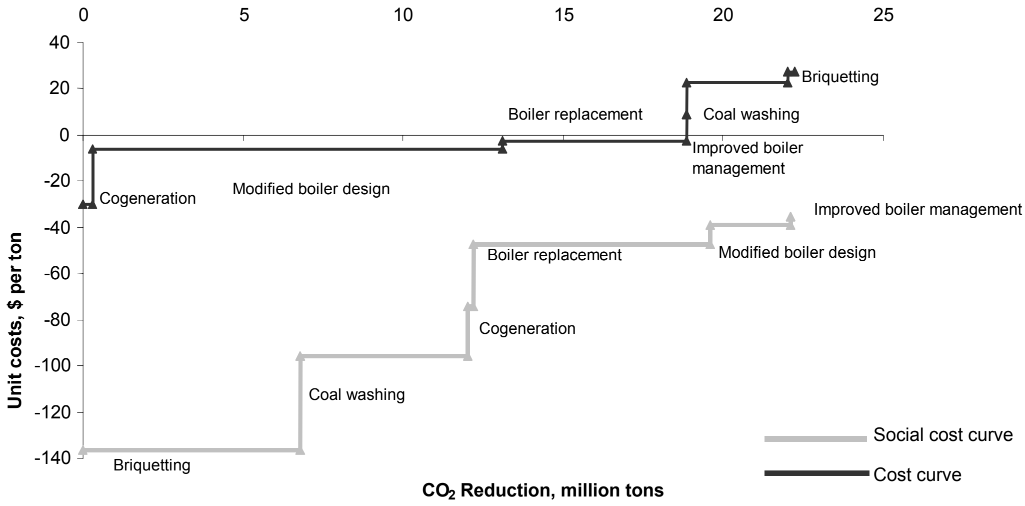

Figure 6.2. Marginal cost curve and marginal social cost curve for the six abatement options (from Aunan et al., 2001).[14]

7 Lessons learned and future prospects

To fulfill the dual objective of the CDM, projects must improve cost-effectiveness and promote sustainable development. The CDM could be an important mechanism for improving global cost-effectiveness in mitigating greenhouse gas emissions because of the generally high greenhouse gas intensities and low abatement costs in developing countries. However, there are numerous challenges related to securing real and measurable emissions reductions and at the same time keeping transaction costs low. Of particular importance is the design of a monitoring and verification system that is able to document whether, and to what extent, the emission mitigation of a CDM project is additional compared to the relevant baseline.

Sustainable development is a key concept for combining economic growth in developing countries with equity considerations such as poverty reduction, in addition to managing environmental resources to the benefit of both current and future generations. However, the concept is vague, and a main challenge is therefore to define sustainable development in operational terms to provide guidelines for choosing among different combinations of development and environmental policies. For this purpose, we have chosen to develop a list of criteria for evaluating non-carbon benefits of CDM projects.

For CDM projects to achieve each of the two objectives is a considerable challenge, and not least when the objectives are to be fulfilled simultaneously. The discussion of the two case studies from Brazil and China has shown that CDM projects can have significant impacts on environment, development, and equity. Some of the energy options in the Brazilian case have negative impacts on the environment, whereas the impacts on development and equity are predominantly positive (or neutral). In the Chinese case, most energy projects have neutral environmental impacts (the exception being the positive impacts on air quality but positive impacts on development. Furthermore there seems to be a trade-off between cost-effectiveness, as indicated by the quota price, and the score on the sustainability indicators for some of the energy options. This means that a high cost per ton of carbon dioxide abated is linked to a high score on our sustainability indicators. Conversely, a low abatement cost per ton of carbon dioxide is linked to a low score on our sustainability indicators. On the other hand, some of the CDM project candidates have a negative abatement cost, indicating that

[14] The social cost curve represents the investment and operation costs of the option minus the (economic) health effects.

they could have problems being accepted since they seem to be 'no-regrets' options and thus in conflict with the requirement that the emissions abatement generated should be additional to the baseline emission level. The assessment of secondary impacts has the largest effect on the ranking among the Brazilian energy projects, whereas only one of the Chinese energy projects (coal-washing) is disqualified because of negative environmental impacts. The estimates of the health benefits of only some of the Chinese energy projects are sizeable, and sufficient to change the ranking of the projects with respect to their cost-effectiveness. These findings indicate that there can be a built-in conflict in some CDM projects between fulfilling cost-effectiveness criteria and meeting sustainability criteria, especially at the same time.

The potential built-in conflict between the two objectives points to the importance of having a tool to assess not only cost-effectiveness features but also sustainability features. The proposed set of environmental, development, and equity indicators seems to be a useful tool for assessing sustainability impacts of CDM projects. Such a tool can be employed either by a host country or municipality, or by regional or international bodies that are appointed to certify CDM projects. Due to the large span in type of indicators, such an assessment must be qualitative since it would be meaningless to generate an aggregate score. However, this approach opens for defining one or more core indicators (or critical indicators) that must at least be neutral, but preferably positive. Some core indicators can be general and applicable to all CDM project candidates, for instance that poverty should at least not be enhanced but preferably reduced, whereas others can be related only to a specific CDM project type and country, for instance that the Chinese projects should have a positive or neutral effect on water resources availability and quality due to the scarcity of water resources in the Shanxi province in China. Another important general sustainability indicator could be compliance with international environmental agreements such as the UN Convention on Biological Diversity. More research should be conducted on improving sustainability indicator tools of the type employed in this paper. Better availability of data, for example through case studies, would make such assessment efforts more valuable.

The future of the CDM mechanism is linked to the future of the Kyoto Protocol. Given the right design and verification system, the mechanism can contribute to involving developing countries in the climate process, achieve an improved level of international cost-effectiveness, and help developing countries choose a sustainable development path built on equitable, environmentally sound, and energy-efficient technology alternatives. CDM projects can be an important channel for exporting efficient, green technologies to developing countries, which may be the most efficient way of reducing global climate change. One challenge is to make certain that CDM projects are competitive with emissions trading and Joint Implementation among industrialized countries. If strict sustainability criteria are adopted, one consequence might be higher transaction costs, which would result in higher prices for CDM projects and thus a smaller global CDM market. Given these insights, there are reasons to believe that the size of the CDM market in some studies is over-estimated since transactions costs and the challenge of promoting sustainable development are not fully accounted for. In any case, fulfilling the objectives for CDM projects requires the development and employment of reliable methods for assessing CDM projects' impacts on sustainability.

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