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Kyoto commitments: macro and micro insights on trading and the Clean Development Mechanism *

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The purpose of this paper is twofold. First, we raise some issues related to the expected dimension of the carbon market. This analysis is based on a survey of model results on the implementation of the Kyoto goal with and without reliance on emissions trading. In particular, we consider both the emissions and the financial implications associated with different trading scenarios. Transfers related to international GHG trading might be equivalent to a 400% increase in foreign direct investment to countries with economies in transition. A closer look at the GHG reductions expected from the developing world also suggests that global models may be overly optimistic in their assessment of the contribution of flexibility mechanisms in meeting the Kyoto emission goals. OECD countries may need to rely more on domestic policies to reduce their emissions than what has so far been projected by global models. Second, we use a simple microeconomic model to test the potential contribution of typical power generation technologies in the context of the Clean Development Mechanism. Projects that are defined as additional in terms of the environment but already profitable can bring about significant results at a relatively low price of certified emission reductions. To assume that the contribution of the CDM will come close to what is projected by global models (both for prices and quantities) is to assume that such projects could be credited under the CDM.

1. Introduction

The Kyoto Protocol, agreed in December 1997, sets legally-binding greenhouse gas emission objectives for industrialised countries, as listed in its Annex B. These countries should, as a whole, achieve at least a 5.2% reduction in emissions from 1990 levels over the 2008–2012 period. Today's emission levels confirm that this would represent a significant departure from current trends. New policies must be introduced in order to foster the adoption of new, more efficient technologies, as well as to change the behaviour of a multitude of economic agents, especially in the energy sector (production and consumption).

Minimising the short-term and long-term costs of the required changes is a priority for policy-makers. Emissions trading, joint implementation (JI) and the Clean Development Mechanism (CDM), the so-called Kyoto mechanisms, were introduced in the Kyoto Protocol to enable economic efficiency gains by allowing transfers of emission reductions from low abatement cost Parties to higher abatement cost Parties.[1] A number of global macroeconomic models have formulated scenarios that show the potential for reduction in cost through the Kyoto mechanisms.

The costs of implementing the Protocol emission goals are viewed as crucially linked to Parties' ability to trade emission reductions in an unrestricted fashion. While the European Union and associated Parties wish to limit the use of Kyoto mechanisms in order to promote domestic policy, others argue that this would represent a costly barrier to trade, and indeed make it impossible for them to achieve the targets agreed at Kyoto. More and more, the success of the Kyoto Protocol seems to hinge on the future contribution of emissions trading, joint implementation and the Clean Development Mechanism.

The purpose of this paper is twofold. First, we raise some issues related to the expected dimension of the green house gas market. This analysis is based on a survey of model results on the implementation of the Kyoto goal with and without reliance on emissions trading. These results provide us with an idea of the kind of contribution expected from the energy sector. Second, we discuss the potential for industry participation towards the implementation of the Kyoto Protocol goals, especially through the CDM.

2. Implementing Kyoto Protocol goals: a reality check on international emissions trading

The Kyoto Protocol has established clear greenhouse gas emission goals for a number of developed countries and provided for the possibility of trading these commitments. Macroeconomic models that had already run a number of scenarios of greenhouse gas emission reductions were able to address this question quickly. Of obvious interest is the magnitude of cost reductions that can be attained with emissions trading and the other flexibility tools introduced in the Kyoto Protocol (JI and CDM). It became all the more relevant as some Parties had proposed to limit the use of these mechanisms in order to encourage domestic actions.

* This study does not necessarily reflect the views of the International Energy Agency or any of its member countries. The authors wish to thank two anonymous referees for their suggestions.

[1] The inclusion of these mechanisms is in agreement with the call for cost-effective actions to combat global warming, as expressed in the Principles of the United Nations Framework Convention on Climate Change (article 3.3).

In September 1998, the Organisation for Economic Co-operation and Development organised a workshop with modellers to look at the implications of the Kyoto Protocol on the world economy. Van den Mensbrugghe [14] provides a summary of the modelling results, looking in particular at the variations of cost for different regions depending on the implementation mode:

- √ Independent implementation: each region must reach its own emission target without using the flexibility mechanisms;
- √ Annex I trading: countries/regions with emission goals under the Kyoto Protocol (so-called Annex I Parties) can trade among themselves;
- √ Global trading: Annex I Parties can now acquire emission reductions from developing countries, via the CDM. It is assumed that developing countries could trade all reductions from their business-as-usual emissions.

The results of these scenarios confirm the rather straightforward intuition that the more Parties are allowed to trade emission reductions, the lower the overall cost of achieving the agreed target.[2] In particular, the participation by developing countries adds to the overall potential for low-cost reductions and substantially reduces the marginal cost and overall economic burden of the Kyoto commitments. In short, their relatively low energy prices and their fast economic growth explain the low-cost potential in developing countries. These results are summarised in table 1. As usual, differences in marginal cost of reductions from one model to the others can be explained by: (a) variations in business-as-usual projections of CO_2 emissions (which determine the magnitude of the effort); (b) different assumptions on the availability and cost of carbon-saving technology; (c) more or less detailed treatment of end-use energy and corresponding prices and taxes.

Table 1
Marginal cost of abatement with and without trading (US$ 1995 per ton of carbon).[a]

	No trading			Trading	
	US	Europe	Japan	Annex I	Global
SGM	163			76	27
MERGE	274			114	80
G-Cubed	63	167	252	37	13
POLES	82	130–140	240	112	33
GTEM	375	773	751	123	
WorldScan	38	78	87	20	
GREEN	149	196	77	67	25
AIM	166	214	253	65	43
Average	164	260	277	82	28

[a] Sources: SGM: Sands et al. [15], MERGE: Manne and Richels [11], G-Cubed: McKibbin et al. [8], POLES: Capros [4], GTEM: Tulpulé et al. [17], WorldScan: Bollen et al. [2], GREEN: Van den Mensbrugghe [13], AIM: Kainuma et al. [7].

[2] Note that all the models presented here assume that all reductions come at a cost, except for regions where emissions would be lower than their Kyoto target during the budget period 2008–2012.

The introduction of trading enables the main OECD regions to acquire reductions from countries with economies in transition (Annex I trading) and from developing countries (global trading). The reduction in marginal cost would range from 50 to 70% with Annex I trading, and from 80 to 90% under global trading. Total economic cost (GDP or welfare cost), would be reduced by as much as 80% between the independent implementation (no trading) and the Annex I trading scenarios (see table 2).

Under Annex I trading, OECD regions would first acquire reductions resulting from the difference between the allocation and the business-as-usual trends of Parties with economies in transition, e.g., the Russian Federation and Ukraine. In the World Energy Outlook [6], this represents some 156 million tons of carbon.[3] As we will see, this would not be enough to cover the needs of the OECD; it is assumed that further reductions could take place in transition economies to meet the excess demand for emission credits from OECD. Of course, OECD regions would reduce their emissions up to the point where their marginal cost meets the international price for tradable permits. Ta-

Table 2
Aggregate economic cost (in 2010, as % reductions in GNP, GDP or income).[a]

	No trading (%)	Trading	
		Annex I (%)	Global (%)
SGM	0.4	0.28	0.12
MERGE	1		0.25
G-Cubed	0.3, 0.8, 1.4	0.2, 0.2, 0.5	<0.2
GTEM	1.2	0.3	–
GREEN	0.5	0.1	–
AIM	0.45	0.3	0.2
	0.25	0.15	0
	0.3	0.17	0.07

[a] SGM: results for the US only. MERGE: US only. G-Cubed: results for US, Japan, other OECD. AIM: results for US, Japan, and European Union.

Table 3
Share of reduction commitments and tons acquired through Annex I emission trading.[a]

	% of total reductions[b]	Quantities[c] (million tons of carbon)
Europe	63	213
Japan (or OECD Pacific)	66	83
North America	39	221

[a] Sources: see table 1, Van den Mensbrugghe [14] and Ellerman et al. [5].
[b] These data were constructed from the results of models sampled in table 1. We computed the average share of commitments met through trading for each region based on these models.
[c] These quantities were computed using the IEA World Energy Outlook [6], which provided business as usual emission scenarios, as not all model-based scenarios provided detail on the emission growth of the different regions.

[3] In comparison, Victor et al. [18], find that the Russian and Ukrainian "bubble" would range between 12 and 1100 million tons of carbon for the 2008–2012 period, or 2.4–220 million tons annually.

ble 3 gives an indication of the share of commitments that would be acquired from the international trading market by different OECD regions. In other words, it represents how much of the gap between business-as-usual and the Kyoto commitment is acquired externally. Total annual transfers in CO_2 emissions from countries in transition would amount to about 517 million tons of carbon (to be compared with the above 156 million tons available without any effort).

Interestingly, all the models surveyed indicate that Europe would acquire a larger portion of its total commitment than North America, whereas the negotiating positions of the different group of Parties indicate otherwise. Indeed, Europe has been advocating for a ceiling on the use emissions trading while North America, Japan and others are against this principle, seen as a barrier to trade that would entail losses in economic efficiency. We do not look any further into this issue in the rest of the paper.

The question we need to ask when looking at these modelling results is: what would it take, in terms of institutional arrangements and domestic policies, to fully benefit from the flexibility provided by trading and the CDM? Furthermore, can we realistically expect such a fluid market, in which all Parties have a full knowledge of their marginal cost curves, and can trade on that basis without any loss of efficiency? A few elements can help provide an answer to these questions.

First, the models must assume that policies are introduced domestically in a fully efficient manner, so that countries only buy from (sell to) the international market when the international market price is lower (higher) than their own marginal cost. For all regions of the world participating in trading, a carbon tax would be applied on fossil fuels, which is set at the level of the international permit price. Alternatively, a broad domestic emissions trading could be introduced. Two issues arise here:

– Although carbon taxes have been the instrument of choice of a number of countries in Europe, they have not, to date, been applied at a unique rate covering all CO_2 emission sources.[4] Similarly, very few countries are considering applying domestic emission trading in a way that would cover all sources of GHG emissions. One can question whether trading could take place on the basis of all of nations' emissions sources, as assumed by models, or on the basis of a limited number of activities.[5]
– If we cannot expect such policies from Annex I Parties, can we expect developing countries to achieve such a level of policy efficiency? These countries currently have no commitments to reduce greenhouse gas emissions.[6] The only vehicle to trade emissions with non-Annex I Parties is the CDM, which is so far viewed as based on specific projects, and not economy-wide policy changes. In that respect, it is not clear that *any* reduction from business-as-usual would qualify as a CDM activity, e.g., if it does not meet the requirement of sustainability. The global models assume that any change from business-as-usual would qualify.

Second, one needs to take a close look at the orders of magnitude of a number of variables underlying these scenarios in order to check their realism in the current context. Of particular interest are: the financial transfers between developed countries and economies in transition under the Annex I trading scenario, and similar transfers to developing countries under a global trading regime. Another important reality check is the magnitude of reductions that countries in transition and developing countries would need to generate, in light of the short time available to achieve such progress. We now turn to these two questions, and try to provide answers based on the models quoted above.

The financial flows needed to sustain emissions trading can be computed from the share of commitments achieved externally and the market price of traded emissions. For the sake of simplicity, we rely on a single business-as-usual scenario to determine the quantity of reductions that would be acquired by Parties on the international emission market: the scenario of the World Energy Outlook [6].[7] The total traded quantities under the Annex I trading scenario would amount to 517 million tons of carbon (see table 2). The average market price would be around US$82 per ton. Hence, some US$42 billion would be transferred annually from OECD regions to transition economies under Annex I trading, as payment for emission reductions. In 1995, foreign direct investment to Czech Republic, Hungary, Poland and Russia, the largest recipients for such transfers, amounted to US$10.5 billion (IFC, 1996). In brief, transfers related to international GHG trading might be equivalent to a 400% increase in foreign direct investment to countries with economies in transition. With that goal being 10 years away, one can question the realism of these financial transfers, which would take place only for the sake of climate change.[8]

Even more striking may be the additional reductions that would be required in countries with economies in transition to provide the quantities to be traded on the market. Indeed, the 517 million tons traded by countries in transition imply that their emissions would be 34% below what they would be under the no-trading case. Note that un-

[4] See Baron [1].

[5] In addition, the models used here ignore the possibility of Parties banking GHG emission reductions for use in the next budget period. This is another factor that leads to over-estimating the volumes traded on the international market.

[6] Argentina and Kazakhstan have announced that they would be taking national emission goals in the near future, but major emitters like China, India, Indonesia and Brazil have not yet made such commitments.

[7] Not all the models quoted in this paper give information on the total quantities traded in different scenarios, which is why we chose to use a single and well-documented reference scenario to estimate the quantities reported here.

[8] Victor et al. [18] note that Russian earnings from natural gas amounted to US$10 billions in 1997.

der business-as-usual, emissions would already be 13% below their 1990 level. Emissions in economies in transition would therefore be reduced to about 50% of their 1990 levels for these countries to meet the demand for emission reductions from the international market. This may be possible in a modelling world, but the mind boggles at the magnitude of policy changes that would be required in order to see such dramatic changes in energy use occur in these countries.

Turning to the global trading scenarios, one finds similar results albeit with differences in magnitude. The financial transfers to developing countries would amount to US$9 billion annually, not an impressive number compared to the US$90 billion dollars of foreign direct investment to developing countries in 1995. This relatively low number is explained by the low price for traded emissions that would be achieved through the participation of developing countries (US$28, against US$82 per ton under Annex I trading only, according to global macroeconomic models surveyed here).

Most, although by no means all, reductions through the CDM are likely to come from stationary fossil fuel projects, either in the power sector, in other industries, or in residential projects. Indeed, at present there is no agreement on the inclusion of forestry in the Clean Development Mechanism. As for the transportation sector, its emissions are difficult to monitor, and the number and size of sources do not facilitate the design of GHG reduction projects.

If we look at the quantity of traded emissions, and assume that they would all take place during the first budget period (2008–2012), we find that some 340 million tons of carbon would be reduced in the developing world from business-as-usual, on an annual basis. As a comparison, this quantity represents a 30% reduction in emission levels of all new stationary fossil fuel uses in the developing world by 2010, compared to the business-as-usual scenario.

Of course, if projects were to start more quickly under the CDM, as soon as 2000, CDM reductions would not represent as big a share of total consumption. But the order of magnitude, according to global models, is unlikely to be much lower than a 20% reduction from business-as-usual in new stationary uses. This number simply means that developing countries would, from now on, make energy investment decisions with full account taken of climate change impacts, and endure the cost of re-directing investments towards low-carbon sources.

Based on this discussion, we should consider the validity of model results dealing with international emissions trading and the contribution of developing countries to the Kyoto Protocol emission objectives. We can question the realism of such numbers on at least two grounds:

– A 20–30% reduction in emissions from business-as-usual for all new stationary sources would mean that developing countries are undertaking significant actions to mitigate climate change. With most capital stock remaining in place for 20–40 years, and given the fairly limited contribution of renewable energy sources to the increase in energy demand in these regions [6], such development is not probable.
– Even if the CDM becomes a major element in energy policy of developing countries, this mechanism remains based on projects. It would not allow wide-ranging energy reforms to be credited for greenhouse gas reductions. Only such reforms (e.g., reforming energy subsidies) may deliver the 20–30% reduction in emissions from business-as-usual, which would be necessary to meet the demand of the developed world.

From this discussion we draw the following conclusions:

– Macroeconomic models are too optimistic in their assessment of the contribution of flexibility mechanisms to the fulfilment of the Kyoto target. The realism of the orders of magnitude for both the transfers and the necessary reductions by the selling Parties can be seriously questioned. It simply reflects the full market efficiency (and policy efficiency) assumed by global macroeconomic models, as well as the absence of transaction costs in trading. We also note that the possibility to bank emission reductions for future use is not simulated either.
– OECD countries would need to rely more on domestic action than what is projected by models, as they cannot count on as large a market as what is predicted.

These results also beg for the question: what can we realistically expect from the Clean Development Mechanism? What, in its design, could deliver a large quantity of reductions from developing countries, to get closer to projections presented by models? This is the subject of the next section of the paper. It also provides an opportunity to look at the marginal cost of reductions in developing countries, based on simple examples taken from the power sector.

3. The Clean Development Mechanism: does the private sector have the right incentives?

The economic rationale of the Kyoto “flexibility” mechanisms, including the Clean Development Mechanism, is to exploit differences in marginal costs of climate change mitigation among countries.

In brief, the CDM differs from the other two flexibility mechanisms (joint implementation and emissions trading) in that it allows for joint emission reductions between industrialized (Annex I) countries, and developing countries (non-Annex I), the latter being the host, and the former the investor. The CDM includes an additional dimension: its purpose is to assist developing countries in achieving sustainable development.[9]

CDM projects would basically be international investments in emission reduction projects, with Annex I Parties,

[9] Sustainable development is not defined explicitly in article 12 on the Clean Development Mechanism in the Kyoto Protocol.

or private entities therefrom, being the investors, and non-Annex I Parties being the host countries.[10] The investor would earn a higher return from its investment through the crediting of certified emission reductions (CERs hereafter). The Protocol allows the investor to use these CERs to meet its own commitment. It could also sell the earned CERs on the international market for greenhouse gas emission reductions, if there is a profit to be made from such activity, that is, if the market price is higher than the marginal abatement cost of the CDM project.

A number of issues related to the CDM have yet to be clarified, including the role of its executive board. The board must be chosen during the first meeting of the Parties soon after the ratification of the Protocol.

Among other aspects, the role that should be played by the private sector has received a considerable attention in the discussion about the main features of the Kyoto Protocol.

The incentive for a private firm to participate in a CDM project will depend on a number of factors. First and foremost, it will depend on how the government of the Party has decided to fulfill its obligations under the Kyoto Protocol: entirely through domestic actions, or with some reliance on international cooperation through the Kyoto mechanisms. Assume that there are both domestic and international measures in a Party's portfolio. A firm could invest in a CDM project and generate CERs that it could use for compliance with an emission goal devolved to it by the Party.

Alternatively, if the Party has decided to rely on domestic actions only, a firm of this country could still undertake a CDM project for the sake of financial gains it could generate through the sale of CERs to another Party, or on an international market for greenhouse gas reductions. This activity would be totally independent of its Party's choice not to rely on flexibility mechanisms.

From an economic point of view CDM projects would attract investors if reducing emissions under the CDM were more cost-effective than any other available option. But from a broader perspective, the incentive for a company in an Annex I Party to participate in CDM activities can be seen as separate from its government's choice, as long as there is an efficient market for carbon reductions.

The dimension of this economic incentive is hard to quantify. As we have shown in the first part, global macroeconomic models find the market price to be around US$28 per tonne of carbon, but that number is based on strong assumptions about developing countries' ability to mobilise their economies towards climate change goals. It also depends upon a number of different elements, some of which are still under debate.

[10] Article 12.9 allows private and/or public entities to participate to the CDM, with further guidance to be given by the executive board.

In order to be eligible as a CDM project the investments must presumably fulfil certain criteria in order to be certified, but these criteria have not yet been established.

The first and (probably) the most important one is often referred to as the additionality criteria.

This issue is at the core of an intense debate related to the notion of additionality as stated in article 12 of the Kyoto Protocol. Summing up a large debate, one of the crucial characteristics to be eligible as a CDM project is that the achieved reductions "... are additional to any that would occur in the absence of the certified project activity".[11] Before the initiation of projects, a baseline would be established to show that the proposed GHG reductions are "additional".

There is also an important second point related to the notion of financial additionality. The Protocol seems to refer only to environmental additionality while in the expert debate the issue of financial additionality has been raised several times. According to some authors, in order to be eligible as a CDM project an investment must also be additional in financial terms. This means that a commercially viable project cannot be eligible as a CDM project. As an example, we can consider a project that reduces emissions but is profitable (i.e., commercially viable) while emissions could be additional (depending on the baseline). According to some authors this project should not be eligible as a CDM project. Others argue that financial additionality is not required by the CDM and profitable projects, as long as they reduce emissions from a baseline, should be creditable under the CDM. Further negotiations are needed to solve these issues and some of them are in the Buenos Aires Plan of Action.

For the rest of the paper we assume that our proposed projects are eligible to CDM and they are able to produce CERs for the investors. However, notwithstanding these open questions, the proposed examples are useful to flag some critical points.

Other possible criteria for eligibility under the CDM could include:

- method or extent of technology transfer;
- specific performance or design standards for transferred technology;
- capacity and willingness of both national and local governments to host the project;
- existence and nature of agreements for sharing project benefits (CERs and financial returns);
- project liability between investor and host; and
- limits on local environmental or other social impacts.

Another particularly important question is what criteria might be established for determining "sustainable development" and other benefits for host countries.[12] All these complex issues are not discussed in this paper.

[11] Article 12.5.c of the Kyoto Protocol.

[12] For an introductory discussion see Toman and Cazorla [16].

In this section we present a simple model aimed at illustrating orders of magnitude of the economic incentive to enter a CDM activity. Such information is important to draw a parallel with the quantified results of macroeconomic models presented in the previous section of the paper.

We consider two different situations. In the first situation, the project is financially viable even without the addition of revenues from CERs sales. In the second example, the extra-revenues from the sale of certified emission reductions are crucial to make the project viable. For this illustration, we look at two investments in power generation. The main difference between these two investments relates to the levelised unitary cost of the new investments compared to the old one. In the first case we assume that the new unitary cost is lower than the old one, while it is higher in the second example. Hence, everything being equal, the first project is already profitable without the revenues from the CERs, while for the second project the carbon value is *conditio sine qua non* for its implementation.

In the first example we assume that a new combined-cycle gas turbine, fuelled by natural gas is planned in a non-Annex I country; the investor is from an Annex I Party. If this new investment takes place, it will substitute for a coal power station. We assume that the two power stations have the same dimension. In the second example the coal power plant is substituted by a large-scale renewable energy projects with a higher unitary cost (e.g., wind power).

Tables 4.1 and 4.2 present an analysis related to the first investment under discussion while tables 4.3 and 4.4 deal with the second investment. All relevant parameters have been derived from literature [9].

In table 4.1 the incentive is shown for different CER prices ranging from US$5 to 30 per tonne of carbon (A). Table 4.2 shows the level of the incentive (D) for different levels of the new levelised unitary cost, from 35 to 30 mills per kilowatt-hour. Tables 4.3 and 4.4 show similar results for the renewable energy project.[13]

As far as the first project is concerned the existence of a carbon market will make the investment even more profitable (see table 4.1). The differences in levelised unitary cost assure the profitability of the project even without the inclusion of CERs revenues. Obviously, the profitability increases as the price of carbon emission reduction increases. Note that for a US$30 per tonne of carbon, close to the price

[13] The unitary cost of production of power from wind is based on Bourillon [3].

Table 4.1

(A)	(B)	(C)	(D)
5	14.720.000	24.232.127	0,65
10	14.720.000	26.384.254	0,79
15	14.720.000	28.536.381	0,94
20	14.720.000	30.688.507	1,08
25	14.720.000	32.840.634	1,23
30	14.720.000	34.992.761	1,38

Assumptions:		
Annual productior (million kWh)		1840
CO_2 emissions t CO_2/kWh	(NEW)	0,404
CO_2 emissions t CO_2/kWh	(OLD)	1,262
Levelised unitary cost (mills per kWh) NEW		33
Levelised unitary cost (mills per kWh) OLD		37
Selling Price (mills per kWh)		45

Table 4.2

(A1)	(B)	(C)	(D)
35	14.720.000	20.552.127	0,40
34	14.720.000	22.392.127	0,52
33	14.720.000	24.232.127	0,65
32	14.720.000	26.072.127	0,77
31	14.720.000	27.912.127	0,90
30	14.720.000	29.752.127	1,02

Assumptions:		
Annual productior (million kWh)		1840
CO_2 emissions t CO_2/kWh	(NEW)	0,404
CO_2 emissions t CO_2/kWh	(OLD)	1,262
Carbon Value US $/ tons. (Price of CERs)		5
Levelised unitary cost (mills per kWh) OLD		37
Selling Price (mills per kWh)		45

Table 4.3

(A)	(B)	(C)	(D)
90	14.720.000	10.987.553	-0,25
95	14.720.000	14.153.528	-0,04
100	14.720.000	17.319.503	0,18
105	14.720.000	20.485.478	0,39
110	14.720.000	23.651.454	0,61
115	14.720.000	26.817.429	0,82

Assumptions:		
Annual productior (million kWh)		1840
CO_2 emissions t CO_2/kWh	(NEW)	0,000
CO_2 emissions t CO_2/kWh	(OLD)	1,262
Levelised unitary cost (mills per kWh) NEW		70
Levelised unitary cost (mills per kWh) OLD		37
Selling Price (mills per kWh)		45

Table 4.4

(A1)	(B)	(C)	(D)
60	14.720.000	-21.268.050	-2,44
58	14.720.000	-17.588.050	-2,19
56	14.720.000	-13.908.050	-1,94
54	14.720.000	-10.228.050	-1,69
52	14.720.000	-6.548.050	-1,44
50	14.720.000	-2.868.050	-1,19

Assumptions:		
Annual productior (million kWh)		1840
CO_2 emissions t CO_2/kWh	(NEW)	0,000
CO_2 emissions t CO_2/kWh	(OLD)	1,262
Carbon Value US $/ tons. (Price of CERs)		10
Levelised unitary cost (mills per kWh) OLD		37
Selling Price (mills per kWh)		45

Legend:
- (A) Price of CERs (US$ per tonne of Carbon)
- (A1) Levelised unitary cost (US$ mills/kWh)
- (B) Old cash flow (Revenues-Cost) (US$)
- (C) New cash flow (including CERs) (Old Cash Flow + CERs*Carbon Value) (US$)
- (D) % increase in cash flow (New Cash Flow-Old Cash Flow)/Old Cash Flow

projected by macroeconomic models for global trading, the revenues from the sales of CERs add about 58% to the cash flow of the project. The CDM, therefore, provides a very strong additional incentive to realise the investment in a combined-cycle gas turbine plant instead of coal. The central issue remains whether this project would be qualified for CDM. One can argue that its environmental additionality is well established, as it reduces emissions by more than 60% from business-as-usual. Being financially viable at the outset, it is its financial additionality that is at stake.

The second case is more interesting. Here, the unitary cost is higher than the unitary cost of the coal power plant, which is not surprising for an investment in renewable energy. The project is not viable on its own. However, its carbon dioxide emissions are zero, and the revenues from CERs could help to offset the difference in terms of cash flow. In this example, a price of about US$ 100 per tonne of carbon is required to make the project financially viable, as the electricity sales cannot cover production cost at the prevailing electricity price. Of course, the crucial variable is the difference between the business-as-usual and the new production costs.

It is difficult to extrapolate from such microeconomic analysis to the broader question of supply of CERs in developing countries. Nevertheless, it is clear from these examples taken from the power sector that the low prices projected by macroeconomic models would give a very strong incentive to those projects which bring a well-established environmental benefit, but are already profitable, or fairly close to it. The substitution from coal to gas is a good example of such situation. On the other hand, these price levels are not sufficient to trigger no-emission projects such as renewable energy projects, at least at the unitary cost we have chosen here. These results give a good indication of what to expect from the CDM, if we are looking for projects with a high potential at low marginal cost.[14]

4. Some policy implications

What kind of policy lesson (if any) could be drawn from this analysis? Is it possible to look at the potential CDM projects in a positive and optimistic way?

For projects that are already feasible from an economic point of view the CDM framework could provide a strong additional incentive. Coal to gas substitution is an obvious candidate for such projects. However the eligibility of these projects in a CDM framework is still under discussion: their environmental additionality is well established, but as they may already be profitable, one could question whether they would not have happened without the CDM. Other kinds of projects, such as renewable, because they face higher unitary costs, require a fairly high level of price for CERs in order to be financially viable.

While differences in unitary costs could be considered as a continuum, in practice the energy industry may provide two types of projects, not unlike the ones we have sketched in this paper. Energy analysts are already considering the use of natural gas in developing countries (including for power generation) with great attention. The World Energy Outlook, for example, forecasts a substantial increase of the share of natural gas used in power generation in China (from 0 in 1995 to 3% in 2010 [6]). In the case of new gas developments, the expected revenues could be used to contribute to the realisation of the necessary natural gas infrastructure. The additional revenues from the CDM may even become a *sine qua non* to develop gas terminals and bring gas to the region.

The case of renewable sources or, more generally, of technologies whose unitary costs are much higher than the prevailing technology, is different. In this case, neither the environmental nor the financial additionality issue are in question since the project would not be viable without revenues generated by the CDM. But a relatively high price for CERs is necessary to make the project possible. If we consider the carbon values that models are suggesting in the case of global trade (around 10–30 US$/tC) we see that the investment becomes possible when the difference between unitary costs is very small. In our example if we fix the carbon value and the old unitary cost respectively to 10 US$/tC and 37 mills per kWh the investment is feasible if the new unitary cost is around 40. This may restrict CDM activities to sectors where alternative technologies are available at costs that are roughly equivalent to business-as-usual costs.

5. Conclusions

A closer look at results from global macroeconomic models show that they may be over-optimistic about the magnitude of international transfers of emission reductions under trading, whether it is limited to Annex I or extended to include developing countries through the CDM. While some reductions in costs can be expected from international trading, provided transactions are motivated by economic reasons and not political ones, the orders of magnitude indicated by models do not seem realistic. This result is reinforced by the assumption made in these models that markets operate in full competition, and that Parties would not bank GHG emission reductions. As a result, the domestic efforts required in OECD countries in order to achieve the Kyoto Protocol emission goals should be more significant than what is projected by these models.

We then consider the power sector as a case study for the Clean Development Mechanism; we try and assess the kinds of projects that would be necessary in order to meet the projections of the CDM contribution to the Kyoto commitments. We show that the CDM can bring about cost reductions if projects that are well established as environmentally beneficial, but also (close to) profitable before inclusion of CERs revenues, can be credited under the CDM.

[14] Other low cost potential projects could include energy efficiency improvements, but these may be more difficult to monitor.

Renewable energy projects, although they bring clear local and global environmental benefits, would require much higher prices of CERs to be profitable, at least in the near future. If the CDM is to bring about the reductions in cost projected by global models, it will need to include fuel-switching projects such as the ones described in this paper.

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