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The Future of ETS and CDM in a post-Kyoto World

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Abstract:
This paper discusses the developments in the trading of emissions rights since the Kyoto Protocol has been signed. The different emission trading schemes dominated by the ETS of the European Union and the Clean Development mechanism are surveyed. These schemes will need to be incorporated in a Post-Kyoto multilateral agreement. Based on a small model the incentives among developing and developed countries for continuing or transforming the Clean Development Mechanism in the light of a stricter world wide emission control are discussed.

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1. Introduction

The challenge for finding an agreement to mitigate Greenhouse gas emissions after the Kyoto-Protocol expires in 2012 seems to become increasingly difficult to master. Climate change apparently progresses faster than so far expected and predicted by climate models, emissions have been rising faster than envisaged in the worst case scenarios of the IPCC (Raupach et al. 2007), the world wide economic crisis has slowed down economic growth and thus CO_2 emissions but it has also made it politically less likely that significant action will come forth at a time where accelerating economic growth seems more important than controlling emissions. Past emissions and current emission trends combined with the new insights about the dynamics of the climate system seem to suggest that either a world wide immediate curb on emissions will be needed or – if an agreement to reduce greenhouse gas emissions will not be found soon – drastic reductions with zero net emissions and possibly negative emissions will be called for in the coming decades if dangerous climate change is to be avoided as required by Art. 2 of the United Nations Framework Convention on Climate Change (UNFCCC) that has been signed by practically all countries.

Despite these challenges and an apparently insufficient reduction target agreed upon in the Kyoto-Protocol, the Kyoto period has brought about a number of institutional and market developments that may provide a building block for a Post-Kyoto agreement. The emission trading scheme of the European Union (EU-ETS) controls about half of the CO_2 emissions of the EU but more importantly its introduction has led to a well developed market for carbon permits such that carbon has become a traded commodity and a price – although too low at the moment for providing sufficient incentives for significant reductions – has been established that can guide business in its energy input decisions. Similarly, other markets such as the market for project credits from the Clean Development Mechanism (CDM) are also well established in the business community by now.

There has been a discussion as to whether emission trading is a sensible concept for a Post-Kyoto agreement at all.[1] This discussion will not be taken up here. Instead I will start with the presumption that emission trading in one or the other form will remain a major instrument in climate policies. The question raised here concerns the experience with the two major emission trading schemes, the EU-ETS and the CDM, and the challenges that they face in a possible climate regime after 2012. Especially the role of the flexible mechanisms under

[1] Prominent examples are Nordhaus (2006) and Barrett (2006).

the Kyoto-Protocol such as CDM has been questioned when discussing Post-Kyoto climate policy instruments.

For example, Hagem and Holtsmark (2009) argue that the CDM mechanisms itself is an obstacle to a global climate agreement as it provides developing countries with an instrument that raises considerable income from selling emission rights to the developed world without taking on binding agreements. If the developed world were to accept a cap on its own emissions sufficiently strong to reach the emission targets advocated by climate scientists such as a 550 ppmv goal for atmospheric CO_2 concentrations – they argue - the CDM system would not be able to handle the huge demand for CDM projects that would be created by the countries facing emission caps.

The EU Commission proposes to reform the Clean Development Mechanism. In particular "for advanced developing countries and highly competitive economic sectors, the CDM should be gradually replaced by a sectoral crediting mechanism and cap-and-trade systems" (EC 2008). This has been strongly criticized by IETA, the International Emission Trading Association, as it asks for a "clarification, at the earliest possible date, about which sectors will remain open to CDM activity over the medium and long-term (e.g. after 2020)" (IETA 2009).

Any climate agreement in the Post-Kyoto period will need to subject the industrialized world to significant reduction commitments for greenhouse gases and achieve sustainable economic development in the poor regions of the world without increasing their greenhouse gas emissions by too much. Klemperer (2009) summarizes the prerequisites for this objective: "The main challenge is to improve the energy or carbon efficiency in the developing world. This requires first of all mechanisms that remove barriers to technology transfer and support private and public activities in this area. At the same time, new low carbon technologies will only be successful on the market if they are supported by appropriate carbon prices. Hence, a sufficiently developed market for carbon emissions brings about the profitability of low carbon technologies." The instruments with which such a challenge can be met have so far been the flexible mechanisms of the Kyoto Protocol, emission trading, CDM, and JI. The question is in which form they can be improved upon and whether and - if so - how they can contribute to the above objectives.

The paper will discuss in the next section the experience with the existing carbon trading schemes most notably the EU-ETS and the CDM market which currently dominate carbon markets. It is followed by a simple model for a Post-Kyoto carbon market which is used to identify the effects of different institutional arrangements on the distribution of the

cost of achieving the climate mitigation that is demanded by Art. 2 of the UNFCCC and advocated by bodies like the IPCC.

2. Experience with Carbon Trading Schemes

Emission trading as a theoretical idea is a well established approach now present in practically every textbook. However, the move from the theoretic idea with its elegant approach for controlling a global externality to the introduction of a workable trading mechanism into a day to day business is a difficult and voluminous task. In addition, there is not only one solution to establishing a carbon market but many. Consequently, several carbon markets coexist with sometimes very different designs.

The largest carbon trading scheme today is the European Emission Trading Scheme (EU-ETS) that covers roughly half of the emissions of the European Union (EU). The EU-ETS issues about two third of the volume of carbon credits (EUAs) world wide and almost 80 percent of carbon credit markets in terms of value. Details on the market size are given in the Appendix table A1. The second largest market is that for CDM credits (CERs)[2]. Compared to these two markets the other carbon markets in the United States or Australia are tiny with less than 2 percent of the market in terms of value traded.

The EU-ETS controls roughly half of the CO_2 emissions in the EU, namely the large energy installations having a net energy input of more than 20 MW. As a consequence, the major emission sources within the ETS are electricity producing companies as well as the chemical and the steel industry whereas other industries with small installations are not included.[3] This also means that other sectors such as transport or household heating that also emit a considerable amount of CO_2 are not included in the ETS. The ETS currently covers about 11.500 installations.

The allocation of emission permits takes place through the National Allocation Plans (NAPs) on the national level. They determine the amount of emissions that the country is allowed to emit during a particular period within the facilities that are covered by the ETS. This amount of emissions is equal to the number of European Union emission allowances (EUA) that are distributed to the emitters. The first NAP from 2005 to 2007 was intended as a test period. During this period a rather generous amount of allowances was given to the

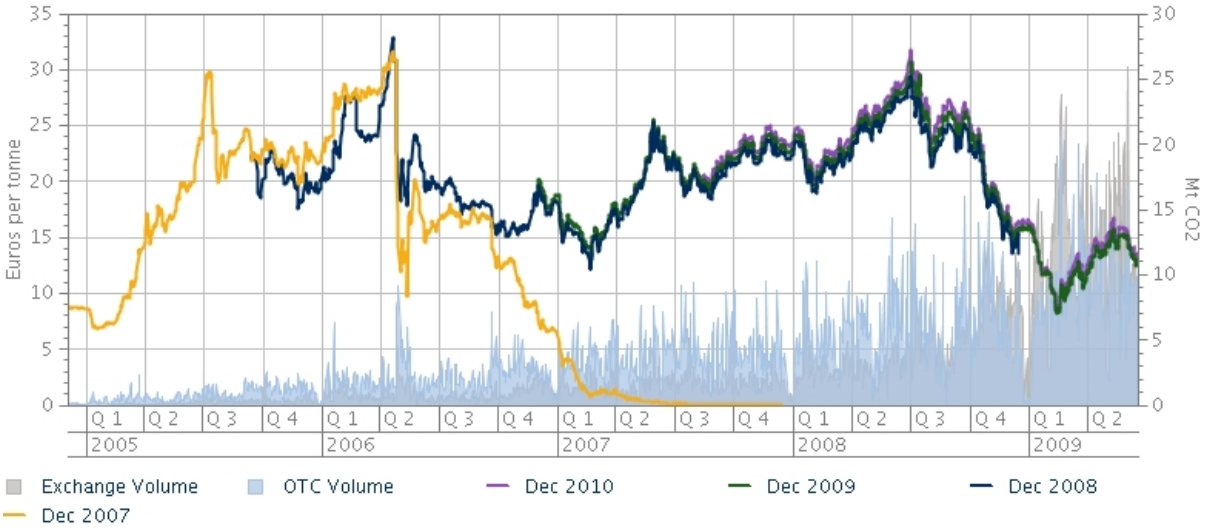
[2] For abbreviations see Table A1 in the Appendix .

[3] There has been a discussion to increase the minimum size even further. This would have excluded a large number of small installations which only contribute a small percentage to the overall emissions currently covered by the ETS thus reducing the administrative burden significantly.

facilities covered by the ETS. The EUAs of this period could also not be transferred to the next NAP period from 2008 to 2012. A number of experiences came out from this test phase.

- Since allowances could not be banked beyond the NAP period the prices for EUAs fell to zero at the end of the first commitment period as shown in Figure 1.
- The collapse of the market was also a consequence of the generous allocation of allowances prices. In the starting period there was no information about the actual demand for emission permits but as soon as the first data about actual emissions were published it was clear that the allocation was too generous.
- The generous allocation within the ETS would – if continued in the second period – lead to an inefficient distribution of emission reduction activities between ETS sectors and non-ETS sectors. In order to meet the Kyoto targets of the EU the countries would have to rely on abatement activities outside the ETS with much higher abatement costs than within the ETS. Simulation exercises showed that in some countries these costs would have been up to ten times higher than the allowance prices in the ETS (Klepper/Peterson 2006). Without reliance on the flexible mechanisms of the Kyoto-Protocol, the Joint Implementation (JI) and CDM projects several member states would need to impose high costs on the sectors outside the ETS that would have to compensate for the emission levels within the ETS.

Figure 1 Development of EUA Prices in the EU-ETS



Source: PointCarbon (2009) (http://www.pointcarbon.com/news/historicprices/)

The allocation of emissions in the second National Allocation Plans (NAP2) is now somewhat tighter after the Commission of the EU has rejected most of the national plans and demanded a smaller allocation of emission rights. But there would still by substantial imports of of emission rights from CDM and JI projects required in many member states of the EU in 2012 in order to meet the Kyoto targets. Another option would be a much stronger reduction of emissions from households, traffic, and small installations which is rather unlikely given the relatively low price elasticities especially in the transport sector and household energy demand.

Debated Features of the EU-ETS

There exist a number of generic problems that have impaired the acceptance and credibility of the EU-ETS at least in the public perception. One of the most discussed images was the free allocation of emission allowances to the installations as demanded by industry and opposed by many economists. Another problem arises from the fact that only half of the emissions in the EU are subject to an explicit carbon price whereas the rest is more or less regulated with a large number of national instruments but no EU wide policy. This is due to the fact that the EU-ETS is designed as a downstream system in which emissions are controlled directly at the source thus preventing mobile sources and small incineration facilities to become included in emission trading. These two aspects are discussed in turn.

Within the EU-ETS national governments have allocated practically all allowances in the first commitment period for free to the installations. Up to 5 percent of the allocated allowances could have been auctioned but most countries decided not to use this option. In the second period up to 10 percent of the allocation can be auctioned and several countries will use this opportunity. The allocation rule for the Post-Kyoto period starting in 2013 is still contended. Proposals of the EU Commission call for full auctioning starting 2013 for sectors able to pass through costs (such as the power sector) and gradual auctioning (from 20% in 2013 to 100% in 2020) for those sectors that are exposed to international competition and thus at the risk of carbon leakage. However, this proposal is strongly opposed by some member states.

The experience with a free allocation combined with the downstream allocation at the level of the incineration facility has been a political disaster. The haggling among companies over the allocation of emission rights, the European Union Allowances (EUAs), has been fierce and prolonged. After the EUAs had been allocated and the prices for EUAs started to rise above 20 €/tCO_2 and twice even beyond 30 € (see Figure 1) it became apparent that many

companies were passing on these costs to consumers in terms of higher electricity prices. The public reacted heavily to these apparent windfall profits and the EU-ETS lost credibility.

The negotiations for the allocation of EUAs in the second NAP were equally demanding and the political compromises that have been found have created some perverse incentives. Newly built power plants get emission allowances according to the fuel they use, i.e. a coal fired power plant receives twice as many emission rights than a plant fired with natural gas. This provision undermines the competitiveness of natural gas vis-à-vis coal for a long time and does not provide incentives to fuel switching.

The negative experience with the free allocation has convinced the Commission of the EU to move towards an auctioning system of emission rights in the third commitment period starting in 2013. The latest directive on the ETS states that "full auctioning should be the rule from 2013 onwards for the power sector, taking into account its ability to pass on the increased cost of CO2" (EU 2009). Exceptions should be provided to industries that face world market competition and sectors in which carbon leakage is a threat. Their share of freely allocated allowances will be slowly reduced until it reaches 30 percent in 2020 and from 2027 on all allowances will be auctioned.

The choice of having an upstream or a downstream emission trading scheme was decided early and without much discussion. The EU-ETS is a permit trading scheme that is as far down-stream as possible by controlling the emissions at the source, that is, at the fuel burning facility. In doing so it only covers large incineration facilities with more than 20 MW energy input as this is the only reasonable solution for administrative reasons. The alternative of going upstream has the advantage that small emitting sources can also be covered by the emission trading scheme without a large administrative burden.

Already in the late 1980s, a simple scheme that essentially covers the complete input of fossil fuels into the economy has been proposed in an expert report to the German government (Heister et al. 1991). The proposal amounted to the requirement that emission rights have to be possessed by importers or wholesalers of fossil fuels in order to market these energy sources in Germany or the EU. This would have created a transparent market that covers all emissions and would thus provide an efficient price signal to all energy users.[4] Such a solution while covering all emission sources has some inaccuracies since not all fossil fuels are immediately burned an turned into CO_2 and since not all incineration processes produce the same amount of CO_2. The first point mainly concerns the non-thermic use of

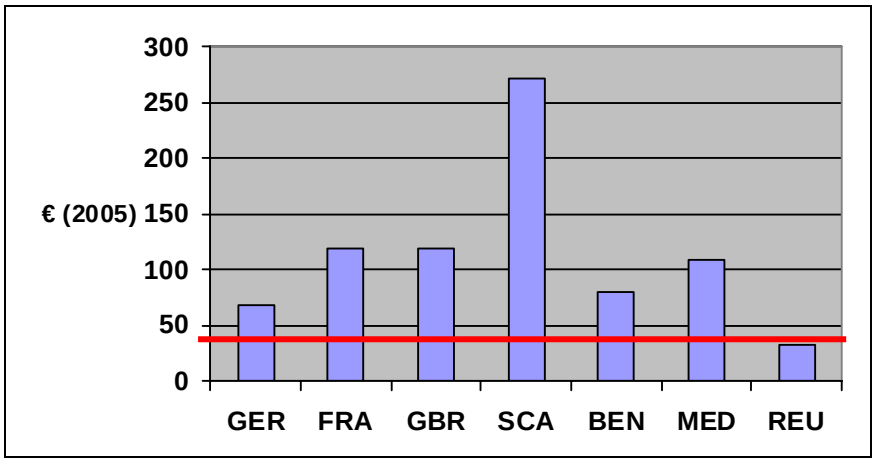
[4] This proposal was rejected by the German government at that time in favour of a CO_2 tax. Only years later the decision to support a cap-and-trade scheme was taken and then with the downstream solution.

fossil fuels in the chemical industry and can relatively easily be dealt with, the installation specific emission coefficients would remain although their impact may not be too large.

The divergence of the prices of EUAs in the ETS and the expected marginal abatement costs outside the ETS-sectors as given by the implicit carbon prices for reaching the Kyoto-targets indicates that the ETS with its downstream approach combined with the free allocation of emission rights has created an inefficient system in which governments for many reasons decided not to impose an emission path that leads to the achievement of the Kyoto targets in an efficient way. They either decided to rely on tougher targets in the second allocation period or to impose the additional cost of meeting the targets on consumers instead of the large scale incineration facilities.

Even in the second commitment period the NAPs seem to favour the EU-ETS sectors relative to the rest of the economies. The simulation results in Figure 2 illustrate this for the European target of a 20 percent reduction of CO_2 emissions with the allocation of emissions rights under NAP2. A price of 33 €/tCO_2 for EUAs (the red line in Figure 2) corresponds to shadow prices for the non-ETS sectors of up to 270 €/tCO_2 in Scandinavia. Only the member states of the EU not listed explicitly (REU) have prices slightly below the EUA price indicating an excess supply of EUAs.

Figure 2 Shadow Prices of CO_2 in non-ETS sectors (selected member states of the EU in 2020, simulation results)[5]



Source: Peterson (2009)

[5] GER=Germany, FRA=France, BGR=United Kingdom, SCA=Scandinavian EU, BEN=Benelux, REU=Rest of EU 25.

The EU-ETS shows some features that have unnecessarily created inefficiency in climate policies and political-economy problems. These could have been avoided by auctioning emission rights and moving the emission trading upstream such that it covers essentially all emissions. The auctioning of permit would have been easy in the first allocation period since the prices for emission rights would have started at a very low level because of the relatively large amount of permits put to the market. Switching to auctioning when the caps are more binding will be more difficult. In fact, the phase in outlined by the EU Commission has already created a debate similar to the process of free allocation as to who will get the free allowances and who has to auction for the allowances.

3. The CDM market for the Kyoto-Period 2008-2012

Besides the EU-ETS the market for emission rights is dominated the CDM markets. Table A1 in the Appendix gives an overview over the latest development in the market. The volume of emission rights traded and its value have almost doubled from 2007 to 2008. Essentially three quarters of the carbon market took place within the EU-ETS in 2008 while another 20 percent came from the secondary CDM market. The other allowance markets play hardly any role so far. The market for project-based transactions itself is also dominated by CDM projects where there is a direct transaction between the project in the developing country and a buyer from an industrialized country. JI and voluntary markets have traded only 65 $MtCO_2$ compared to 463 $MtCO_2$ of emissions contracted in CDM projects.

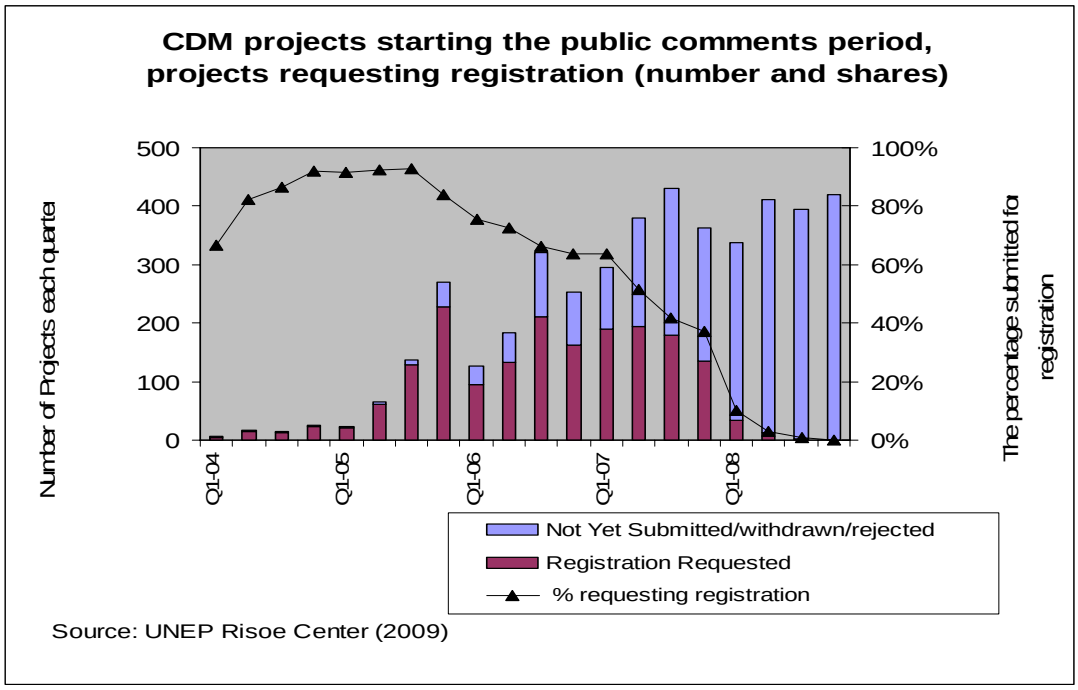
The overall number of CERs that have been issued since the start of the program has reached almost 300 million with 296.5 mio. tCO2eq by June 2009 (PointCarbon 2009). This is significantly less than the number of CDM projects that have been approved but not yet been certified to become CERs, i.e. they can not be used within the ETS. The issued CDM projects stand at roughly 500 mio. tCO2eq by 2009 and are expected to grow to 1.52 billion during the Kyoto period 2008 – 2012 (CARBONfirst 2008). The overall amount of CDM projects that are “in the pipeline” amounts to almost 3 billion tons by 2012 and 7.4 billion by 2020 according to the UNEP Risoe Center responsible for the book keeping of CDM projects (Fenhann 2009). Whether those will actually become issued and registered as CERs is an open question.

Given the reduction commitments of ANNEX I countries within the Kyoto protocol of roughly 700 to 1000 mio tCO_2eq, current ANNEX B emissions of about 14 billion tons of CO_2, and taking into account the 5 year Kyoto period, up to one third of the reduction

requirements in the Kyoto period could be supplied by CDM credits. The World Bank has estimated – based on National Communications – the demand for emission allowances from the Kyoto mechanisms, i.e. AAUs from Annex I parties, CERs from CDM, and ERUs from JI projects. Total demand is estimated to be around 2.4 billion tCO_2e over the period 2008-2012. Private sector demand accounts for 73% and government demand for the remainder. Private demand is likely to be almost completely met by CERs, whereas the World Bank assumes that 50% of government demand will be met by AAUs (World Bank 2008). This also results in a CDM demand in the range of somewhat over 1.5 billion CERs.

Whether these projections are indeed likely to materialize, falls into doubt if one considers the recent developments in the CDM project registration. In fact, the number of projects which are submitted for registration has declined drastically in 2008. At the end of last year essentially no projects have been submitted for registration to the CDM authorization bodies although the number of new projects in planning has remained at a level of 300 to 400 each quarter in 2008 (Figure 3).

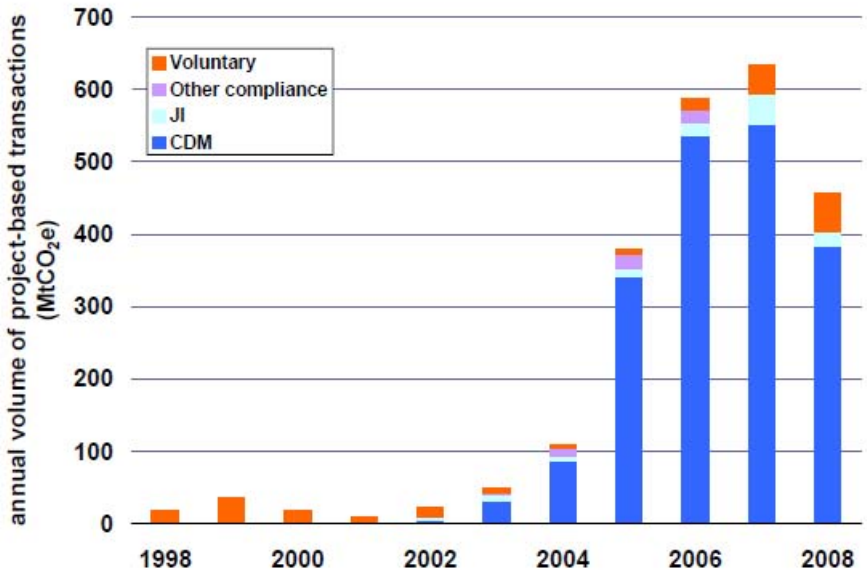
Figure 3: Development of CDM project submissions



The World Bank in its report on the "State and Trends in the Carbon Market 2009" reports that the current economic crisis is the main factor for the slow-down in the volume and value of the project-based transactions, i.e. the primary CDM market as shown in Figure 4. The reduced demand for emission reduction credits (ERUs) is seen as the main factor. At the same time, the allowance markets – especially the ETS – still continue to grow by almost

100 percent. The secondary CDM market even grew almost fivefold despite the crisis. It is also likely that the uncertainty about the role of CDM project credits in a Post-Kyoto agreement or in a situation without any international agreement has led to a reluctance to engage in long-term projects in the CDM market. This conjecture is supported by the fact that other markets, especially the voluntary market, still continue to grow whereas the flexible mechanisms of the Kyoto Protocol (CDM and JI) see a contraction in transactions.

Figure 4 Project-based Emission Reductions Transactions (vintage up to 2012)



Source: World Bank 2009.

So far, CDM projects have been concentrated on the reduction of HFCs, methane and other non-CO_2 Greenhouse Gases. In fact, HFC reduction has created so far around 55 percent of the the CERs issued.[6] In addition, most of the projects have been created in China. Especially smaller developing countries and many African countries have not been successful in attracting CDM projects. This can be due to a lack of expertise in these countries but it can also be the result of a general lack of profitability of suitable projects. Since the carbon credits created in a CDM project are only supplemental to the overall profitability of a CDM project, low market returns of the CDM project may not be sufficiently compensated by the carbon credits.

This geographical concentration of CDM projects goes hand in hand with a small share of CDM project in the area of transport, infrastructure, or rural energy supplies. Such projects would have significant co-benefits in terms of sustainable development in poor

[6] A phase out of HFC projects may be proposed by the EU in Copenhagen.

areas.[7] The emission reduction opportunities from reducing emissions from deforestation and forest degradation (REDD) have been excluded from the CDM mechanism completely although this is also an area where a large potential for emission reductions rests with an estimated annual reduction potential of 1.6 Gt CO_2.

The concentration of CDM projects towards large scale projects in the area of HFC and methane reduction has led to a discussion about improvements in the CDM mechanism that would make it more attractive to engage in smaller projects and in areas that have not been seeing CDM activities. Among other reasons, high transaction costs have so far prevented such projects. Two proposals are currently under discussion, the so called programmatic CDM projects (pCDM) and sectoral approaches. Programmatic CDM has been defined by the UNFCCC as "a local/regional/national policy or standard cannot be considered as a clean development mechanism project activity, but project activities under a programme of activities can be registered as a single clean development mechanism project activity[8]. The methodologies for pCDM have already in 2007 been accepted by the Executive Board of the CDM but so far no project has been approved. pCDMs have the advantage that they can encompass a large number of smaller regional projects, even across countries, thus reducing transaction costs. At the same time the risk of misrepresenting emission reductions has increased and the Designated Operational Entities (DOEs) that are responsible for the correct performance of CDM projects vis-à-vis the Executive Board have not been willing to accept the liability for the functioning of such projects. Nevertheless, the pCDMs are a step towards regional and even transnational CDM projects.

The sectoral CDM approach would not be defined for a single project but along a certain policy that a government imposes on a particular sector. The procedures would be similar in that a target is set be the government and upon reaching the target carbon credits created could be sold on international markets. Such approaches will only become relevant in the Post-Kyoto Phase and it remains an open question how they will be integrated into regional or global carbon trading schemes.

The sectoral approach requires the definition of a baseline against which the emission reductions within a sector could be measured. Such a baseline and the emission reduction that will be achieved against this baseline amounts to little less than a sectoral cap on emissions. The country engaging in sectoral CDM activities would enter a partial cap-and-trade system with the baseline being the defined cap. This would not create a substantial constraint on

[7] A few project have been approved to the so called "Gold Standard" that certifies additional benefits for a sustainable development and have received a significant premium for the credit generated.
[8] Quoted from Figueres et al. (2008).

emissions in that sector but it would define a publicly defined emission path which can be easily interpreted as a "business as usual" baseline. Determining such a path itself could generate a debate that could trigger demand for a revision of baselines that seem too high in the light of current economic developments and that could result in stronger political pressure to agree to reduction targets as this has been happening in the light of the recent rapid increase of China's CO_2 emissions.

4. Market Segmentation and Convertibility

A large number of carbon markets with many currencies and only limited convertibility is now in existence. In fact, most markets are connected only through the CDM market and to some extent through the JI-project mechanism. Figure 5 illustrates the markets and their currencies.

Figure 5 Convertibility of Currencies in different Carbon Markets

	Kyoto	EU-ETS	Keidanren VAP	NZ ETS	NSW	RGGI	CCX	Volun-tary
AAU								
CER								
t/l CER								
ERU								
RMU								
EUA								
NZU								
NGAC								
CFI								
VER								

No restrictions Restrictions

Abbreviations in Appendix A Source: World Bank (2008)

It is apparent that the CERs from CDM projects are the permits that can most easily be exchanged in different permit markets. At the same time the EU-ETS as the largest market has restrictions on the use of CDM and of JI credits but does not accept other emission reduction currencies at all. On the other hand, most small national emission trading schemes and the voluntary markets accept emission permits from other systems. However, given the

lower prices in these markets the incentive to use EUAs from the EU-ETS is essentially nonexistent.

This multitude of carbon markets poses a challenge for reducing market segmentation and creating a common carbon markets with a uniform price. This can not be done by simply making all “Carbon Currencies” convertible. The different system rely on different types of restrictions on emissions with different restrictiveness of caps, their validity and credibility may be different depending on the monitoring and verification scheme, and most importantly, they sometimes cover the same geographic area thus contradicting the idea of a unique cap on emissions as a prerequisite for emission trading.

It is therefore likely that some small markets will remain independent whereas larger markets will need to make their procedures and coverage similar to those of the EU-ETS as the most developed and largest market so far. This situation may change if the USA is moving towards an emission trading scheme which would quickly reach a size similar to the EU-ETS.

5. The distributional consequences of CDM in a Post-Kyoto Framework

The project-based mechanisms of the Kyoto-Protocol have been designed to create incentives for countries not being subject to caps on their emissions to reduce emissions by receiving technologies from industrialized countries as well as financial transfers for the carbon credits created. The Post-Kyoto framework, in order to be effective, will require a much stronger involvement of developing countries and, even more importantly, emerging economies to provide a substantial reduction of emissions relative to their expected baseline emissions. This will require new forms of incentives that go beyond the current framework of CDM projects. At least for the largest emerging economies such as China and India who incidentally also provide most of the CDM projects some form of a commitment to reduce emissions below some specified level will be necessary if a substantial reduction of global emissions is to be achieved. At the same time, most CDM project last for many years and many well into the Post-Kyoto period. The question therefore is what interaction takes place between the CDM projects and a possible future cap and trade system.

In the following a simple model is developed that illustrates the role of multi-period CDM projects in a Post-Kyoto global emission trading scheme.

Suppose there are two countries (i,d), an industrialized country facing an emission constraint $c_i = \gamma c$ and a developing country facing no constraint. The constraint c could be a globally desired emission reduction below an unconstrained emission level that, e.g. achieves

a path towards a 2°C goal of climate warming. The industrialized country's cap achieves only part of that objective. In reaching the constraint it can engage in CDM projects in the developing country that reduce country d's emissions by e_d and thus getting the credit for emitting the same amount saved in country d by buying the CERs. Both countries are assumed to exhibit quadratic marginal abatement cost curves where a is the relative cost difference between country i and d.[9]

$$MAC(e_j) = ae_j^2 \qquad j = i,d \quad and \quad a > 1 \; if \; j = i \; ; \; a = 1 \; if \; j = d \; .$$

There is a competitive national or international market in emission permits such that the price for emission permits p equals the marginal abatement costs[10]

$$MAC(e_i) = MAC(e_d) = p \qquad j = i,d$$

Without a CDM option and with an emission constraint c for country i only, the carbon price in country i will be $p = a(\gamma c)^2$. The corresponding welfare cost of meeting the target c can be computed as $W_i(\gamma c) = \frac{1}{3}a(\gamma c)^3$.

Now suppose a CDM market is available such that country d faces no emission constraint but can sell emission permits to country i through CDM projects. This resembles the current situation of the flexible mechanisms of the Kyoto-Protocol.[11] The emission constraint for country i remains the same, i.e. γc. The new equilibrium will be given by emission abatement in both countries such that the marginal abatement costs are equalized and the sum of emission reductions $e_i^* + e_d^*$ just meets the emission constraint γc.

$$e_i^* + e_d^* = \gamma c$$
$$e_d^{*2} = a e_i^{*2}$$

The corresponding welfare costs of the two countries are given by

[9] Such cost curves have been computed with CGE models. For an example see Klepper/Peterson (2006).

[10] Transaction costs of CDM projects are ignored here since they do not influence the qualitative results. However, the redistribution of resources is reduced for both sides in the presence of transaction costs as these costs are essentially not available for redistribution. These costs can substantially influence the price of carbon as is shown by Klepper/Peterson (2005).

[11] This not only true for CDM but also for JI projects which can be undertaken between companies located in countries which have agreed to emission targets in the Kyoto-Protocol. Such JI projects are most likely in countries which have a supply of "hot air", i.e. their benchmark emissions are smaller than the emission constraint.

$$W_i(e_i^*, e_d^*) = \int_o^{e_i^*} a e_i^2 de_i + p_{CDM}\, e_d^*$$

$$W_d(e_i^*, e_d^*) = \int_o^{e_d^*} e_d^2 de_d - p_{CDM}\, e_d^*$$

A simple computation shows that

$$e_i^* = \frac{k\gamma c}{\sqrt{a}} \quad with \;\; k = \frac{\sqrt{a}}{1+\sqrt{a}} \geq \frac{1}{2}$$

$$e_d^* = k\gamma c$$

$$p_{CDM} = (k\gamma c)^2$$

and the corresponding welfare costs of the two countries are[12]

$$W_i(e_i^*, e_d^*) = \left(1 + \frac{1}{3\sqrt{a}}\right)(k\gamma c)^3$$

$$W_d(e_i^*, e_d^*) = -\frac{2}{3}(k\gamma c)^3$$

As mentioned above, CDM projects last for several years to over a decade. Many CDM projects signed in the current Kyoto period will have an impact on the costs and benefits of a cap and trade system in a Post-Kyoto Climate Agreement. Without going into the details of CDM projects of different life times we just assume that all old CDM contracts have a life time that surpasses that of the first Post-Kyoto phase.

There are several ways one can imagine building scenarios for the Post-Kyoto phase. If there is a world wide consensus for emission reductions by c the essential question for the distribution of cost and benefits of climate mitigation is the allocation of emission rights.

$$c = \gamma c + (1-\gamma)c$$

where γ is the share of c that is allocated to country i in the Kyoto period. In other words, $(1-\gamma)c$ denotes the reduction that is now imposed upon country d.

There are essentially two possibilities for allocating emission reductions in a post Kyoto framework given an overall emission goal of c is agreed upon. Either the CDM contracts remain valid or they will be discontinued or phased out.

We start first with the case that CDM projects will be discontinued. In this scenario (PK-) there will be just one emission reduction constraint for each country defined by γ and c. International emission trading will equalize carbon prices. The corresponding welfare functions are

[12] Notice that a negative welfare cost is a welfare gain, i.e. country d benefits from engaging in the CDM market.

$$W_i^{PK-}(e_i^{PK-}, e_d^{PK-}) = \int_o^{e_i^{PK-}} a e_i^2 de_i + p_{PK-}(\gamma c - e_i^{PK-})$$

$$W_d^{PK-}(e_i^{PK-}, e_d^{PK-}) = \int_o^{e_d^{PK-}} a e_d^2 de_d - p_{PK-}(\gamma c - e_i^{PK-})$$

In this case emission levels, carbon prices and welfare costs amount to

$$e_i^{PK-} = \frac{kc}{\sqrt{a}} \quad and \quad e_d^{PK-} = kc \qquad with \quad k = \frac{\sqrt{a}}{1+\sqrt{a}} \geq \frac{1}{2}$$

$$p_{KP-} = k^2 c^2$$

$$W_i^{PK-}(e_i^{PK-}, e_d^{PK-}) = \left\{ \frac{\gamma}{k} - \frac{2}{3}\frac{1}{\sqrt{a}} \right\} k^3 c^3$$

$$W_d^{PK-}(e_i^{PK-}, e_d^{PK-}) = \left(\frac{1-\gamma}{k} - \frac{2}{3} \right) k^3 c^3$$

If both countries experience equal marginal abatement cost curves (MACCs) they will reduce the same amount of emissions and trade is only determined by the emission constraint γ. The steeper the MACC of country I becomes the higher the carbon price and the higher the emission reduction in country d.

The second scenario can be seen as a situation where both countries agree on national caps and continue to honour the CDM projects (PK+). In this case the previously signed CDM contracts continue to be traded in the Post-Kyoto Agreement. In addition, international emission trading allows countries to obtain emission permits from abroad. There will be two carbon prices if the price of the CERs agreed upon in a CDM project has been negotiated for the whole period or a unique price if only the quantity of the CERs created in a CDM project has been set and the price of a CER depends on the time at which it is transferred. In reality it is most likely that the price of a CER is determined in a competitive market at the time of the creation of the project. In other words, the prices of CERs from the Kyoto period are given in the Post-Kyoto period.

The welfare of the two countries amounts to

$$W_i^{PK+}(e_i^{PK+}, e_d^{PK+}) = \int_o^{e_i^{PK+}} a e_i^2 de_i + p_{CDM}\, e_d^* + (\gamma c - e_i^{PK+} - e_d^*) p_{PK+}$$

$$W_d^{PK+}(e_i^{PK+}, e_d^{PK+}) = \int_o^{e_d^{PK+}} a e_d^2 de_d - p_{CDM}\, e_d^* - (\gamma c - e_i^{PK+} - e_d^*) p_{PK+}$$

The corresponding emission levels and the carbon prices are given by

$$e_i^{PK+} = \frac{kc}{\sqrt{a}} \quad ; \quad e_d^* = k\gamma c \quad ; \quad e_d^{PK+} = (1-\gamma)kc$$

$$p_{CDM} = (k\gamma c)^2 \quad ; \quad p_{PK+} = (kc)^2$$

$$W_i^{PK+}(e_i^{PK+}, e_d^{PK+}) = \left(\frac{2}{3\sqrt{a}} + \gamma(\gamma^2 - 1) + \frac{\gamma}{k}\right)k^3c^3$$

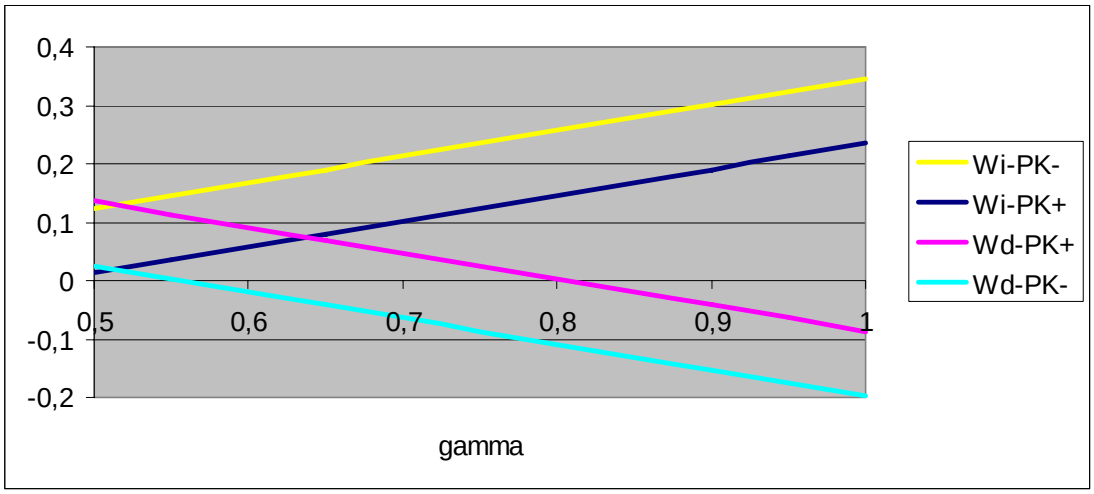
$$W_d^{PK+}(e_i^{PK+}, e_d^{PK+}) = \left(\frac{1-\gamma}{k} - \frac{2}{3} + \gamma(1-\gamma^2)\right)k^3c^3$$

It is clear that the market price for Post-Kyoto emission rights ("Post-Kyoto AAUs") would be the same in both scenarios PK- and PK+. The CER prices for CDM credits are however lower since they have been negotiated under a setting where there were no restrictions on the emissions of country d. In fact, in this example with quadratic marginal abatement cost curves the CER price p_{CDM} will be lower by γ^2 than the Post-Kyoto permit price. A low γ means a soft target in the Kyoto period and a low CDM price but also a high additional constraint on country d thus a high Post-Kyoto carbon price. Since the CER prices have been set in advance the overall emission reduction for both countries will be the same in scenario PK+ as in PK-. The only difference is the price at which the emission permits are sold from country d to country i. Hence there is only a distributional effect but no allocation effect.

In this quadratic example the welfare effects are in all scenarios and for both countries scaled by the overall cap c. The welfare functions show that the welfare cost of a tighter target rises with the power of three for all countries and in each scenario because of the quadratic MAC function. Hence, the distributional impacts can be identified within this framework for agreements with different restrictions on emissions. Essentially, the welfare effect for the two countries depends on the interplay between the distribution of the caps among countries i and d as well as the differences in abatement costs.

A comparison of Scenario PK+ with PK- in terms of its distributional effects for any given $\gamma<1$ and a given $a>1$ gives a clear result. The industrialized country is better off by keeping the CDM projects (PK+) and the developing country is better off in phasing out these projects (PK-). The size of the difference in welfare costs in country i between PK+ and PK- depends on the degree to which country i has contributed to the reduction (γ). The higher the share of country d in the reduction commitment the higher are her welfare costs and the higher the difference between PK+ and PK- (see Figure 6). This effect is of course amplified by the fact that the industrialized country does not increase her reduction commitment and only the developing country faces an additional constraint in form of the cap $(1-\gamma)c$.

Figure 6 Welfare Effects for Different Emission Sharing Targets[13]



The impact of the future of CDM contracts on the welfare of country d depends strongly on the share of the reduction imposed on her, i.e. on γ. If the Post-Kyoto agreement imposes only a small reduction share in country d its welfare effect of selling emission permits remains positive. In this case the gains from selling CDM credits outweigh the cost from complying with the small reduction target. If the cap goes far beyond the old Kyoto targets (a low γ) then the reduction commitment starts to dominate the effect of the CDM market. In the scenario with a phase out of CDM contracts (PK-) the income generated at low CER prices will be replaced by higher carbon prices for all emissions traded but this is counterbalanced by the increasing cost of additional emission reduction requirements. In the scenario PK+ the fixed CER prices lead much more quickly to a situation where the sales of emission permits do not compensate for the emission reduction required by the emissions constraint. In other words the trajectory of welfare effects in γ is much steeper in PK- than in PK+. In summary, if country d were to accept an emission cap it would prefer discontinue the CDM contracts.

Of course, it is unrealistic to assume that the reduction commitment of the industrialized countries in the Kyoto period will be maintained in the Post-Kyoto phase and an additional cap will be imposed on the developing world as shown above. Instead, one would expect that the low γ in the Kyoto period will be replace by a higher one in the Post-Kyoto phase. This resembles the need for stronger action by the developed world before a commitment is to be expected from the developing world.

[13] Parameters a=4, c=1, γ for CDM credits is set to 0.5.

In order to illustrate the relative size of the effects a simple exercise with some reasonable parameter values is shown below. The current Kyoto targets are in general viewed as much too low in order to stabilize CO_2 concentrations in the atmosphere. Suppose the current reduction targets achieve only half of what they would have needed to achieve in the Kyoto period up to 2012. This would mean γ could be in the area of 0.5 in the scenario of the Kyoto phase with a CDM market and γc would be the reduction commitment under the Kyoto protocol. Suppose also that the Post-Kyoto agreement assigns the reduction commitments in such a way that the industrialized countries (country i) take 80 percent of the reduction responsibility and the developing world (country d) 20 percent. In other words, the world wide reduction would be twice as high as in the Kyoto period as the overall target c remains the same and the industrialized countries take up the larger part of the additional reduction.

The marginal abatement costs are assumed to differ between the countries either by a factor of 2 or of 4, i.e. a=2 or a=4 which is not too unreasonable given the estimates of marginal abatement cost curves (MACCs) in the literature.[14] Table 1 illustrates the results of the computation with these parameters.

Table 1 Welfare Effects of Different Reduction Commitments

	A=4		a=2	
	I	d	I	D
CDM	0,043	-0,024	0,031	-0,017
PK+	0,146	0,002	0,104	0,010
PK-	0,257	-0,109	0,180	-0,065
Parameters: $\gamma = 0.5$ at CDM, $\gamma = 0.8$ at PK+ and PK-, c=1				

The welfare costs of the Kyoto agreement are shown in row CDM. With very low cost abatement opportunities in countries supplying CDM projects (a=4) exactly two third of the emission reduction would be served by CDM projects whereas one third would be done at home. If the cost difference is lower (a=2) the import of CDM credits is smaller thus resulting in a smaller price of credits.

Moving now to a Post-Kyoto agreement where the emission reduction c will be achieved and the CDM projects are honoured in the Post-Kyoto phase (PK+). For country d the emission cap together with the sale of CDM credits leads to a welfare effect of practically

[14] Klepper and Peterson (2006) and the literature cited there

zero. This comes from the fact that the industrialized country has increased its emission reduction relative to the Kyoto period and thus demands emission permits beyond the quantity it has imported in the Kyoto phase but the reduction requirement within the country imposes additional costs. The welfare cost of the industrialized country, however, increase about fourfold when moving from the Kyoto phase to scenario PK+.[15] A doubling of welfare costs comes about through the higher price for the purchase of emission permits from country d and the additional reduction commitment. Country d in contrast can gain even more as it is able to sell additional emission permits at a higher price to country i.

The situation is similar in the case when the difference in marginal abatement costs between the two countries is only half as big (a=2). The welfare cost of country i increase when moving from the Kyoto phase (CDM) to the Post Kyoto scenarios PK+ and further to PK-. Country d's benefit in the Post-Kyoto scenario PK+ is lower because there is less additional demand from abroad and the movement along the marginal cost curve is not as steep. The increase in welfare benefits from moving from PK+ to PK- is of similar magnitude as in the case of large differences of marginal abatement cost curves.

The little example also shows that the welfare effect of country d in scenario PK+ again becomes positive as soon as the share of the Post-Kyoto reduction of country d is lowered from 20 percent to 15 percent. In contrast, a phase out of CDM (PK-) would yield positive welfare for country d even if her share in reducing emissions goes up to 40 percent.

One could imagine that the industrialized countries impose unilaterally a much stronger reduction commitment but maintain the CDM projects without a requiring a cap on emissions in the developing world. Suppose the current Kyoto commitments of the Annex B states (country i) amount to one half of the necessary reductions (denoted by c) and they agree to take on the whole reduction requirement c (implying γ=1) in the Post-Kyoto agreement. This would lead to much higher costs for country i paired with large welfare gains for country d. In fact, if one were to maintain the same welfare gain for country d that she achieves in the Kyoto phase with CDM projects a sharing of the reduction requirements of 85 to 15 would be necessary. In this regime country i would be able to half its welfare costs, hence a Pareto improvement from the Kyoto to the Post-Kyoto phase would be realized.

Of course, this numerical example only highlights some of the interactions between the CDM projects and a future cap and trade scheme. These relationships should be investigated within a larger numerical model that is calibrated to real world parameters more closely and that takes into account the different size of the country groups.

[15] CER prices are $(k\gamma c)^2$ with γ =0.5 whereas the new PK+ prices for AAUs are $(kc)^2$.

6. CDM and Emission Trading in a Post-Kyoto Regime

The CDM mechanism will last well into the Post-Kyoto phase since the majority of already approved projects will lead to the issuance of CERs for many years to come. The fundamental problem with these credits is that they do not lead to an additional emission reduction but they simply replace existing reduction commitments by the industrialized countries, especially the member states of the EU. In order to create a real reduction in emissions any increase in CERs would need to be matched by making even more stricter the emission targets in the country in which the CERs are to be used. Hence, the incentive to maintain or to even develop further the CDM mechanism in a Post-Kyoto agreement should be very unequally distributed. If the Annex I countries are interested in a strong climate regime they would need to accompany the CDM mechanism by very ambitious reduction commitments that would compensate for the lack of reductions in the Non-Annex I countries.

The numerical example above highlights the fact that expanding the CDM mechanism without a restriction on emissions of developing and emerging economies would raise the cost to the Annex I countries strongly and would lead to large benefits in the developing world (see Figure 6). Some form of a commitment to restrict emissions by the developing world would be needed to lower the welfare cost to the Annex I countries and move towards a more equitable burden sharing of global abatement cost. If one takes as a benchmark the notion that the emerging economies and the developing world should at least not gain from emission reduction constraints in the industrialized countries then a sharing of emission reduction commitments is necessary. Given such a benchmark the degree to which a sharing of reduction commitments remains in this sense fair depends on the way in which the CDM mechanism is dealt with in a Post-Kyoto agreement.

A continuation of CDM projects would seem to favour developing countries. But it entails a redistributive element since the low cost abatement options would have already been allocated to the CDM projects whereas the additional higher cost options would count against the reduction commitment in a Post-Kyoto agreement. Therefore, the developing countries are unlikely to accept a large share in reduction commitments if the bulk of already signed CDM projects do not count against their emission cap. At the same time a phase out of CDM would be make it easier for developing countries to accept a larger share of the emission reduction obligation.

A phase out of CDM has been proposed by the European Commission. In the communication to the institutions of the European Union it states (EC (2008):

"In order to ensure that a large part of EU emission reductions is done domestically, and to enhance environmental integrity, the EU ETS limits the use of CDM credits based on quantitative and qualitative criteria. In the UNFCCC context, the CDM should be reformed, crediting only those projects that deliver real additional reductions and go beyond low cost options. In addition, for advanced developing countries and highly competitive economic sectors, the project based CDM should be phased out in favour of moving to a sectoral carbon market crediting mechanism. Such mechanisms can be an efficient tool to drive development and deployment of low-carbon technologies in developing countries, and pave the way for the development of cap and trade systems. To ensure a coherent transition, the EU should seek common ground with the US and other countries implementing cap-and-trade systems and generating demand for offset credits in a coordinated manner."

This proposal would effectively eliminate all major emittors if India is also considered to be an "advanced developing country" and CDM would refer to a group of developing countries with less than 10 percent of global emissions. In a sense this implicitly sets the stage for a system where the poorest countries will not participate in a cap and trade system but will only benefit from the CDM mechanism. This has the advantage that mechanisms like CDM offer both a transfer of financial funds and of advanced technologies to these countries. Both are urgently needed to bring these economies on a growth path that is sustainable in terms of economic development and in terms of energy consumption and environmental preservation. Since these countries offer a large potential for climate mitigation through efficiency improvements their contribution to the overall climate protection should not be underestimated. In fact, if one envisages some form of regional emission limits on the idea of contraction and convergence most African countries as well as India could increase their emissions for the next decades even if a reduction of emissions by 50 percent in 2050 is to be reached (Klepper/Peterson 2007)[16].

The incentive to agree to some form of a cap-and-trade system in a Post-Kyoto agreement including the existing CDM mechanism is strongly diminished for those countries that have already committed to a large amount of CDM projects leading to a flow of emission reduction services well into the Post-Kyoto phase. Especially advanced emerging economies like China where the majority of CERs has been created will have little incentive to accept such a system. The emerging economies would increasingly be able to benefit from higher permit prices and their low abatement opportunities if the CDM projects are discontinued and counted towards a national emission constraint.

[16] Based on the assumption that by 2050 emission rights are distributed on an equal per capita basis. In the intermediate periods a linear path from current per capita is selected.

The proposal of the EU favours sectoral approaches which would effectively result in sectoral cap-and-trade approaches in the major non-Annex B countries. However, as long the emission reduction is counted against some business as usual baseline the reduction in global emissions could only be achieved through a further reduction of emission commitments in Annex B countries. The financing of all abatement costs would still remain with the industrialized countries that are buying the CERs.

Sectoral CDM approaches also carry the danger of creating separated carbon markets with unequal prices in a similar way as it has happened in the EU-ETS although with the opposite sign in the price divergence. In the EU-ETS the non-ETS sectors are facing higher implicit carbon prices than within the ETS. In a sectoral CDM mechanism the sector subject to a sectoral crediting would face higher carbon prices than the rest of the economy. In both cases distortions are the result of such a segmentation.

The European Union ETS will continue to work regardless whether a Post-Kyoto agreement will be reached in whatever form. This means that a substantial part of the emission permit market will remain in place anyhow. This demand will at least stabilize the market for CERs to some extent. This is also reflected in the fact that companies are setting up funds for post 2012 CDM projects[17].

7. Summary

Trading of CO_2 emissions and other greenhouse gases is taking place in many markets. The by far largest markets are the Emission Trading Scheme of the European Union (EU-ETS). Its introduction has led to a well established carbon market with several trading places in which spot as well as future contracts are traded. There is also a significant OTC market. The second largest CO_2 market is that for secondary emission reduction units (CERs) from the Clean Development Mechanism (CDM) followed by the primary CDM market. These markets together completely dominate carbon markets relative to several other national schemes and the voluntary market.

The EU-ETS market has a relatively clear structure with only one carbon permit, the EUA, traded. In contrast, the CDM market has a large number of different products that make the market quite intransparent. The discussion about the future of the CDM mechanism seems to add even more products to the already existing different CER types. Sectoral and programmatic CERs are intended to expand the market but they also make it more segmented.

[17] PointCarbon News 6/18/2009; http://www.pointcarbon.com/news/1.1140568

The convertibility of emission permits across different markets is rather limited. Especially the EU-ETS is currently not open to most other carbon credits with the exception of a limited amount of CERs. This restriction is understandable since most other markets rely on emission constraints that are less tight or on no constraint at all thus resulting in much lower carbon prices than within the EU-ETS. This situation might change if another large carbon market will be established. Such a market could be an American market. However, the caps imposed in the two markets need to be comparable in order to maintain the credibility and price level in the European market.

The EU-ETS will continue to exist after 2012 whether or not a Post-Kyoto agreement will be reached that includes a global are at least partially global trading mechanism. The next trading periods are already determined and a plan for moving to a complete auctioning of emission rights has been set. The institutional framework that has been set up for the EU-ETS including a registry, trading places, as well as companies and fonds specializing in carbon trading. These institutions could provide the basis for an expanded trading mechanism that includes other countries which are willing to set caps on their emissions.

The CDM mechanism has created important incentives in developing and emerging economies for investing in greenhouse gas reduction projects. Over the last few years the CDM market has been growing at a fast rate. However, in the light of the current economic crisis and the uncertainty surrounding the future of the CDM mechanism in a Post-Kyoto agreement the number of projects submitted for approval has almost completely dried out. However, the list of projects that already are in operation will create a significant number of carbon credits for many years to come.

These projects currently provide a low cost source of emission reductions for industrialized countries. However, they also move those countries that have provided the bulk of CDM projects up their marginal abatement cost curve. The willingness to agree to a limit on emissions in these countries is limited given that their abatement activities are essentially counted towards emission constraints in the industrialized countries. The treatment of these CDM projects in a Post-Kyoto agreement is therefore interlinked with the ability and willingness of developing countries to accept a significant limit on their emissions.

The proposals of slowly replacing the CDM projects by sectoral and programmatic approaches can be seen as first steps towards an expansion of abatement activities in developing countries. However, they also create the danger of further segmenting emission abatement activities thus leading to distortions as no single price for carbon will exist.

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Appendix

Table A1: Size of the Main Allowance Markets in 2007 and 2008

	2007		2008	
	Volume ($MtCO_2e$)	Value (MUS$)	Volume ($MtCO_2e$)	Value (MUS$)
Project-based Transactions				
Primary CDM	552	7433	389	6519
JI	41	499	20	294
Voluntary market	43	263	54	397
Subtotal	636	8195	463	7210
Secondary CDM				
Total	240	5451	1072	26277
Allowance Markets				
EU ETS	2060	49065	3093	91910
New South Wales	25	224	31	183
Chicago Climate Exchange	23	72	69	309
RGGI	na	na	65	246
AAUs	na	na	18	211
Sub total	2108	49361	3276	92859
Total	**2984**	**63007**	**4811**	**126345**

Source: World Bank (2009)

Appendix A2:

Table B1: Currencies of emission permits in different emission trading regimes

	Currencies of Emission Units	Trading Scheme
AAU	Assigned Amount Units	Kyoto Protocol
CER	Certified Emission Reductions	Clean Development Mechanism (CDM)
t/l CER	Temporary/longterm CERs	Afforestation / Deforestation in CDM
ERU	Emission Reduction Units	Joint Implementation (JI) Projects
RMU	Removal Unit	Land Use Change in CDM
EUA	European Union Allowances	European Union Emission Trading Scheme (ETS)
NZU	New Zealand Unit	New Zealand Emission Trading Scheme NZ ETS
NGAC	NSW Greenhouse Gas Certificates	New South Wales Greenhouse Gas Abatement Scheme (NSW)
CFI	Carbon Financial Instrument	Chicago Climate Exchange (CCX)
VER	Verified Emission Reductions	Voluntary Market

Table A1 Abbreviations for different emission reduction units