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Carbon Markets

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Executive Summary

A carbon market is a market for greenhouse gas emission reductions (credits) and rights to release greenhouse gas emissions (allowances). Each greenhouse gas emissions trading system creates its own market. Although there are a number of different markets, they can be, and to a limited extent are, linked. The largest markets are established by the Kyoto Protocol and Parties that have emissions limitation commitments under the Protocol.

Activity in the largest carbon markets during 2006 is summarized in the following table.

Market	**Sales (2006 USD billion)**	**Quantity ($MtCO_2e$)**	**Price (2006 USD/tCO_2e)**
Kyoto Protocol markets			
Clean Development Mechanism (CDM)	$5	475	$10.70/$17.75
Joint Implementation (JI)	<$1	16	$8.80
Markets in Kyoto Protocol Parties			
EU emissions trading scheme (Phase I)	$24	820	$19.50 ($5-$40)
EU emissions trading scheme (Phase II)		280	$23.00 ($5-$40)

The estimated revenue from the sale of the certified emission reductions (CERs) generated by the CDM projects registered during 2006 is 2006 US$1.0 to $1.5 billion per year. The capital that is or will be invested in those projects is estimated at almost 2006 US$7 billion. Of that amount approximately 35% represents capital invested in unilateral projects by host country project proponents. Renewable energy and energy efficiency projects accounted for $5.7 billion of the overall investment. This compares with official development assistance of 2005US$2 billion and 2006 USD 6.5 billion of private investment in similar projects in all developing countries during 2006.

Carbon funds are a significant feature of the carbon market, especially the markets for CERs and emission reduction units (ERUs) from JI projects. A carbon fund receives money from investors to participate in the carbon market. The number of funds and the capital invested have grown rapidly since 2000. Annex B Party governments are another important feature of the markets for CERs and ERUs, directly and through carbon funds. Governments have purchased, or committed to purchase, about 45% of the estimated 2008-2012 compliance requirement.

There is a surplus of Phase I (2005-2007) allowances in the EU ETS due to excess allocation and emission reductions by participants. Phase I EU allowances (EUAs), with a few exceptions, can not be carried over for use in Phase II. As a result the price of Phase I EUAs dropped from over €30 in April 2006 to €0.25 on 1 June 2007. The price of Phase II 2008 EUAs has remained over €20 because the allocations suggest a shortage of allowances during Phase II leading to the use of CERs and ERUs for compliance and because the primary Phase II market participants with compliance obligations at this point (power producers) are short and need to hedge their delivery of 2008 power.

Estimates of the international carbon market for 2010 and 2030 based on projected compliance needs are summarized in the following table.

Year	Market	Sales (2006 USD billion)	Quantity ($MtCO_2e$)	Price (2006 USD/tCO_2e)
2010	Compliance by Annex B Parties to the Kyoto Protocol (mainly CDM and JI)	$10 to $15 ($5 to $25)	400 to 600 ex Canadian government	$23.60 ($13.50 to $33.75)
2030	Purchases by current Annex I Parties to the Convention from developing countries			
	Low estimate	$10 to $15 ($5 to $25)	400 to 600	$23.60 ($13.50 to $33.75)
	High estimate	$100 ($90 to $125)	4,000 to 6,000	$23.60 ($13.50 to $33.75)

For 2008-2012 the supply of Kyoto units will be abundant relative to the compliance demand by Annex B Parties. Demand is unlikely to change significantly unless the Canadian government changes its decision not to buy Kyoto units. The supply has been increased by decisions to expand the scope of the CDM and furher expansions are under consideration.

The estimated supply of CERs and ERUs is almost sufficient to meet the projected demand. The potential supply of CERs has been increased by the addition of afforestation and reforestation projects and programs of emission reduction activities. Approval of CDM projects for HFC-23 destruction at new HCFC-22 plants, CO_2 capture and storage and/or reduced deforestation could increase the supply of CERs significantly. On the other hand, uncertainty about the market for CERs after 2012 could dampen the flow of new projects soon.

Most of the potential supply for 2008-2012 consists of surplus assigned amount units (AAUs) held by Russia, Ukraine and other eastern European countries. Applications by Belarus and Kazakhstan to adopt commitments under the Kyoto Protocol could increase the supply further. Rules relating to the use and carryover of Kyoto units suggest that CERs and ERUs will be used for compliance while surplus AAUs will be carried over to future periods. With a high demand post-2012, the carryover could be absorbed relatively quickly. But with a low demand, it could affect the market for a decade or more.

The low estimate of demand in 2030 is the same as in 2010. The current flow of projects under the CDM would be sufficient to meet that demand. The high estimate of demand in 2030 is a market of 2005UD$100 billion per year. It assumes ambitious commitments by all Annex I Parties, including Australia and the United States, and none by any current non-Annex I Party. To supply this demand a large fraction of the potential emission reductions, from all existing and some new categories of projects, would need to earn

credits. That would require new mechanisms, such as sectoral targets, "no lose" targets, and policy CDM, in addition to the current types of CDM projects.

During 2006 the voluntary market accounted for estimated sales of about 13.4 $MtCO_2e$ at an average price of about 2006 US$4.10/$tCO_2e$. Rapid growth is forecast to continue leading to annual sales of 250 $MtCO_2e$ (120 to 400 $MtCO_2e$) during 2008-2012 at an average price of 2006US $10/$tCO_2e$. Then the voluntary market would represent about 15% of the total market. Growth of the voluntary market is contingent on satisfactory resolution of concerns about the integrity of the emission reductions being sold.

1. Introduction

This paper provides an analysis of the international carbon market to 2030. A carbon market is a market for greenhouse gas emission reductions (credits) and rights to release greenhouse gas emissions (allowances).[1] A credit or allowance usually corresponds to 1 metric ton of CO_2 equivalent (1 tCO_2e).[2]

There are a number of carbon markets, some of which are linked. Each greenhouse gas emissions trading system creates its own market. A trading system establishes an overall limit on specified emissions by a defined set of sources. At the end of each year, every source must remit enough allowances and credits to cover its actual emissions during the year.[3] The organization that establishes the system determines the rules relating to issuance, trade and use of allowances and credits.[4]

The Kyoto Protocol creates an international emissions trading system for Annex B Parties. They can trade allowances and credits and purchase credits from non-Annex I Parties. Some Annex B Parties, the European Union and its member states and Norway, have established emissions trading systems for electricity generators and large industrial sources.

In addition, there are greenhouse gas emissions trading systems in countries – Australia and the United States – that are not Parties to the Kyoto Protocol. Finally, individuals and entities with no regulatory obligation to reduce their emissions can purchase credits to offset part or all of their emissions. This is called the voluntary market.

The next chapter reviews the existing markets. The largest markets are those established by the Kyoto Protocol and Parties that have emissions limitation commitments under the Protocol. Chapter 3 focuses on the prospects for the international carbon market in the short term – 2008-2012. Chapter 4 develops estimates of the potential size of the international carbon market in 2030.

2. Carbon Markets

2.1 Existing Carbon Markets

Table 1 provides an overview of the existing carbon markets. The Kyoto Protocol established emissions limitation commitments for industrialized country (Annex B) Parties for the period 2008-2012 and created three mechanisms – the Clean Development Mechanism, Joint Implementation and International Emissions Trading – they can use to help meet those commitments.

Table 1
Overview of Existing Carbon Markets

	Start Date	**Number of Projects or Participants**	**Emissions Limit 2006 (Mt CO_2e)**	**Volume Traded during 2006 (Mt CO_2e)**	**Average Price ($/t$CO_2e$)**
Kyoto Protocol					
Clean Development Mechanism Primary	2000	1,468[a]	251[a]	450	$10.70
Clean Development Mechanism Secondary		94[b]	24[b]	25	$17.75
Joint Implementation	2008	146[a]	25[a]	16	$8.80
Emissions Trading	2008			0	
Protocol Parties					
European Union ETS Phase I	2005	10,500	2,088	820	$19.50
European Union ETS Phase II	2008	[c]	[c]	280[c]	$23.00
Norway	2005	51	7		
United Kingdom[d]	2002	32[d]	30 to 20[d]	2[e]	$4.10[e]
Non-Party Systems					
New South Wales-ACT	2003	33	53	20	$11.25
Chicago Climate Exchange	2002	237	230	10	$3.80
Voluntary Market					
Voluntary	1995			13	$4.10

Notes: a Number of projects in the pipeline at the end of 2006 and the estimated annual emission reductions for those projects
b Number of projects with issued CERs and the quantity of CERs issued.
c Some national allocation plans for Phase II have not yet been approved, but the number of participants will be higher, and the emissions limits will be about 8% lower, than for Phase I. Contracts for Phase II allowances are already trading.
d As discussed in Section 2.5 this reflects the Direct Entry component of the scheme, which accounted for most of the allowance allocation and trading activity.
e During the first nine months of 2006.

Sources: Capoor and Ambrosi, 2006; Capoor and Ambrosi, 2007; Ellis and Tirpak, 2006; Fenhann, 2006; Enviros, 2006, Hamilton, et. al., 2007.

Most Annex B Parties plan to use emissions trading systems to regulate the emissions of fossil-fired electricity generators and large industrial emitters to help comply with their 2008-2012 Kyoto Protocol commitments. Those emissions trading systems are already operational in the member states of the European Union and Norway. The United Kingdom has sources that participate in the EU emissions trading scheme (ETS) and others that participate in a domestic scheme.

The European Union ETS is by far the largest market in terms of number of participants and trading activity. Trading activity is shifting from allowances that can be used for compliance during Phase I (2005-2007) to allowances that can be used for compliance during Phase II (2008-2012). Credits created by Clean Development Mechanism (CDM) projects – certified emission reductions (CERs) – are the second largest market. The CDM was the first of the three Kyoto mechanisms to be implemented.

Emissions trading systems are also operating in Australia – the New South Wales-ACT greenhouse gas abatement scheme – and the United States – the Chicago Climate Exchange. The quantities traded in the markets established by these systems and the voluntary market are much smaller than the EU ETS and the CDM.

2.2 Kyoto Protocol Markets

Annex B Parties can meet their 2008-2012 commitments under the Kyoto Protocol through a combination of domestic emission reduction and sink enhancement actions and purchases of various allowances and credits from other countries, through the three Kyoto mechanisms. Each of these mechanisms creates a market for specific units (allowances/credits). These markets are at different stages of development, with the Clean Development Mechanism being the most advanced.

2.2.1 Clean Development Mechanism

The CDM (Article 12) enables a project to mitigate climate change in a non-Annex I Party to generate certified emission reductions (CERs).[5] The CDM was launched in November 2001, the first project was registered about three years later, and the first CERs were issued in October 2005. CERs can be issued for verified emission reductions achieved since 1 January 2000.

Rules for some categories of CDM projects were adopted later; afforestation and reforestation projects (December 2003), small-scale afforestation and reforestation projects (December 2004) and programmes of emission reduction activities (December 2005). As a result only 4 of the 1,468 projects in the pipeline fell into these new categories at the end of 2006.[6]

CERs are issued by the CDM Executive Board only after the emission reductions achieved have been verified and certified by an accredited DOE. Thus a CDM project

incurs costs – validation of the project – before it can be registered and further costs – certification of the emission reductions – before CERs are issued.[7] If the project proponent in the developing country Party bears all of these costs before selling the CERs, the project is called a unilateral project. At the end of 2006, about 60% of the projects representing about 33% of the projected annual emission reductions were unilateral projects.[8]

2.2.1.1 Annual Reductions and Revenue

To help defray the cost of implementing the project, proponents often agree to sell some of the expected CERs before the project has been implemented. Capoor and Ambrosi indicate that expected CERs from projects "at an early stage command US$10.40-12.40 …[,] registered project transactions command … close to US$14.70 …[and] [i]ssued CERs are trading [at US$17.75]…"[9] The lowest prices reflect risks that the proposed project might not be registered and might not deliver the expected emission reductions.[10] Once a project is registered the uncertainty is limited to the timing and size of the emission reductions. Once CERs are issued, delivery to an Annex B Party registry where they can be used for compliance is the only uncertainty so they command the highest prices.[11]

At the end of 2006 the 1,468 projects in the pipeline (having a public project design document) were expected to yield annual emission reductions of 251 $MtCO_2e$.[12,13] Experience to-date suggests that CDM projects achieve about 85% of the projected emission reductions.[14]

Because the CDM is still in its infancy, both the projects registered during 2006 and the projects that entered the CDM pipeline during 2006 are used as measures of activity. The distribution of projects registered during 2006 by country is shown in appendix Table A-1 together with the estimated annual emission reductions, potential revenue from the sale of the CERs, estimated investment generated by the projects, and estimated unilateral investment. The same information for projects that entered the CDM pipeline during 2006 is shown in appendix Table A-2.

The estimated annual emission reductions of the 403 projects registered during 2006 is 89 $MtCO_2e$ generating 2006 US$1.0 to $1.5 billion per year from the sale of the CERs. The estimated annual emission reductions of the 954 projects that entered the pipeline during 2006 is 146 $MtCO_2e$ generating 2006 US$1.5 to $2.5 billion per year from the sale of the CERs. China dominates the CDM market, being the source of over 53% of the estimated annual emission reductions of the projects that entered the pipeline during 2006.

Capoor and Ambrosi report transactions for about 450 $MtCO_2e$ in this market during 2006 at an average price of about $10.70 /$tCO_2e$. Thus the transactions averaged about three to five years of projected emission reductions for the new projects. Capoor and Ambrosi note that as the dominant supplier in the CDM market, China's informal policy of requiring a minimum acceptable price (around US$10.40-$11.70 or €8-9 in 2006)

before providing approval to projects had a significant stabilizing impact on the market price.

2.2.1.2 Annual Investment

The capital that is, or will be, invested in 403 projects registered during 2006 is estimated at almost 2006 US$7 billion, of which about 35% represents capital invested in unilateral projects by host country project proponents. The capital that is, or will be, invested in 954 projects that entered the CDM pipeline during 2006 is estimated at over 2006 US$26.4 billion.[15] Of that amount approximately 50% represents capital invested in unilateral projects by host country project proponents. India is home to the most unilateral projects (33 per cent of projected annual emission reductions of projects in the pipeline at the end of 2006), followed by China (20 per cent), Brazil (11 per cent) and Mexico (6 per cent).

Over 80% of the investment in projects registered during 2006 (2006 US$ 5.7 billion) and over 90% of the investment in projects that entered the pipeline during 2006, almost $24 billion, went into renewable energy and energy efficiency projects. These projects represented only about 20% of the emission reductions, but as can be seen in Table 2 they have high capital costs per 1000 tCO_2e of annual reductions, so they account for a much higher share of the total investment.

The capital invested in renewable energy and energy efficiency CDM projects during 2006 (2006 US$ 5.7 billion for registered projects and almost 24 billion for projects that entered the pipeline) dwarfs the ODA support for energy policy and renewable energy projects – about 2005US$2 billion (see appendix Table A-3). The total for registered CDM projects is comparable to the private investment in renewable energy and energy efficiency in developing countries; 2005 US$ 4.6 billion during 2005 and over 2006 US$ 6.5 billion during 2006 (see appendix Table A-3). China and India receive most of the CDM investment and private investment. For most countries the CDM investment exceeds both ODA and private investment in renewable energy and energy efficiency.

The capital invested in afforestation and reforestation has been very low. Only three afforestation and reforestation projects were among the 1,468 projects in the pipeline at the end of 2006. The recent authorization of such projects is part of the explanation. But the attractiveness of these projects is reduced by uncertainty stemming from the temporary nature of temporary CERs (tCERs) and long term CERs (lCERs) and the fact that installations in the EU ETS can use CERs, but not tCERs or lCERs, for compliance.

The revenue earned from the emission reductions credits has very different impacts on the profitability of different types of projects. Appendix Table A-4 shows the effect of different CER prices on the profitability, measured by the internal rate of return, of HFC-23, methane from landfill, and renewable energy projects. The sale of CERs makes HFC-23 projects, which have a low capital cost per unit of emissions reduced, much more profitable. In contrast, the sale of CERs has little effect on the profitability of renewable energy projects, which have a high capital cost per unit of emissions reduced.

Thus the carbon market alone is unlikely to provide a significant stimulus to the deployment of renewables in developing countries.

2.2.1.3 Technology Transfer

Roughly one-third of all CDM projects accounting for almost two-thirds of the annual emission reductions claim some technology transfer (Haites, et al., 2006). Table 2 shows that technology transfer varies widely across project types; cement, coalbed/coalmine methane, fossil fuel switching, and transport involve very little technology transfer while almost all energy supply, household energy efficiency and solar projects claim technology transfer. Technology transfer is more common for larger projects and projects with foreign participants. Equipment transfer only is more common for larger projects while smaller projects involve transfers of both equipment and knowledge or knowledge alone.

Statistical analyses reported by Haites, et al. (2006) find that the host country has a significant impact on technology transfer for 12 of 23 countries analysed. Technology transfer was found to be more likely for projects in China, Ecuador, Guatemala, Honduras, Malaysia, Mexico, Peru, South Africa, Thailand and Viet Nam and less likely for projects in Chile and India. The reasons for the higher or lower level of technology transfer are not given.[16] Since the host country must approve each project, it can influence the extent of technology transfer involved in its CDM projects.

2.2.1.4 Secondary Market

Trades of issued CERs – Capoor and Ambrosi's secondary market – do not involve project or registration risks. The higher price, \$17.75 /tCO_2e, reflects the absence of these risks. The first CERs were issued during 2006 and many of them had already been purchased, so it is striking that the volume traded is approximately equal to the quantity of CERs issued.

The secondary market has been growing rapidly and this is expected to continue as more CERs are issued and as the international transaction log links the CDM and Annex B Party national registries in 2007. Transfers of issued CERs are governed by the rules for international emissions trading. Annex B Parties must meet specified conditions before they are eligible to participate in international emissions trading.

As the quantity of issued CERs rises, exchanges are beginning to trade them. This will enable trades of CERs on an exchange, with the assistance of a broker, or directly between the buyer and seller. The Asia Carbon Exchange has held periodic auctions of primary and secondary CERs since November 2005. The Asia Carbon Trade Exchange began to trade CERs about a year later. Nord Pool launched secondary CER contracts on 1 June 2007. And the European Energy Exchange (Leipzig) has announced that it will offer trading of CERs on a spot basis (prompt transfer of the CERs) as soon as the EU transaction log has been linked to the international transaction log.

Table 2
CDM Technology Transfer and Investment by Project Type

Project Type	**Number of Projects**	**No Technology Transfer**	**Equipment Only**	**Knowledge Only**	**Knowledge and Equipment**	**Average Investment ($/000 tCO_2e/yr)**
1 Afforestation	0					
2 Agriculture	91	18.5%	0.6%	35.9%	45.0%	$137.39[a]
3 Biogas	32	43.2%	0.9%	12.1%	38.4%	$33.12
4 Biomass energy	194	61.6%	15.3%	2.8%	7.5%	$261.68
5 Cement	22	100.0%				$137.39[a]
6 Coal bed/mine methane	2	99.6%			0.4%	$38.65
7 Energy distribution	2	7.2%		92.8%		$137.39[a]
8 Energy Efficiency households	4	7.6%	41.1%		51.3%	$160.80[b]
9 Energy Efficiency industry	109	81.6%	8.5%	9.5%	0.3%	$160.80[b]
10 Energy Efficiency service	10	80.5%	19.5%			$160.80[b]
11 Fossil fuel switch	32	92.0%	8.0%			$377.65
12 Fugitive	7	85.0%	4.0%	11.1%		$137.39[a]
13 Geothermal	6	57.4%		18.0%	24.6%	$577.83
14 HFCs	13	15.0%	62.6%	1.6%	20.0%	$0.29
15 Hydro	145	81.0%	9.7%	1.4%	7.0%	$306.48
16 Landfill gas	74	36.2%	17.3%	23.2%	22.2%	$31.90
17 N_2O	3		92.9%		7.1%	$1.47
18 Reforestation	2	30.9%				$113.62
19 Solar	5	1.0%	99.0%			$137.39[a]
20 Tidal	1				100.0%	$137.39[a]
21 Transport	1	100.0%				$137.39[a]
22 Wind	99	38.2%	30.9%	5.1%	25.9%	$640.63
Total	854	34.5%	41.2%	6.6%	16.1%	

Note: Based on the estimated annual emission reductions. Percentages in a row may not sum to 100% due to exclusion of "other" technology transfer.
a The average for all CDM project types is used when capital cost data for the specific project type is not available.
b Average capital cost calculated for all types of energy efficiency projects.

Source: Technology transfer from Haites, et al., 2006, Table 7. Average investment from Philippe Ambrosi of the World Bank and Stephen Seres by personal communication.

2.2.2 Joint Implementation

Joint Implementation (Article 6) enables a project to mitigate climate change in an Annex B Party to generate emission reduction units (ERUs) that can be used by another Annex B Party to help meet its emission limitation commitment. Projects can be implemented under rules established by the host country (Track 1) or international rules administered by the Joint Implementation Supervisory Committee (Track 2). The Joint Implementation Supervisory Committee was established in December 2005 and no national process had been established by the end of 2006, so JI is just starting.[17]

At the end of 2006 there were 146 JI projects in the pipeline with expected annual emission reductions of 25 Mt CO_2e. Of these 53 projects with estimated annual reductions of 15 Mt CO_2e entered the pipeline during 2006. No JI projects had yet been approved. Capoor and Ambrosi report JI transactions totaling 16 Mt CO_2e at an average price of \$8.80 /tCO_2e. In effect the purchases were equivalent to the expected annual emission reductions of the projects that entered the pipeline during the year.

ERUs are equivalent to CERs for purposes of compliance with Annex B Party commitments under the Kyoto Protocol and for compliance use by industry during Phase II of the EU ETS. Thus the price of ERUs is expected to be very similar to that for CERs. During 2006 the price of ERUs was lower than the primary market price for CERs because the regulatory structure for JI is still being developed, so the risks are higher.

The distribution by country of the 53 projects that entered the pipeline during 2006 is shown in Table 3 together with the estimated annual emission reductions, potential revenue from the sale of ERUs and estimated capital invested. Russia dominates the market, being the source of over 80% of the estimated annual emission reductions of the new projects in 2006. Russia's dominance of the supply of ERUs does not have much impact on the overall market price because ERUs and CERs are substitutes and the JI emission reductions are much smaller than those for the CDM.

The estimated revenue from the sale of the ERUs generated by the JI projects that entered the pipeline during 2006 is 2006 US\$0.1 to \$0.3 billion per year. Applying the estimated investment by project type for CDM projects to the JI projects that entered the pipeline during 2006 yields an estimated capital investment for these projects of 2006 US\$ 6 billion.

Only about 30% of the JI investment, almost \$2 billion, was for renewable energy and energy efficiency projects. This compares with 2006US\$ 4.5 billion of private investment in renewable energy and energy efficiency in the same countries during 2006. However, this comparison is distorted by Germany, which accounts for over 90% of the total private investment in renewable energy and energy efficiency in these countries. In all of the other countries renewable energy and energy efficiency JI projects generate more investment. T he only JI host country to receive ODA for renewable energy and energy efficiency during 2005 was the Ukraine, which received 2005 US\$143 million.

Table 3
JI Project Revenue and Investment by Country
Based on Projects that Entered the Pipeline During 2006

Country	Number of projects that entered the pipeline during 2006	Estimated annual emission reductions of those projects (thousands of ERUs)	Estimated annual revenue (million USD)		Estimated capital invested in 2006 projects (million US$)	Private investment in renewable energy and energy efficiency 2006 (million US$)
			2006 US$ 8.80/ERU (primary market)	2006 US$ 17.75/ERU (secondary market)		
Bulgaria	11	960	8	17	680	0
Czech Republic	2	45	-	1	118	0
Estonia	2	145	1	3	169	0
Germany	1	87	1	2	21	4,044
Hungary	2	42	-	1	180	0
Lithuania	3	123	1	2	62	0
Poland	3	192	2	3	177	33.6
Romania	7	1 194	11	21	561	0
Russian Federation	19	12,086	106	215	3,810	0
Ukraine	3	988	9	18	491	0
Total	**53**	**14,976**	**132**	**266**	**6,269**	**4,473**
Notes: Capital invested estimated using the factors for CDM projects shown in Table 2.						
Source: Number of projects and estimated annual emission reductions from Fenhann, 2006, 20 December 2006 and 22 December 2005. Private investment from New Energy Finance, Private Sector Investment Database.						

2.2.3 International Emissions Trading

International Emissions Trading (Article 17) allows an Annex B Party to transfer Kyoto units (assigned amount units (AAUs), ERUs, CERs, tCERs, lCERs and Removal Units (RMUs)) to the national registry of another Annex B Party. The transfers may include Kyoto units originally issued by that Party or units previously acquired from another Party. Some Parties allow companies and other entities to participate in international emissions trading.

An Annex B Party must meet specified conditions to be eligible to participate in international emissions trading. Which Annex B Parties meet the eligibility conditions for international emissions trading has not yet been established. As well, Annex B Party national registries are still in the process of being linked to the international transaction log which governs the transfer of the allowances and credits between national registries. As a result this market is not yet active.

2.3 European Union Emissions Trading Scheme

Almost all member states of the European Union (EU) are Annex B Parties of the Kyoto Protocol and hence have emissions limitation commitments for 2008-2012. To help meet those commitments, each member state is required to implement an emissions trading scheme (ETS) covering CO_2 emissions by electricity generators and specified industrial sources. Allowances issued by a member state can be used for compliance by an installation in any member state.

The ETS is implemented in phases; 2005-2007, 2008-2012 and five-year periods thereafter. To facilitate compliance with Kyoto Protocol commitments, surplus Phase I allowances can not, with very limited exceptions, be carried over to Phase II.[18] Beginning in 2008, surplus allowances can be carried over indefinitely with no restrictions. During Phase I installations can use CERs, but not tCERs or lCERs, for compliance. During Phase II installations they can also use ERUs for compliance.

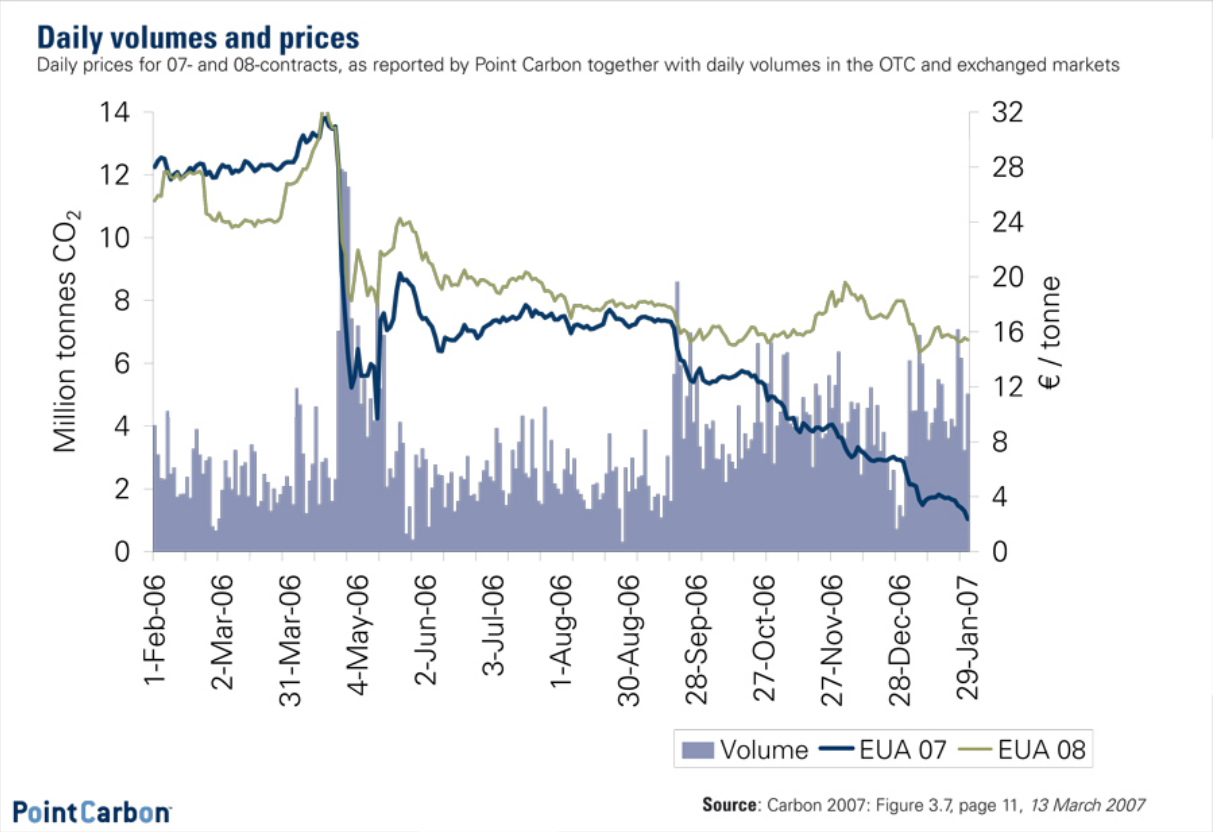
2.3.1 Phase I: 2005-2007

During 2005 the ETS covered about 10,500 installations responsible for about 45% of the EU's CO_2 emissions.[19] Approximately 2,088 million allowances were issued for 2005. Actual emissions were about 2,007 $MtCO_2$, leaving about 80 million surplus allowances.[20] The 2005 emissions data, released in April 2006, confirmed the likelihood of a surplus of Phase I allowances causing the price to drop from over €30 to €12 and to decline to €4 by the end of the year as shown in Figure 1.

During 2006 actual emissions increased to 2,028 $MtCO_2$ but that still left a surplus of about 61 million allowances for the year.[21] With only one year remaining, this confirmed that a surplus of allowances was virtually certain for Phase I. Since Phase I allowances, with a few exceptions, can not be carried over for use in Phase II, surplus allowances at the end of the compliance period for 2007 will have no value. As a result the price of Phase I allowances continued to decline, reaching €0.25 on 1 June 2007.

Was the surplus due to allocation of too many allowances or larger than anticipated emission reductions? Ellerman and Buchner (2006) attempt to answer this question. They estimate that emissions were reduced by between 50 and 200 $MtCO_2$ and that up to 100 million excess allowances were issued. They conclude that at least part of the price decline is due to the excess allocation, but over half, and perhaps all, of the surplus is due to emission reductions. Responses to surveys conducted by Point Carbon suggest that 65 to 75% of installations have implemented some emission reduction measures, but that the reductions are not large.[22]

Figure 1
EU Allowance Prices and Volumes Traded



With the decline in the price of Phase I allowances, trading started to shift to Phase II allowances.[23] Of the 1,101 million allowances traded during 2006, about 820,000 were Phase I allowances and 280,000 were Phase II allowances. The Phase I allowances traded at prices ranging between €30 and €4 while the Phase II allowances traded between €30 and €16.

2.3.2 Phase II: 2008-2012

The coverage of the ETS is expected to be expanded for Phase II. Norway, Iceland and Liechtenstein are expected to join the ETS in 2008.[24] Some member states propose to include additional sources beginning in 2008. Turkey could join in 2010. And the Commission proposes to include aviation beginning in 2011.

As shown in Figure 1, the price of Phase II allowances remained between €16 and €20, while the price of Phase I allowances declined, reflecting the expectation that the allocations for Phase II would be more stringent. Based on the national allocation plans approved through 15 May 2007, Phase II allocations will be about 8% lower than in Phase I. As a result there is expected to be a shortage of Phase II allowances, which has kept the price of Phase II allowances over €20 through 18 May 2007.

Installations will be able to use CERs and ERUs for compliance in Phase II.[25] The limits established by the 21 national allocation plans approved by 18 May 2007 would allow use of over 200 million CERs or ERUs per year.[26] If the price of CERs or ERUs is lower than the price of Phase II allowances, an installation can profit by selling some of its allowances and buying as many CERs or ERUs as it can use for compliance.[27] Given this incentive, the use CERs and ERUs could approach the overall limit even though the quantity each installation can use is limited. As a result the prices of Phase II EUAs and those of CERs and ERUs in the secondary market are expected to converge.

2.4 Norway

Norway implemented an emissions trading system whose design is very similar to that of the EU ETS on 1 January 2005 for 51 onshore installations with annual emissions of about 7 $MtCO_2$.[28] Actual emissions were lower than the allocation for both 2005 and 2006.[29] There has been very little trading.[30] Prices are not disclosed, but were probably equal to or lower than those for Phase I EU allowances.[31] On 1 January 2008 Norway's ETS is expected to be integrated into the EU ETS with coverage expanded to 104 installations with annual emissions of about 23 $MtCO_2$.

2.5 United Kingdom

At the start of 2002 the United Kingdom launched an emissions trading system with two components – Direct Entry and Climate Change Levy Agreement (CCLA) participants.[32]

Direct Entry participants submitted bids for declining absolute emissions targets for the years 2002 through 2006 in return for incentive payments. The 32 successful bidders promised emission reductions of 20.78 $MtCO_2e$ over the five years.[33] Actual allocations declined from slightly over 30 $MtCO_2e$ for 2002 to just over 20 $MtCO_2e$ for 2005.[34]

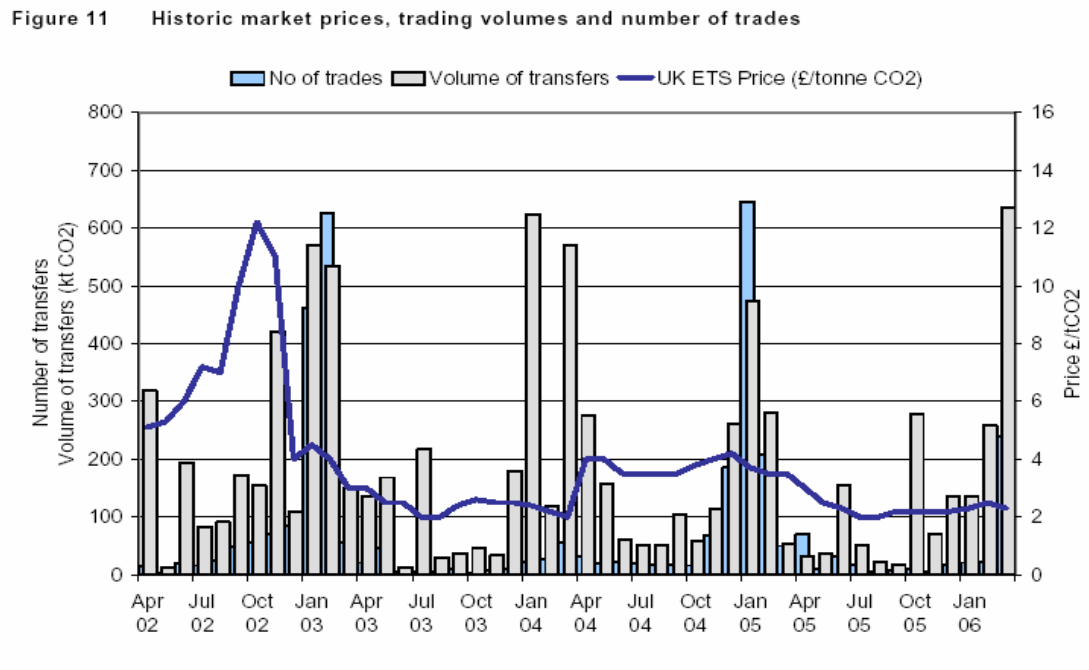
Climate Change Levy Agreements with energy efficiency improvement or greenhouse gas emission reduction targets for two year intervals through 2012 were negotiated with roughly 10,000 establishments in 43 energy intensive sectors. Compliance with the target reduces its Climate Change Levy, an energy tax, for the period by 80%. CCLA participants can earn tradable allowances for the difference between their target and their actual CO_2 emissions. However, only a small fraction of the installations covered by a CCLA choose to go through the verification process needed to collect the allowances.

CCLA participants could agree to absolute or intensity targets for energy efficiency or emissions. Most adopted energy efficiency intensity targets. A "gateway" was established to prevent a net inflow of allowances from CCLA participants with intensity targets to Direct Entry and CCLA participants with absolute targets.[35] In practice the absolute sector accumulated surplus allowances and was a net seller. The Direct Entry

component of the scheme concluded at the end of 2006 and many of those participants are now covered by the UK component of the EU ETS.

The number of trades, quantity traded and price are shown in Figure 2. The number of trades peaks every two years in advance of the compliance deadline for CCLA participants. Direct Entry participants have annual compliance deadlines and are, on average, much larger emitters so the quantity traded has an annual peak. The price increased from £5 in April 2002 to £12 in September 2002, and then fell to £4.00 by the end of the year, and has remained between £2.00 and £4.00 since. The price spike was due to a limited supply of allowances, created by administrative delays, at the time of the first compliance deadline.

Figure 2
Number of Trades, Quantity Traded and Market Price



2.6 New South Wales-ACT Greenhouse Gas Abatement Scheme

The greenhouse gas abatement scheme establishes a cap on greenhouse gas emissions associated with electricity consumption in New South Wales, and since 1 January 2005, the Australian Capital Territory (ACT).[36] Electricity retailers and industries supplied directly by the grid (33 firms) must purchase greenhouse gas abatement certificates equal to the emissions associated with the electricity they sell/use. Abatement certificates can be generated by accredited projects that reduce emissions or enhance removal of greenhouse gases.

During 2005 about 10 million certificates were generated by 206 accredited projects and about 8 million were used for compliance. Almost 13 million certificates are forecast to be needed for 2006 compliance. About 20 million certificates were traded during 2006 at an average price of US$11.25.[37] This price is close to the non-compliance penalty.[38]

Proposals for a national emissions trading system are under consideration in Australia, which could lead to replacement of the NSW-ACT scheme.[39]

2.7 Chicago Climate Exchange

Members of the Chicago Climate Exchange (CCX) made a voluntary, legally-binding commitment to reduce their GHG emissions by 1% per year from their 1998-2001 baseline, a 4% reduction during 2006.[40] The members had an overall emissions limit of 221 $MtCO_2e$ for 2006.[41] The CCX transacted 10.3 $MtCO_2$ in 2006 at an average price of US$3.80.[42]

2.8 Voluntary Market

Many companies and non-profit organizations offer to offset emissions from vehicle use, air travel, and other energy consumption for individuals and entities not subject to a regulatory obligation to reduce their emissions.[43] The integrity of the offsets offered varies significantly with regard to the:

- additionality of the project (making sure the project is not claiming reductions that would already occur),
- actual existence of the emission reductions (making sure the project activity is monitored and the emission reductions claimed are verified),
- exclusion of double-counting (making sure the same emission reductions are not sold to several buyers),
- permanence of the reduction, and
- existence of community benefits.

To address these issues a voluntary standard for emission reductions is being developed and regulations are being considered in some countries.

The voluntary market has existed for more than a decade, but grown significantly since 2003 to 2004. Bellassen and Leget report that prices range from US$ 1–78 per t CO_2 eq. Capoor and Ambrosi estimate the size of the market during 2006 at about 20 million tonnes with an average price of about US$ 10 per t CO_2 eq. Hamilton, et al. (2007) estimate that 13.4 Mt CO_2 eq were traded at an average price of US$ 4.10 during 2006 for a total value of US$ 54.9 million.

2.9 Links among Emissions Trading Systems

Although there are a number of different carbon markets, they can be, and to a limited extent are, linked. At present the trading systems are linked as follows:

- The national systems that comprise the EU ETS are fully linked with each other and all allow the use of CERs, but not tCERs or lCERs, and, beginning in 2008, ERUs.
- Norway's ETS allows the use of Phase I EU allowances and CERs, but not tCERs or lCERs, for 2005-2007. It is expected to become part of the EU ETS in 2008.
- The NSW-ACT greenhouse gas abatement scheme has no links to other systems.
- The UK domestic scheme has no links to other systems.
- The CCX allows the use of CERs and EU allowances for compliance, but suspended imports of Phase I EU allowances in December 2006.

The surplus of Phase I allowances in the EU ETS means that participants will not use CERs for compliance during 2005-2007. During Phase II EU ETS participants are expected to use CERs and ERUs for compliance, which should cause the prices of CERs, ERUs and Phase II allowances to converge.

2.10 Carbon Funds

Carbon funds are a significant feature of the carbon market, especially the markets for CERs and ERUs. A carbon fund receives money from investors to participate in the carbon market. The first fund, the Prototype Carbon Fund (PCF), was established by the World Bank in 1999. Its investors, national governments and private firms from several Annex B Parties, provided capital of US$180 million. The PCF played an important role in the development of the CDM and JI.

The number of funds has grown rapidly from three with capital of €351 million in 2000 to 54 with capital of over €6,250 million early in 2007.[44] Investors include Annex B governments (24%), private firms (29%) or both (47%).[45] Their structure and role vary. Some focus exclusively on purchasing CERs and/or ERUs for compliance use by their investors. Others purchase allowances and credits and hope to resell them at a higher price. More recent funds take equity stakes in emission reduction projects and provide both financial returns and credits to their investors.

The importance of carbon funds in the carbon market is illustrated in Table 4. It shows the annual increase in secured capital relative to the market value of transactions for verified emission reductions for Kyoto compliance and the voluntary market. The capital contributed in 2003 was almost double that for previous years as the pace of CDM project development accelerated. Entry into force of the Kyoto Protocol in 2006 brought another doubling of the capital contributed.

From 2000 through 2004 the annual increase in contributed capital exceeded the value of the market transactions by a large margin. Since additional capital was contributed each

year, it suggests that substantial amounts of money were being invested in emission reduction projects, mostly CDM and JI projects, for reasons other than the purchase of verified emission reductions. During the past two years the value of the transactions has exceeded the capital contributed to carbon funds, suggesting that the diversification and expertise provided by the funds has become less important for project development as the market has grown.

It is not possible to determine the quantities of CERs and ERUs that have been purchased by carbon funds because virtually all funds keep this information confidential for competitive reasons.

Table 4
Money Available to Carbon Funds and the Value of Verified Emission Reduction Transactions

	Cumulative secured capital (million euros)	**Annual increase in secured capital**		**Estimated value of market transactions for emission reductions (million US$)**
		(million euros)	**(million US$)**	
2000	€351	€351	$324	$50
2001	€701	€350	$313	$50
2002	€1,111	€410	$386	$100
2003	€1,930	€819	$925	$300
2004	€2,977	€1,047	$1,301	$600
2005	€3,835	€858	$1,066	$2,700
2006	€5,492	€1,657	$2,079	$5,000
Note: The market value of emission reductions includes reductions for the voluntary market as well as reductions intended to earn CERs and ERUs.				
Sources: Cumulative secured capital from ICF International, 2007, Figure 10. Value of market transactions from various issues of *State and Trends of the Carbon Market*.				

3. Prospects for the International Carbon Market 2008-2012

The Kyoto Protocol mechanisms (CDM, JI and IET) and the emissions trading systems established by Annex B Parties (EU ETS) will be the dominant carbon markets for the 2008-2012 period. They are already the largest markets by far. The EU ETS is expected to expand to include Norway, Iceland and Liechtenstein in 2008, to link with a Swiss emissions trading system, incorporate Turkey if it joins the EU, and to cover aviation beginning in 2011.

The Regional Greenhouse Gas Initiative (RGGI) covering the CO_2 emissions of electricity generating units in ten states in the northeastern United States is scheduled to begin in 2009. Canada has announced a system for 2010. Proposals for a national emissions trading system are under consideration in Australia. New Zealand is working on the design of a system. And various regional and national systems have been proposed for the United States. Those systems are unlikely to begin operation before 2011.

Since the EU ETS allows Kyoto Protocol mechanisms to be used for compliance, this section focuses on the market for Kyoto Protocol compliance units. Capoor and Ambrosi conclude that the current projected demand-supply balance excluding Canada implies that the price of CERs/ERUs is likely to help set the market equilibrium price for EUAs during this period.[46] The analysis considers 2010 as a representative year for the 2008-2012 compliance period.

3.1 Demand

Annex B Parties can use Kyoto Protocol units to help meet their commitments. The demand for these units is the difference between the actual emissions and the commitment for each Party whose emissions exceed its commitment. Thus the forecast demand depends on the forecast emissions of individual Annex B Parties.

Three recent estimates of the demand are presented in Table 5. The estimates vary widely, from about 400 Mt CO_2e per year to over 850 Mt CO_2e per year. The Canadian demand is a significant uncertainty for the estimates. In April 2007 the Canadian government stated that it does not plan to purchase Kyoto units, but firms covered by the emissions trading system will be able to use specified types of CERs for up to 10% of their total emissions.[47] If purchases by the Canadian government are excluded, the Point Carbon and Capoor and Ambrosi estimates are virtually identical at 400 $MtCO_2e$, while the ICF International range of 500 to 671 $MtCO_2e$ is somewhat higher.

Annex B governments have already committed to purchase CERs and ERUs equivalent to 917 $MtCO_2e$, 183 $MtCO_2e$ per year, which is over 45% of the demand as estimated by Point Carbon and Capoor and Ambrosi.[48]

The estimates of the demand by EU ETS installations are all close to the maximum use of CERs and ERUs allowed by the national allocation plans.

Table 5
Estimates of the Demand for Kyoto Units in 2010
(Mt CO_2e)

	Point Carbon[a]	**Capoor and Ambrosi**[b]	**ICF International**[c] **Mid Demand**	**ICF International**[c] **Range**
Annex I governments	140		318	289 - 349
EU 15 governments		90		
EU ETS installations	217[a]	228	260	211 - 322
Japan, public + private	40	70		
Other governments		12		
Estimated demand excluding Canada	**397**	**400**[b]	**578**	**500 - 671**
Canada		260	5[d]	0 - 187
Estimated demand		**660**	**583**	**500 - 858**

Note: a Point Carbon, *CDM/JI supply: Will there be enough for everyone?* 14 May 2007, converted to annual averages for 2008-2012. EU ETS demand is the overall limit on the use of CERs and ERUs for 21 countries based on approved national allocation plans, *Carbon Market Europe*, 18 May 2007. Point Carbon, *Carbon 2007 - A new climate for carbon trading*, March 2007, Figure 2.2 suggests a demand of about 140 $MtCO_2e$ for Canada and 410 $MtCO_2e$ for other Annex B Parties.
b Capoor and Ambrosi, 2007, Table 4, converted to annual averages. Over 45% of the demand excluding Canada has already been contracted.
c ICF International, 2007, Table 2.
d This reflects the April 2007 policy announcement that the government will not purchase Kyoto units, but that firms in the emissions trading system that will begin in 2010 may use CERs for up to 10% of their compliance needs.

The demands estimated in Table 5 are unlikely to change significantly. Canada's decision reduced the projected demand substantially. But no further reductions are anticipated. Any growth in demand will be limited and come after 2010. Expansion of the EU ETS to include aviation could increase the demand for CERs/ERUs. And new emissions trading systems in Australia or the United States could allow the use of Kyoto units, which might increase the demand. ICF International estimates an average demand of 0 to 30 $MtCO_2e$ per year for CERs/ERUs from the United States (RGGI) during 2008-2012.[49] Point Carbon Research estimates that the 2009-2014 cap could exceed actual emissions.[50]

3.2 Supply

Kyoto units are supplied by CDM projects, JI projects and Annex B Parties with surplus allowances (AAUs). Estimates of the supply are presented in Table 6.

Table 6
Estimates of the Supply of Kyoto Units in 2010
(Mt CO_2e/yr)

Source	Point Carbon[a]	Capoor and Ambrosi[b]	ICF International[c] Mid supply	ICF International[c] Range
Clean Development Mechanism				
April 2007 pipeline	460			
Additional projects	240			
Projected reductions	700			
Estimated CERs issued	330	300[b]		
Joint Implementation				
April 2007 pipeline	46			
Additional projects	55			
Projected reductions	101			
Estimated ERUs issued	60	40		
Sub-total CERs and ERUs	**390**	**340**	**340**	**220 - 450**
Surplus AAUs				
Russia	950[d]	640		
Ukraine	300[d]	440		
Other	400[d]	340		
Sub-total AAUs	**1,650**	**1,420**	**400[c]**	**240 - 600[c]**
Total	**2,040**	**1,785**	**740**	**460 - 1,050**

Note: a Point Carbon, *CDM/JI supply: Will there be enough for everyone?* 14 May 2007, converted to annual averages for 2008-2012.
b Capoor and Ambrosi, 2007, Table 4, converted to annual averages. CERs are based on the March 2007 *CDM Pipeline* (Fenhaan) adjusted for observed yields and no allowance for additional projects.
c ICF International, 2007, Table 2, AAUs are only units sold through Green Investment Schemes and are converted to annual averages.
d Point Carbon, *Carbon 2007 - A new climate for carbon trading*, March 2007, Figure 2.2 converted to annual averages.

Point Carbon and Capoor and Ambrosi project the supply of CERs and ERUs from the projects in the pipeline in early 2007. They discount the project estimates of emission reductions to calculate the CERs and ERUs issued. Point Carbon adds CERs and ERUs

from projects in its database that have not yet released a project design document (PDD). That increases its estimate of the supply of CER/ERU supply to 390 $MtCO_2e$ per year compared with 340 $MtCO_2e$ for Capoor and Ambrosi and ICF International. Cames, et al., expect an average annual supply of 300 to 500 Mt CO_2e for 2008-2012.[51]

The flow of new projects and the CERs/ERUs they can generate by 2012 is uncertain due to delays in negotiating the post-2012 regime. Until a new international agreement is negotiated, the ability of emission reductions after 2012 to earn CERs or ERUs is uncertain. This means delays in negotiating a post-2012 regime will progressively reduce the period during which investors can recover their costs.[52] Soon only the most profitable projects, such as HFC and N_2O destruction projects, will be able to recover their investment prior to 2013.

Russia, Ukraine and some eastern European countries will have surplus AAUs they can sell to other Annex B Parties. Some of these countries are establishing Green Investment Schemes, which use the revenue from the sale of AAUs to fund emission reduction measures. ICF International assumes that only AAUs from Green Investment Schemes will be purchased by other Annex B Parties. Point Carbon and Capoor and Ambrosi estimate the surplus AAUs available, but do not assume they will be sold.

Point Carbon and Capoor and Ambrosi find that the projected supply of CERs and ERUs is almost sufficient to meet the estimated demand, excluding Canada. The supply of surplus AAUs is huge relative to the residual demand. In its mid-case, ICF International projects that, in addition to CERs and ERUs, some AAUs from Green Investment Funds will be used to meet the estimated demand. All of the estimates suggest that supply will exceed the demand.

The supply of Kyoto units could increase further due to:

- CDM projects for "programs of emission reduction activities". No project of this type has been registered yet, but such projects could generate relatively large emission reductions.
- HFC-23 destruction projects at new HCFC-22 plants. The eligibility of such projects has been under negotiation for a few years. If approved, they could generate large quantities of CERs quickly.
- CO_2 capture and storage. The eligibility of such projects has been under negotiation for a few years. If approved, they could generate large quantities of CERs, although the time needed to implement such projects would limit the quantity issued before the end of 2012.
- Tradable credits for reduced deforestation. This has been proposed, but it now appears unlikely during the 2008-2012 period.
- Emissions limitation commitments proposed by Belarus and Kazakhstan. The proposed commitments probably would leave each country with surplus AAUs, although it could take some time for them to meet the eligibility conditions to sell AAUs.

The supply of CERs and ERUs will be affected by several factors over the next few years, including:[53]

- Uncertainty about the post-2012 regime. The value of emission reductions after 2012 is uncertain, so projects with longer payback periods become progressively less attractive, reducing the flow of new projects.
- Administrative uncertainty. Inconsistent decisions, possible review upon registration, and possible review on issuance present relatively small risks for project developers. Due to the relative lack of experience, the risks are higher for JI projects than CDM projects.
- Market liquidity. The secondary market for CERs is still small so accurate price information is not readily available. This should change over the coming year as the number of issued CERs rises. The secondary market for ERUs will lag by a year or more.
- Possible changes to the rules. The rules for the CDM could be changed to generate a wider geographic distribution of projects and/or to favour projects that have more development benefits.

Despite the uncertainties, the analyses suggest the supply will be abundant relative to the demand. Demand for 2008-2012 is unlikely to change significantly. But the supply of Kyoto units could increase substantially.

3.3 Prices

Will the surplus supply lead to a collapse of CER/ERU/AAU prices as has happened during Phase I of the EU ETS? Probably not. Phase I EU allowances can not be carried over for use beyond 2007, so they have no value after the end of the period. In contrast, Kyoto units can be carried over (banked), so they should have a value at the end of the period provided they can be used for compliance after 2012. The EU ETS will allow the use of CERs and ERUs after 2012. As well, a post-2012 international agreement is expected to retain the Kyoto mechanisms and so maintain the market for those units.

To date all government purchases have been CERs and ERUs. And participants in the EU ETS can only use CERs and ERUs for compliance. The supply of CERs and ERUs is still less than the demand even without Canada. As long as these policies continue, the demand for AAUs from Russia, Ukraine and eastern European countries will be limited to the demand not supplied by CERs and ERUs causing them to carry over most of their surplus AAUs.

Banking (carry over) of different units by an Annex B Party is restricted as follows:[54]

- RMUs may not be carried over;
- ERUs, which have not been converted from RMUs, may be carried over up to a maximum of 2.5% of the Party's assigned amount;
- CERs may be carried over up to a maximum of 2.5% of the Party's assigned amount;
- tCERs and lCERs may not be carried over; and

- AAUs may be carried over without restriction.

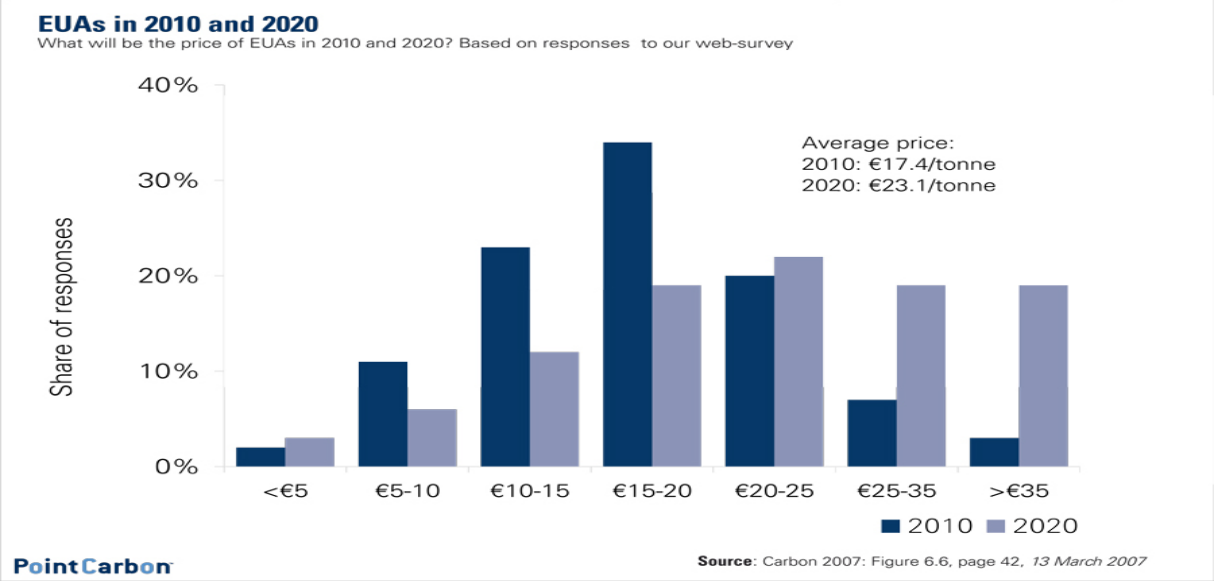
There are no provisions governing carry over of CERs, tCERs and lCERs by non-Annex I Parties or legal entities.

To comply with these rules EU ETS participants should use any issued CERs or ERUs they own for compliance by the end of 2012.[55] And Annex B governments should comply by submitting all CERs, RMUs, and ERUs they own so that only AAUs are carried over.

If the uncertainty relating to carryover by non-Annex I Parties and their legal entities is not resolved, it could cause the price to decline in 2012 as they try to sell the CERs they own. Early resolution of this uncertainty to avoid such a price drop is desirable.

Since CERs and ERUs can, and likely will, be used for Phase II compliance by EU ETS installations the prices for issued CERs, ERUs and Phase II EU allowances should be similar if not identical. As of May 2007 there is still a substantial difference in the prices; issued CERs trade at €12 to €13 while Phase II EU allowances trade at €19. Figure 3 shows the price expectations for EU allowances in 2010 and 2020 of participants in an online survey conducted by Point Carbon early in 2007. For 2010 the average is €17.40 with a roughly symmetrical distribution ranging from less than €5 to over €35.

Figure 3
Expected Prices for EU Allowances in 2010 and 2020



ICF International forecasts the price for CERs/ERUs/Phase II EU allowances at €8 with a range of €8 to €20.[56] ICF recognizes, however, that market behaviour may lead to an average price over the period higher than forecast by market fundamentals. For example,

industrial installations with surplus EUAs have tended to bank them rather than sell them and there may be delays in the delivery of CERs/ERUs into the EU ETS.

Based on the above information, the market price of issued CERs, ERUs and Phase II EU allowances is estimated to average €17.50 (US$ 23.60) with a range of €10.00 (US$ 13.50) to €25.00 (US$ 33.75) for 2008-2012.

3.4 Market Size

With an annual demand of 400 to 600 $MtCO_2$/yr (excluding the Canadian government) the price of 2006US $23.60 suggests a market of $9.4 to $14.2 billion ($5.4 to $20.2 billion) per year, say 2006US $10 to $15 billion (range 2006US $5 to $25 billion) per year.

The above calculation assumes that all CERs, ERUs and AAUs bought for compliance are purchased at the market price. Many CERs and ERUs have already been purchased by Annex B governments in the primary market at lower prices, so the annual compliance cost should be somewhat lower. CERs and ERUs purchased by other buyers could be sold multiple times, so the annual value of transactions could be higher or lower.[57]

3.4.1 Annual Investment

Annual sales of CERs are projected to be between 300 and 450 million. With an average capital cost of $137.39 per 1000 tCO_2e of annual emission reductions (see Table 3) that represents an annual investment of 2006US$ 40 to 60 billion. However, the remaining scope for low cost projects – HFC-23 and N_2O destruction – is limited. If such projects are excluded, the average capital cost rises to about $200 per 1000 tCO_2e of annual emission reductions, and the annual investment would be 2006US$ 60 to 90 billion. Thus, the annual investment in CDM projects is estimated at 2006US$ 40 to 90 billion. At present about half of the capital invested in CDM projects is invested in unilateral projects by host country project proponents.

Annual sales of ERUs are projected to be between 40 and 100 million. Assuming the same range of capital costs per 1000 tCO_2e of annual emission reductions, yields an estimated annual investment in JI projects of 2006US$ 5 to 20 billion.

3.4.2 Share of Proceeds for the Adaptation Fund

The Adaptation Fund receives a “share of proceeds” equal to 2 per cent of the CERs issued for a CDM project activity to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to assist in meeting the costs of adaptation.[58] With annual sales of CERs of 300–450 million and a market price of US$ 23.60 /tCO_2e (range US$ 13.50–33.75) the Adaptation Fund would receive 2006US$ 80–300 million per year for 2008 to 2012 (see Table 7).[59]

Table 7
Possible Levels of Funding for the Adaptation Fund to 2012

Total quantity of CERs issued through 2012 (million)	CERs collected by the Adaptation Fund through 2012 (million)	Total revenue received by the Adaptation Fund at various prices per CER (million Euro)		
		Assumed price per CER		
		€10	€17.50	€25
1,500	30	N.A.	€525	€750
2,000	40	€400	€700	€1,000
2,500	50	€500	€875	N.A.
Note: N.A. This combination of price and quantity is considered to be very unlikely.				

3.5 Voluntary Market

The voluntary market accounted for sales of about 20 $MtCO_2e$ globally in 2006. Trexler estimated that US demand for voluntary offsets could almost double annually to 250 $MtCO_2e$ by 2011.[60] ICF International projects an annual demand in the voluntary market of 250 $MtCO_2e$ (range 120 to 400) for the 2008-2012 period.[61] Assuming an average price of 2006US $10/tCO_2e$ this represents an annual market of 2006US$1 to 4 billion. With a compliance market of 2006US $5 to $25 billion, the voluntary market would represent about 15% of the total market. This growth is contingent on satisfactory resolution of the integrity issues discussed in section 2.8.

4. Potential Size of the Carbon Market to 2030

Apart from the voluntary market, the carbon market depends on the demand for compliance units by national governments or entities that subject themselves to a regime with compliance obligation (e.g. the Chicago Climate Exchange) and the supply of units from countries with commitments or without commitments.

Analyses of the future carbon market focus on the potential demand by Annex I Parties that can be met cost-effectively with credits purchased from non-Annex I Parties.

This section begins with estimates of the potential demand in 2050. Then it reviews demand estimates for earlier periods. After the demand estimates are reviewed, the potential to expand the supply to meet the demand in 2030 is considered.

4.1 Projected Demand in 2050

Two projections of the demand for credits from developing countries in 2050 are available.

4.1.1 Reduction of 60-80% from 1990 Emissions

Greenhouse gas emissions by all Annex I Parties, including Australia and the United States, in 1990 were about 18,100 $MtCO_2e$. A reduction of 60-80% is 10,900 to 14,500 $MtCO_2e$. If half of the reduction is purchased from developing countries, the annual purchases are 5,400 to 7,200 $MtCO_2e$. Assuming the price of issued CERs remains at the current level of €12 to €13, about $\$17/tCO_2e$, this represents a market value of $92 to $122 billion.

4.1.2 World Bank[62]

The World Bank estimated the future purchases from developing countries based on the following four parameters:

1. the objective and scope of post-Kyoto climate policies
2. baseline emissions in each region of the world
3. abatement costs in each region
4. the burden-sharing agreement between parties

IPCC stabilization paths for 450 and 550 ppmv are used as the objective of post-Kyoto climate policies. The 450 path allows total emissions of 272 GtC between 2000 and 2050 while the 550 path allows 333 GtC between 2000 and 2050.

The six IPCC SRES scenarios provide the baseline emissions. Cumulative emissions range between 392 and 574 GtC from 2000 through 2050.

Two sets of abatement costs are used – EPPA model and higher costs based on bottom-up studies. Abatement costs are assumed to rise by 1% per year from 2000 through 2050.

- Total discounted (at 4%) abatement costs for the 450 path from 2000 through 2050 are between 1995US$ 1.2 and 14.9 trillion – annualized costs of $72 to $775 billion.
- For the 550 path total abatement costs from 2000 through 2050 are between 1995US$0.2 and $8.2 trillion – annualized costs of $12 to $427 billion.

Efficiency dictates that half to two-thirds of total abatement spending between 2000 and 2050 occur in developing countries (EPPA 67 to 72%, other cost curves 58 to 65%). This is due to existing opportunities and high growth of emissions in developing countries.

Distributing abatement expenditures on the basis of GDP yields annualized payments by developed countries between 2013 and 2050 of:

- 1995US$20 to $130 billion for the 450 path; and
- 1995US$3 to $68 billion for the 550 path.

4.2 Projected Demand in 2030

The Energy Modeling Forum examines topics to which many existing models can be applied.[63] EMF 21 analysed the importance of non-CO_2 greenhouse gases and land use in climate policy.[64]

Each participating model developed a reference scenario that excludes the Kyoto Protocol. Each model also developed a multi-gas mitigation scenario to stabilize radiative forcing at 4.5 Wm^2 relative to pre-industrial times by 2150 or to a comparable global emissions trajectory.[65] This corresponds to an equilibrium temperature increase of 3.0°C, for a climate sensitivity of 2.5°C per CO_2 doubling.

Results for 16 models with a regional structure were analysed. For each model developing countries were assumed to sell credits equal to the difference between their reference scenario and multi-gas mitigation scenario to Annex I Parties, including Australia and the United States. The implied commitments of Annex I Parties as a group are the sum of their reductions from the reference scenario plus their credit purchases. These are expressed as reductions from their 1990 emissions.

Table 8 shows the results for 2030; the implied commitment of Annex I Parties as a group, their annual purchases, the projected market price, and the market size. The analysis ignores trading among Annex I Parties – Joint Implementation and International Emissions Trading – since this depends on arbitrary assumptions of how the overall commitment would be shared among these Parties.

The results correspond to the maximum demand for the mitigation scenario. Current Annex I Parties, including Australia and the United States, are assumed to have commitments that induce them to purchase all cost-effective emission reductions available in non-Annex I Parties. Rules for credit creation, transaction costs, and other

considerations would prevent all cost-effective reductions estimated by the models being realized in practice. Failure of some Annex I Parties to ratify the agreement in place in 2030, or adopt equivalent commitments, would reduce the demand. Adoption of targets by some current non-Annex I Parties would reduce the estimated supply and hence the maximum demand.[66]

Table 8
Model Estimates of the Maximum Demand in 2030

Model	**Market Size[a] ($MtCO_2e$/year)**	**Market Price[b] (2000 US$/$tCO_2e$)**	**Annual Purchases[c] (billion 2000US$)**	**Annex I/B Commitment[d] (% below 1990)**
AIM	4,648	$28.09	$131	20%
AMIGA	5,233	$60.00	$314	43%
EDGE	4,700	$3.54	$17	7%
EPPA	12,126	$19.49	$236	-81%
FUND	16,920	$109.61	$1,855	105%
GEMINI	7,856	$11.03	$87	31%
GRAPE	3,262	$5.89	$19	5%
GTEM	13,176	$43.93	$579	76%
IMAGE	6,402	$19.00	$122	31%
IPAC	6,287	$13.64	$86	38%
MERGE	1,645	$3.69	$6	-17%
MiniCAM	6,455	$14.30	$92	31%
PACE	986	$0.53	$0.5	31%
POLES	5,806	$26.24	$152	32%
SGM	10,369	$21.50	$223	49%
WIAGEM	10,450	$5.38	$56	55%
Median[e]	*6,345*	*$16.65*	*$107*	*31%*

Notes: a The market size is calculated as the emissions of non-Annex I Parties under the reference scenario less the emissions of non-Annex I Parties under the multi-gas mitigation scenario. In other words non-Annex I Parties are assumed to sell all potential emission reductions with a marginal cost below the market price.
b The market price is the marginal abatement cost reported for the multi-gas mitigation scenario.
c Annual purchases is the market size multiplied by the market price.
d The Annex I commitment is the emissions of Annex I Parties under the multi-gas mitigation scenario less the market size (purchases from non-Annex I Parties) expressed as a reduction from 1990 Annex I emissions. A negative value indicates the commitment is higher than the 1990 emissions.
e When values can not be symmetrically distributed as in this case – market size and price can not be less than zero – the median (half or the values above and below) is a better indicator of the central value than the average.

Source: Links to websites with results for the individual models are provided at http://www.stanford.edu/group/EMF/projects/group21/EMF21ReportingResults.pdf

The results vary enormously due to differences in the reference scenario, marginal abatement costs and model structure. Estimates of the annual sales range from less than 2000US $1 billion to over $1,850 billion and estimates of the price range from less than $1 to over $100 tCO_2e. The low estimate is due to both a small quantity and a low price, indicating that the reference scenario and mitigation scenario emissions are very similar. The high estimate is due to a reference scenario that has much higher emissions than the mitigation scenario, leading to a high marginal abatement cost and large purchases. The high estimate implies a commitment of Annex I Parties greater than their 1990 emissions.

The median quantity traded is roughly 6,400 $MtCO_2e$ per year.[67] The corresponding commitment is a 30% reduction from 1990 emissions for all Annex I Parties including Australia and the United States. The market price is about 2000US $16.50 /$tCO_2e$. This is a little lower than the current price for issued CERs and in the lower half of the range estimated for 2010. The size of the market in 2030 is estimated at 2000US $107 billion with three quarters of the estimates falling between 2000US $17 and $314 billion.

4.3 Projected Demand in 2020

Potential demand in 2020 can be estimated from the EMF 21 model results in the same manner as described in Table 8. The median estimate of the market size is about 3,150 $MtCO_2e$ per year. The corresponding commitment is about a 20% reduction from 1990 emissions for all Annex I Parties including Australia and the United States.

Because the EMF 21 scenarios exclude the Kyoto Protocol, emission reductions and marginal abatement costs rise gradually from 2000. The 2020 marginal abatement cost (price) – 2000 US$6.50 /$tCO_2e$ – is lower than both the current and projected 2010 price. Given the bias introduced by the scenarios, the best assumption is that prices remain roughly constant from 2010 through 2030 at 2006US$ 23.60 (range $13.50 to $33.75).

The annual purchases in 2020 estimated from the EMF 21 scenarios are 2000 US$25 billion (2000 US$2.5 to $70 billion). The low end of the range, up to 2006 $25 billion per year, is the same as the estimate for 2010.

4.4 Projected Demand in 2015

ICF International projects the average demand of Annex I Parties for 2013-2017 at 2,600 $MtCO_2e$ per year (1,200 to 3,100 $MtCO_2e$ per year).[68] The high demand case includes additional demand of 4,400 $MtCO_2e$ per year by non-Annex I Parties that adopt sectoral targets. ICF International projects the 2013-2017 price at 2006 €30/tCO_2e (range €18 to €40/tCO_2e).[69] The implied annual purchases by Annex I Parties are about 2006 €75 billion (range €2 to €120 billion).[70]

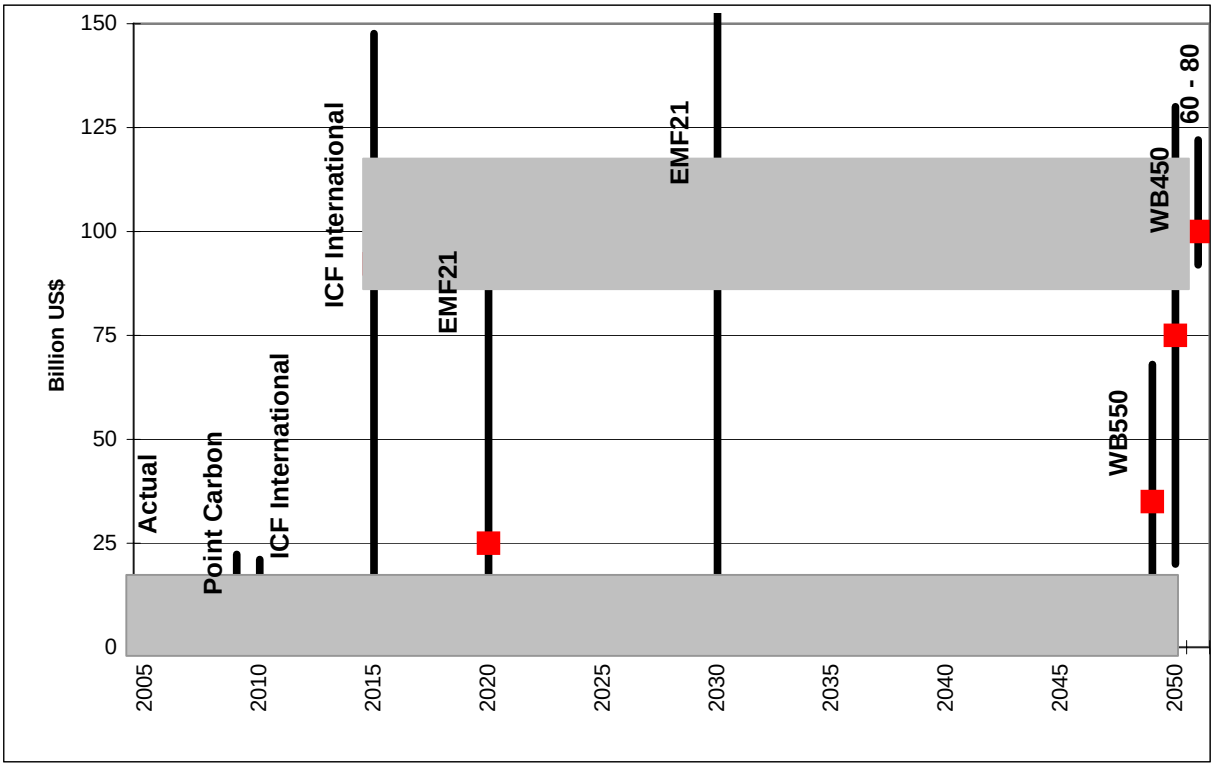
4.5 Summary of Demand Estimates

The foregoing estimates of demand are shown in Figure 4. The estimates cover only purchases credits by Annex I Parties from non- Annex I Parties. The estimates do not include trades between Annex I Parties, such as Joint Implementation and International Emissions Trading. To estimate the size of those mechanisms requires arbitrary assumptions about the commitments of different Annex I Parties.

Each estimate spans a wide range. The low end of the ranges suggests that the demand remains in the range of 2005US $5 to $25 billion per year. Table 1 indicates that CDM transactions during 2006 were a little over 2006 US$ 5 billion. And the demand estimated in section 3.4 for 2010 is 2006US $10 to $15 billion with a range 2006US $5 to $25 billion per year. The value of credit purchases by Annex I Parties from non- Annex I Parties could remain in that range through 2050.

The high end of the ranges suggests that annual demand could reach 2005UD$ 100 billion, but probably not much more. The high demand assumes ambitious commitments – 30% below 1990 by 2030 and 60 to 80% below by 2050 – by all current Annex I Parties including Australia and the United States, no commitments of any type by any current non-Annex I Party, and purchase of all cost-effective emission reductions available in non-Annex I Parties.

Figure 4
Comparison of Demand Estimates



4.6 Potential Supply

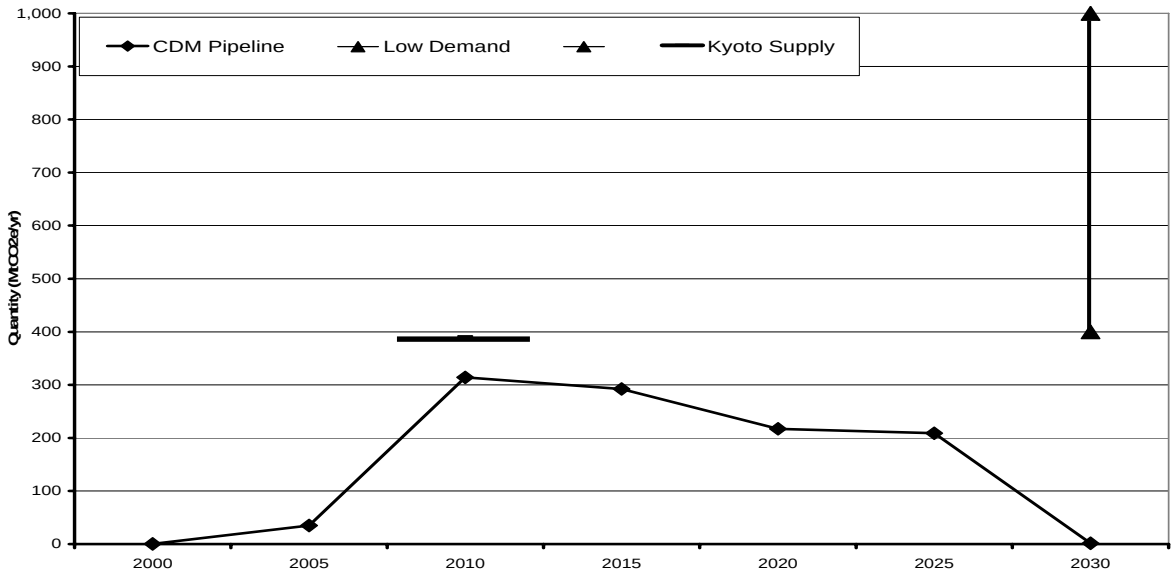
The demand estimates presented above are for purchases of emission reduction credits by Annex I Parties from non-Annex I Parties. At present the only mechanism for such purchases is the Clean Development Mechanism. The demand would also include credit sales under other mechanisms suggested in the literature, such as "no lose" targets and sectoral targets.[71]

The potential supply is assessed relative to both the low and high estimates of demand. The low demand of $5 to $25 billion represents purchases of 400 to 600 $MtCO_2$/yr, ranging up to 1,000 $MtCO_2$/yr. The high demand of about $100 billion corresponds to purchases of ten times the volume -- about 4,000 $MtCO_2$/yr at a price of $23.60/$tCO_2e$ and about 6,000 $MtCO_2$/yr based on the model results presented in Table 8.

4.6.1 Low Demand Estimate

Figure 5 shows the estimated emission reductions of projects in the CDM pipeline as of May 2007. It assumes that each project with a renewable crediting period earns the same annual emission reductions for each renewal. The estimated annual reductions rise rapidly beginning in 2005 as new projects are implemented, reaching 315 $MtCO_2e$ in 2010. The emission reductions achieved by these projects decline between 2010 and 2020 as the projects with 10 year crediting periods lose their eligibility. After 2025 most of the remaining projects lose their eligibility as their third 7 year crediting period concludes.

Figure 5
Estimated Supply from Current CDM Pipeline



The data in Figure 5 are based on the estimated annual emission reductions reported in the project design documents (PDDs). The experience to-date is that CERs are issued for approximately 85% of the estimated reductions.[72]

Figure 5 also shows the estimated average annual emission reductions available for 2008-2012, which includes reductions during the period as well as reductions prior to 2008. This is almost 400 $MtCO_2e$, the low end of the range for 2030. Taking the experience to-date into account, meeting the low demand in 2030 would mean a 20% to a 200% increase in the emission reductions of projects already in the pipeline and then replacing the reductions of those projects as they come to the end of their crediting periods.

A 20 to 200% increase in emission reductions appears very manageable. The existing project pipeline has developed largely in the past two years, so maintaining the current trend for a few months to a few years would be sufficient. Growth of the pipeline will involve a shift in the mix of projects because the potential of a few project types, notably HFC-23 destruction and N_2O destruction at adipic acid plants, has been largely exhausted. On the other hand, project types approved more recently, reforestation and programs of activities, are virtually absent from the pipeline.

In summary, it appears that the current flow of projects under the Clean Development Mechanism would be sufficient to meet the low demand estimate for 2030 although with some changes in the mix of projects.

4.6.2 High Demand Estimate

The high demand is about ten times higher; some 4,000 to 6,000 $MtCO_2e$ per year in 2030. Estimates of the maximum annual emission reduction potential in non-Annex I Parties in 2030 are provided in Table 9. The total reduction potential in 2030 is estimated at almost 8,000 $MtCO_2e$. Cames, et al. estimate the annual emission reduction potential at between 5,500 to 6,600 $MtCO_2e$, excluding reduced deforestation and CO_2 capture and storage, over the period 2010 to 2050.[73] These estimates indicate that existing non-Annex I Parties could supply the high demand if a large fraction, 50% to 75%, of the maximum potential is realized and additional categories of emission reductions, reduced deforestation and CO_2 capture and storage, are included.

Currently the average CDM project estimates annual emission reductions of 165,000 tCO_2e per year. Annual reductions of 4,000 to 6,000 $MtCO_2e$ per year would require 25,000 to 35,000 registered projects. Roughly 1000 projects entered the pipeline during 2006.[74] To have 25,000 to 35,000 registered projects would mean a 4 to 5 fold increase in the flow of registration and renewal requests.

In summary, the high demand would require credits for a large fraction of the potential emission reductions, from existing and some new categories of project types. To process the volume of emission reductions cost-effectively is likely to require new mechanisms, such as “no lose” targets, sectoral targets and policy CDM, in addition to the current types of CDM projects.[75]

Table 9
Maximum Annual Emission Reduction Potential in Non-Annex I Parties in 2030

	Estimated Annual Emission reductions in Current CDM Pipeline ($MtCO_2e$)[a]	**Maximum Annual Emission Reduction Potential in Non-Annex I Parties in 2030 ($MtCO_2e$)**
Biofuels	30	250[b]
Coal bed/mine methane	20	
Energy efficiency and fuel switching	55	2,000[b]
HFC/PFC destruction	81	0[c]
N_2O destruction	42	65[d]
Reforestation	1	1,300[e]
Renewable energy	52	900[b]
Other (mainly landfill gas)	52	[e]
Reduced deforestation		2,000[f]
CO_2 capture and storage		1,200[b]
Total	**333**	**7,715**

Notes: a CDM Pipeline, 31 May 2007.
b Difference between Reference scenario and Beyond Alternative Policies scenario.
c Phase out of ozone depleting substances will largely eliminate waste HFCs/PFCs by 2030. Cames, et al., (p. 41) estimates the potential supply from existing plants at 102 $MtCO_2e$ through 2020 and the potential supply from new plants as increasing from 47 $MtCO_2e$ in 2010 to 183 $MtCO_2e$ in 2030.
d Most reductions are at adipic acid plants and 4 of the 6 plants in non-Annex I Parties are already registered. The rest, about 13 $MtCO_2e$, is at plants producing nitrate for fertilizers. Cames, et al., (p. 38) estimates the potential for N_2O destruction as increasing from 49 $MtCO_2e$ in 2010 to 92 $MtCO_2e$ in 2030.
e Cames, et al., (p. 35) estimates the potential for CH4 capture from landfills as increasing from 479 $MtCO_2e$ in 2010 to 851 $MtCO_2e$ in 2030.
f Calculated from Nabuurs and Masera, et al. 2007, Table 9.3 for reductions at a cost of less than UD$20/$tCO_2$.

4.6.3 AAUs Carried Over from 2008-2012

It is expected that AAUs carried over by Russia, Ukraine and other eastern European countries can be used to meet Annex I commitments for subsequent periods.[76] The amount carried over at the end of 2012 is projected to be 2,500 to 5,500 million AAUs. Under the high demand estimate that surplus could be absorbed relatively quickly. With the low demand estimate, it could affect the market for a decade or more.

4.7 Summary

Estimates of credit purchases by Annex I Parties from non- Annex I Parties span a wide range. The low end suggests that the demand remains in the range of 2005 US$5 to $25 billion per year with purchases of 400 to 600 $MtCO_2e$. The current flow of projects under the Clean Development Mechanism, with some changes in the mix of projects, would be sufficient to meet that demand. That would represent an annual capital investment of 2006US$ 50 to 120 billion. At 2% the annual contribution to the Adaptation Fund would be 2006 US$ 100 to 500 million.

The high end suggests that annual demand could reach 4,000 to 6,000 $MtCO_2e$ per year with a market value of 2005 UD$100 billion by 2030, but probably not much more. It assumes ambitious commitments by all current Annex I Parties including Australia and the United States, and no commitments of any type by any current non-Annex I Party. To supply this demand a large fraction of the potential emission reductions, from all existing and some new categories of projects, would need to earn credits. That is likely to require new mechanisms in addition to the current types of CDM projects. The high demand would represent an annual capital investment of 2006 US$ 500 to 1,200 billion. At 2% the annual contribution to the Adaptation Fund would be 2006 US$ 1 to 5 billion.

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Table A-1
CDM Project Revenue and Investment by Country for Projects Registered During 2006

Country	Number of projects registered during 2006	Projected annual emission reductions of those projects (kCERs)	Estimated Annual Revenue ($ million)		Estimated capital invested in projects registered during 2006 (million USD)	Estimated capital invested in unilateral projects registered during 2006 (million USD)
			$10.70/ CER (primary market)	$17.75/ CER (secondary market)		
Argentina	5	1,170	$13	$21	$54	$12
Armenia	1	63	$1	$1	$9	$3
Bangladesh	1	89	$1	$2	$3	$0
Bolivia	0	0	$0	$0	$0	$0
Brazil	80	13,696	$147	$243	$1,037	$601
Cambodia	1	52	$1	$1	$14	$0
Chile	8	1,562	$17	$28	$287	$274
China	32	45,909	$491	$815	$1,270	$93
Colombia	5	352	$4	$6	$76	$6
Costa Rica	1	6	$--	$--	$2	$0
Cuba	0	0	$0	$0	$0	$0
Cyprus	0	0	$0	$0	$0	$0
Dominican Republic	1	124	$1	$2	$79	$0
Ecuador	8	343	$4	$6	$99	$15
Egypt	2	1,437	$15	$26	$13	$0
El Salvador	2	361	$4	$6	$108	$0
Equatorial Guinea	0	0	$0	$0	$0	$0
Georgia	0	0	$0	$0	$0	$0
Guatemala	4	187	$2	$3	$57	$21
Guyana	0	0	$0	$0	$0	$0
Honduras	5	53	$1	$1	$15	$7
India	119	8,924	$95	$158	$1,239	$944
Indonesia	8	1,557	$17	$28	$530	$27
Israel	1	93	$1	$2	$3	$0
Ivory Coast	0	0	$0	$0	$0	$0
Jamaica	1	53	$1	$1	$34	$0
Kyrgyzstan	0	0	$0	$0	$0	$0
Lao PDR	0	0	$0	$0	$0	$0
Malaysia	12	1,700	$18	$30	$431	$14

Mexico	69	4,695	$50	$83	$435	$138
Moldova	3	48	$1	$1	$8	$0
Mongolia	1	194	$2	$3	$31	$31
Morocco	1	39	$--	$1	$5	$5
Nepal	2	94	$1	$2	$3	$0
Nicaragua	2	337	$4	$6	$177	$15
Nigeria	1	1,497	$16	$27	$206	$0
Pakistan	1	1,050	$11	$19	$2	$0
Panama	3	59	$1	$1	$18	$11
Papua New Guinea	1	279	$3	$5	$161	$161
Peru	1	155	$2	$3	$48	$47
Philippines	7	241	$3	$4	$85	$0
Qatar	0	0	$0	$0	$0	$0
South Africa	4	219	$2	$4	$49	$39
South Korea	5	535	$6	$9	$180	$46
Sri Lanka	1	5	$--	$--	$2	$2
Tajikistan	0	0	$0	$0	$0	$0
Tanzania	0	0	$0	$0	$0	$0
Thailand	0	0	$0	$0	$0	$0
Tunisia	2	688	$7	$12	$22	$0
Uruguay	0	0	$0	$0	$0	$0
Viet Nam	2	681	$7	$12	$94	$0
Total	**403**	**88,547**	**$947**	**$1,572**	**$6,886**	**$2,512**

Notes: " – " means less than $0.5 million. Capital invested is estimated using capital cost/000 tCO_2e of estimated annual emission reduction for different project types estimated by the World Bank and from data in PDDs.

Sources: Number of projects and estimated annual emission reductions from Fenhann, 2006, 20 December 2006 and 22 December 2005.

Table A-2
CDM Project Revenue and Investment by Country for Projects that Entered the Pipeline During 2006

Country	Number of projects that entered the CDM pipeline during 2006	Projected annual emission reductions of those projects (kCERs)	Estimated Annual Revenue ($ million)		Estimated capital invested in projects that entered the pipeline during 2006 (million USD)	Estimated capital invested in unilateral projects that entered the pipeline during 2006 (million USD)
			$10.70/ CER (primary market)	$17.75/ CER (secondary market)		
Argentina	2	1,672	$18	$30	$0	$0
Armenia	4	144	$2	$3	$25	$0
Bangladesh	1	13	$--	$--	$0	$0
Bolivia	2	368	$4	$7	$60	$58
Brazil	96	4,092	$44	$73	$981	$290
Cambodia	0	0	$0	$0	$0	$0
Chile	10	1,409	$15	$25	$70	$0
China	218	78,424	$839	$1,392	$12,130	$3,793
Colombia	4	1,353	$14	$24	$50	$0
Costa Rica	3	90	$1	$2	$31	$9
Cuba	1	344	$4	$6	$55	$0
Cyprus	2	73	$1	$1	$47	$47
Dominican Republic	2	144	$2	$3	$92	$13
Ecuador	4	209	$2	$4	$42	$0
Egypt	5	2,093	$22	$37	$328	$0
El Salvador	4	160	$2	$3	$50	$0
Equatorial Guinea	1	2,356	$25	$42	$324	$324
Georgia	1	73	$1	$1	$2	$0
Guatemala	7	929	$10	$16	$302	$160
Guyana	1	46	--	$1	$12	$12
Honduras	5	162	$2	$3	$42	$13
India	337	27,236	$291	$483	$7,534	$5,998
Indonesia	8	978	$10	$17	$445	$11
Israel	7	310	$3	$5	$41	$39
Ivory Coast	1	944	$10	$17	$30	$0
Jamaica	0	0	$0	$0	$0	$0
Kyrgyzstan	1	73	$1	$1	$2	$0

Laos PDR	1	7	--	--	$1	$0
Malaysia	16	1,947	$21	$35	$455	$0
Mexico	124	2,213	$24	$39	$1,097	$589
Moldova	1	132	$1	$2	$2	$4
Mongolia	5	314	$3	$6	$68	$31
Morocco	1	36	--	$1	$1	$1
Nepal	1	27	--	--	$8	$0
Nicaragua	0	0	$0	$0	$0	$0
Nigeria	1	4,029	$43	$72	$554	$332
Pakistan	2	1,269	$14	$23	$69	$67
Panama	4	385	$4	$7	$118	$106
Papua New Guinea	0	0	$0	$0	$0	$0
Peru	5	1,022	$11	$18	$334	$328
Philippines	10	561	$6	$10	$160	$0
Qatar	1	1,458	$16	$26	$200	$200
South Africa	11	3,276	$35	$58	$271	$261
South Korea	16	3,885	$42	$69	$141	$84
Sri Lanka	9	249	$3	$4	$63	$30
Tajikistan	1	51	$1	$1	$16	$16
Tanzania	1	103	$1	$2	$3	$3
Thailand	7	725	$8	$13	$85	$0
Tunisia	2	688	$7	$12	$22	$0
Uruguay	1	231	$2	$4	$8	$1
Viet Nam	7	307	$3	$5	$93	$74
Total	**954**	**146,607**	**$1,569**	**$2,602**	**$26,465**	**$12,894**
Notes: " – " means less than $0.5 million. Capital invested is estimated using capital cost/000 tCO_2e of estimated annual emission reduction for different project types estimated by the World Bank and from data in PDDs.						
Sources: Number of projects and estimated annual emission reductions from Fenhann, 2006, 20 December 2006 and 22 December 2005.						

Table A-3
Renewable Energy and Energy Efficiency Investments through the CDM, ODA and Private Investment

Country	Investment in renewable energy and energy efficiency CDM projects registered during 2006 (million 2006 US$)	Investment in renewable energy and energy efficiency projects that entered the CDM pipeline during 2006 (million 2006 US$)	ODA for energy policy and renewable energy projects 2005 (million 2005 US$)	Private investment in renewable energy and energy efficiency 2005 (million 2005 US$)	Private investment in renewable energy and energy efficiency 2006 (million 2006 US$)
Argentina	$17	$0	$0	$0	$0
Armenia	$0	$10	$2	$14	$0
Bangladesh	$0	$2	$0	$1	$11
Bolivia	$0	$60	$1	$0	$0
Brazil	$692	$968	$0	$410	$410
Cambodia	$14	$0	--	$0	$0
Chile	$246	$28	$0	$32	$34
China	$1,243	$11,549	$132	$1,958	$3,098
Colombia	$42	$3	$200	$39	$0
Costa Rica	$2	$31	$0	$0	$0
Cuba	$0	$55	$6	$0	$0
Cyprus	$0	$47	--	$0	$0
Dominican Republic	$79	$92	$0	$39	$0
Ecuador	$95	$39	$0	$0	$0
Egypt	$2	$316	$274	$164	$0
El Salvador	$102	$50	$0	$120	$0
Equatorial Guinea	$0	$0	--	$0	$0
Georgia	$0	$0	$0	$0	$0
Guatemala	$57	$303	$1	$0	$0
Guyana	$0	$12	$196	$0	$0
Honduras	$15	$42	$101	$0	$0
India	$1,173	$7,410	--	$666	$2,238
Indonesia	$442	$450	--	$0	$0
Israel	$0	$38	--	$1	$6
Ivory Coast	$0	$0	--	$0	$0
Jamaica	$34	$0	--	$0	$0
Kyrgyzstan	$0	$0	$0	$0	$0
Laos PDR	$0	$1	$0	$0	$0
Malaysia	$429	$450	--	$31	$15

Mexico	$232	$913	$9	$127	$0
Moldova	$8	$0	$4	$0	$0
Mongolia	$31	$68	$37	$0	$0
Morocco	$5	$0	$166	$14	$0
Nepal	$3	$8	--	$0	$75
Nicaragua	$177	$0	--	$0	$0
Nigeria	$0	$0	--	$0	$0
Pakistan	$2	$69	--	$0	$0
Panama	$18	$118	--	$0	$0
Papua New Guinea	$161	$0	--	$0	$0
Peru	$48	$331	$0	$0	$0
Philippines	$83	$157	$0	$113	$414
Qatar	$0	$0	$0	$0	$0
South Africa	$46	$253	--	$3	$12
South Korea	$180	$72	--	$181	$176
Sri Lanka	$2	$63	$1	$47	$0
Tajikistan	$0	$16	$0	$0	$0
Tanzania	$0	$0	--	$0	$0
Thailand	$0	$85	$4	$103	$0
Tunisia	$0	$0	--	$0	$0
Uruguay	$0	$1	$5	$0	$0
Viet Nam	$1	$93	$0	$15	$20
Total	**$5,682**	**$24,226**	**$1,226**	**$4,207**	**$6,509**
Other developing countries			$753	$407	
Developed countries				$49,365	
Notes: " – " means less than $0.5 million. Capital invested is estimated using capital cost/000 tCO_2e of estimated annual emission reduction for different project types estimated by the World Bank and from data in PDDs. ODA includes both bilateral and multilateral assistance.					
Sources: Number of projects and estimated annual emission reductions from Fenhann, 2006, 20 December 2006 and 22 December 2005. ODA from OECD DAC database and private investment from New Energy Finance Private Sector Investment Database.					

Table A-4
Incremental Impact of the CER Price on the Internal Rate of Return (IRR) of Different Project Types

CER Price (US$)	Purchase Period (years)					Impact per unit (US$)
	5	7	10	14	21	
HFC-23 Destruction*						
$5	110.8%	112.3%	112.7%	112.7%	112.7%	
$10	176.7%	177.3%	177.4%	177.4%	177.4%	
$15	227.3%	227.6%	227.7%	227.7%	227.7%	
$20	270.0%	270.2%	270.2%	270.2%	270.2%	
Solid waste – Landfill gas recovery and electricity generation						
$5	17.9%	24.1%	29.2%	31.7%	32.8%	$41/MWh
$10	52.3%	59.1%	62.4%	63.55	63.8%	$82/MWh
$15	88.2%	93.3%	95.4%	95.9%	96.0%	$124/MWh
$20	123.7%	127.3%	128.6%	128.8%	128.9%	$165/MWh
Renewable energy						
$5	0.5%	0.6%	0.8%	1.0%	1.2%	$3.16/MWh
$10	1.0%	1.4%	1.7%	2.1%	2.3%	$6.33/MWh
$15	1.6%	2.1%	2.7%	3.1%	3.3%	$9.49/MWh
$20	2.2%	2.9%	3.6%	4.1%	4.5%	$12.65/MWh
Note: * 65% tax applied to revenue from the sale of the CERs for HFC-23 destruction projects.						
Source: World Bank, personal communication						

Notes

[1] Allowances and credits are also called permits, quotas, offsets, and names unique to the specific market.
[2] Carbon dioxide (CO_2) is the most abundant of the greenhouse gases. Emissions of other greenhouse gases are often expressed as CO_2 equivalents by multiplying the quantity emitted by the global warming potential (GWP) of the gas over 100 years. The GWP is a measure of the radiative effect of 1 kg of a gas relative to that of 1 kg of CO_2 over a specified time period.
[3] Some emissions trading systems have two or three year, rather than annual, compliance cycles. A source that does not remit sufficient allowances and credits is subject to non-compliance penalties.
[4] The organization responsible for the system usually issues and distributes the allowances. It may issue credits or approve the use of credits issued by others. Restrictions may be imposed on the mix of allowances and credits used for compliance. There may also be other restrictions such as a defined life for allowances and credits, limits on carryover (banking), eligibility conditions or fees for trades, and eligibility conditions for market participants.
[5] Afforestation and reforestation projects under the CDM can generate tCERs or lCERs, which have limited lifetimes. For ease of exposition CERs will include tCERs and lCERs unless explicitly stated.
[6] Greater uncertainty about the potential demand for tCERs and lCERs may also be contributing to the relatively small number of afforestation and reforestation projects to-date; installations in the EU ETS can use CERs, but not tCERs or lCERs, for compliance.
[7] This staged approach to issuing CERs increases environmental integrity and reduces financial risks for project proponents.
[8] These figures indicate that unilateral projects are about half the size of the average CDM project.
[9] Capoor and Ambrosi, 2007, p. 32.
[10] In each the price also depends on how the risks are shared between the buyer and the seller through penalty provisions or requirements to replace CERs that could not be delivered.
[11] Issued CERs are delivered to the buyer in a special account in the CDM registry by the CDM Executive Board, but they can not be transferred to an account in an Annex I/B Party national registry until the International Transaction Log (see section 2.2.2) is operational.
[12] Almost all projects that enter the pipeline get registered. Only 10 of 1,478 projects to enter the pipeline by the end of 2006 had been rejected or withdrawn.
[13] The number of projects in the pipeline at the start of the year was 513 with estimated annual emission reductions of 107 $MtCO_2e$.
[14] Fenhann, Jørgen, CDM Pipeline, 31 May 2007, "Analysis" sheet, Table 2.
[15] Many of the projects that entered the pipeline during 2006 will not have been completed by the end of the year, so some of the investment will occur during 2007 and 2008. See Ellis and Kamel, 2007, as well.
[16] The results are based on a statistical analysis which can not explain the causes. The analysis includes the project size and project type, so the result is not due to the project mix of the different countries. Other analyses indicate that host country population, GDP and per capita GDP are not statistically significant.
[17] Contracts to purchase ERUs generated by projects that expect to be approved as JI projects have been announced since 2002.
[18] If installations can bank surplus Phase 1 allowances for use after 2007, their emission reductions during 2008-2012 can be smaller. That would make compliance with the Kyoto Protocol commitments for 2008-2012 more difficult.
[19] New installations increased the total allocation for 2006 and 2007. In addition, Bulgaria and Romania joined the ETS when they entered the European Union on 1 January 2007.
[20] Ellerman and Buchner, 2006. Point Carbon, *Carbon Market Analyst*, 4 June 2007 reports 2005 actual emissions as 2,006 Mt CO_2 with a surplus of 96 million allowances.
[21] Point Carbon, *Carbon Market Analyst*, 4 June 2007.
[22] Point Carbon, *Carbon Market Analyst*, 4 June 2007.
[23] Phase II allowances had not yet been issued. These trades are contracts to deliver Phase II allowances in December 2008.
[24] In Norway coverage will expand to include offshore installations currently subject to a carbon tax raising participation from 51 onshore installations with annual emissions of about 6 $MtCO_2$ to a total of 104 installations with annual emissions of about 23 $MtCO_2$.

[25] In Phase I CERs can be used for compliance, but this option is unlikely to be used because the price of allowances is much lower than the price of CERs.
[26] Point Carbon, *Carbon Market Europe*, 18 May 2007 estimates the limit as 217.23 million per year relative to emission caps of 1,859.27 $MtCO_2$.
[27] Actual emissions are expected to exceed the EUA allocation by more than the overall limit on the use of CERs and ERUs. So CERs and ERUs are expected to be purchased for compliance during Phase II. Currently, there are no restrictions on carry over of EUAs after 2008, but limits on carry over of both CERs and ERUs, so CERs and ERUs should be used before EUAs for compliance. If the price of CERs or ERUs is lower, net of transaction costs, than the price of EUAs it will be profitable for an installation to sell (or bank) surplus EUAs and purchase CERs or ERUs for compliance.
[28] The annual cap increased from about 6 $MtCO_2$ for 2005 to almost 8 $MtCO_2$ for 2007 due to projected increases in output and construction of a new gas-fired power plant. The total allocation for the 3 years was 20.5 $MtCO_2$.
[29] The surplus was about 280,000 allowances in 2005 and 300,000 allowances in 2006 (Point Carbon 14 May 2007).
[30] The registry reports 12 transfers during the first two years.
[31] Phase I EU allowances could be used for compliance. This happened only once, suggesting that the price of Norwegian allowances was no higher than the price of EU allowances at other times.
[32] During the first 4 years of the scheme, Direct Entry participants received about 96% of the 122 million allowances allocated (ENVIROS, 2006).
[33] Establishments not covered by a CCLA were eligible to offer emission reduction commitments in return for incentive payments through an auction. Bids by 32 firms promised emission reductions of 11.88 $mtCO_2e$ over the 5 years. At the end of 2004 six of the firms agreed to revised commitments, bringing the total emission reduction to 20.78 $mtCO_2e$.
[34] ENVIROS, 2006, Figure 7.
[35] The government wanted to ensure that participants with absolute limits reduced their actual emissions. The gateway ensured that this would be the case.
[36] See IPART, 2006.
[37] See Table 1.
[38] The average price of US$11.25 is equal to about A$14.95. The non-compliance penalty is A$11 which is not tax deductible. The cost of purchasing certificates is a tax deductible business expense. Given the 30% corporate income tax rate, the penalty of A$11 is equivalent to a purchase price of A$15.70. This is only 5% above the average price.
[39] See the National Emissions Trading Taskforce http://www.cabinet.nsw.gov.au/greenhouse/emissionstrading and Prime Ministerial Task Group on Emissions Trading http://www.dpmc.gov.au/emissionstrading/index.cfm
[40] CCX Members who emit above the targets comply by purchasing CCX Carbon Financial Instrument™ (CFI™) contracts.
[41] About 33 of the 237 members have emissions limitation commitments. Their actual emissions during 2005 were about 197 $MtCO_2e$ and over 70 $MtCO_2e$ were banked from previous years.
[42] When trading began in 2003 the price was about US$1/$tCO_2$. The price remained roughly constant for about a year and then rose to US$1.70/$tCO_2$ at the end of 2004 and remained at that level through 2005. During 2006 the price rose to US$4.00/$tCO_2$.
[43] Bayon et al., 2007.
[44] See ICF International, 2007, Figure 10.
[45] See ICF International, 2007, Figure 7.
[46] Capoor and Ambrosi, 2007, p. 5.
[47] Canada, 2007, p.14, "The Government of Canada will not purchase credits or otherwise participate in the carbon market." The proposed emissions trading system will begin in January 2010. It will allow participants to use approved CERs to cover up to 10% of their total emissions. The government will determine which types of CERs will be approved. Participants will use CERs only if their price is less than the price cap of C$15/$tCO_2e$.
[48] Capoor and Ambrosi, 2007, Table 4.
[49] ICF International, 2007, Table 2.

[50] Point Carbon Research, 2007 notes that the cap for 2009-2014 is 188 million short tons of CO_2 while actual emissions during 2005 and 2006 were 185 and 164 million short tons CO_2 respectively.
[51] Cames, et al., 2007, p. 42.
[52] Capoor and Ambrosi, 2007, p. 38 and Haites, 2004, p. 63.
[53] See also Capoor and Ambrosi, 2006; Point Carbon, 2007; and ICF International, 2007.
[54] Annex to Decision 19/CP.7, paragraphs 15 and 16.
[55] Each installation has a limit on the quantity of CERs and ERUs it can use for compliance. An installation that owns fewer CERs/ERUs than its limit could buy more CERs/ERUs and sell or bank its surplus EU allowances.
[56] ICF International, 2007, Table 3.
[57] The total value of primary and secondary CER and ERU transactions during 2006 is reported as $5.4 billion by Capoor and Ambrosi, 2007, Table 1.
[58] Decisions 3/CMP.1 and 28/CMP.1. CDM projects in least developed country Parties are exempt from the share of proceeds levy and small-scale afforestation and reforestation projects are exempt from the share of proceeds regardless of their location.
[59] The quantity of CERs issued for projects exempt from the share of proceeds is assumed to be negligible relative to the uncertainty of the estimates.
[60] Trexler, 2007. This would be less than 1 tonne per person when per capita emissions are over 20 tonnes, offsetting about 4% of total emissions.
[61] ICF International, 2007, Table 2.
[62] World Bank, 2006, Annex H, prepared by Franck LeCocq.
[63] The EMF (Energy Modeling Forum) was established at Stanford University and provides for a forum for discussing energy and environmental issues, see: <http://www.stanford.edu/group/EMF/>.
[64] See de la Chesnaye and Weyant, 2006 for results of EMF 21.
[65] The emissions trajectory depends on the emissions sources covered by the model. For models that cover CO_2 emissions from fossil fuel use, cement and land use, methane (CH_4) emissions and nitrous oxide (N_2O) emissions, but exclude HFCs, PFCs and SF_6, global emissions are slightly below 40 $GTCO_2e$ in 2030.
[66] The targets of non-Annex I/B Parties could take a variety of forms including "no lose" targets, sectoral targets, and national commitments similar to those of Annex I Parties. Such targets should represent a reduction from reference case emissions, so only the emission reductions beyond compliance with the target could be sold to current Annex I/B Parties. To estimate the impact on the market price would require new model runs.
[67] When values can not be symmetrically distributed as in this case – market size and price can not be less than zero – the median is a better indicator of the central value than the average. Half of the values are higher and half are lower than the median. The average (mean) is the sum of the values divided by 16 (the number of values).
[68] ICF International, 2007, Table 2.
[69] ICF International, 2007, Table 3.
[70] 2005US$92 billion with a range of $2 to $148 billion.
[71] See Cosbey, et al., 2007 for a review of the possible market mechanisms proposed for future climate change regimes.
[72] Fenhann, CDM Pipeline, 31 May 2007, Table 2, Analysis sheet.
[73] Cames, et al., 2007, Figure 6, p. 43.
[74] The average crediting period is 7.5 years (Fenhann, CDM Pipeline, 31 May 2007, Table 7, Analysis sheet shows 86% choose a 7 year crediting period and 14% a 10 year crediting period, giving an average of 7.5 years). Thus the current flow yields about 7,500 registered projects, then crediting periods need to be renewed.
[75] As discussed above, such mechanisms have the effect of reducing the potential supply somewhat.
[76] Some, or all, of the surplus could be used by those countries to meet their post-2012 commitments and the balance could be sold to other Annex I/B Parties.