Estimating the Market Potential for the Clean Development Mechanism: Review of Models and Lessons Learned

Prepared for World Bank Carbon Finance Business PCF*plus* Research program, the International Energy Agency and the International Emissions Trading Association by Erik Haites, *Margaree Consultants*

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This study is the product of a collaboration between the World Bank Carbon Finance Business, through its PCF*plus* Research program, the International Energy Agency and the International Emissions Trading Association.

The **International Energy Agency** (IEA) is an autonomous body established in 1974 within the framework of the Organisation for Economic Cooperation and Development (OECD) to carry out a comprehensive programme of energy cooperation among twenty-six of the OECD's thirty Member countries. The basic aims of the IEA are to maintain and improve systems for coping with oil supply disruptions; to promote rational energy policies in a global context through cooperative relations with nonmember countries, industry and international organisations; to operate a permanent information system on the international oil market; to improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use; and to assist in the integration of environmental and energy policies.

The **International Emissions Trading Association** (IETA) is a non profit organization created in June 1999 to establish a functional international framework for trading emissions reductions. IETA works for the development of an active, global greenhouse gas market, consistent across national boundaries. The organisation constitutes a neutral platform where members meet and interact with the objective to participate in the design and implementation of national and international rules and guidelines.

The **Carbon Finance Business** (CFB) is part of the global effort of the World Bank to combat climate change, and goes hand in hand with the Bank's mission to reduce poverty and improve living standards in the developing world. Given the threat climate change poses to long-term development and poverty alleviation, the Bank is making every effort to ensure that developing countries and economies in transition can benefit from the emerging market for greenhouse gas emission reductions. The CFB mission is to catalyze this market through the purchase of high quality emission reductions in climate-friendly projects. The CFB manages the Prototype Carbon Fund, the Community Development Carbon Fund, the BioCarbon Fund, the Netherlands Clean Development Facility and the Italian Carbon Fund.

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International Energy Agency (IEA)
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Abstract

The study estimates the market potential for the Clean Development Mechanism (CDM) based on the practical experience to date and developments that could affect the demand for and supply of Certified Emission Reductions (CERs) from CDM projects. It assumes the Kyoto Protocol enters into force without the participation of Australia and the United States. If the Kyoto Protocol does not enter into force a market for CERs from CDM projects might still exist, but the market potential and price would differ from the estimates presented here.

The estimated market potential of the CDM is a demand for CERs in 2010 of 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$) at a price of \$11.00 /tCO_2e (range $\pm$ 50%). This represents a total demand of 1 250 $MtCO_2e$ by 2012. Virtually all of the estimates fall into this range for the demand. Estimates of the potential supply are also consistent with this range. And the price is consistent with current prices and forecasts of the market price for Kyoto units in 2010.

The estimated potential assumes a continued preference for CERs and ERUs by buyers and restricted sales of surplus Kyoto units by Russia and the Ukraine. The minimum demand by industry in Europe and the planned purchases by governments yield an annual demand of at least 100 $MtCO_2e$ for CERs and ERUs. The median demand by industry in Europe combined with estimated government purchases by Annex B governments yields a potential demand for CERs and ERUs of roughly 230 $MtCO_2e$ in 2010.

The estimated potential also assumes a sustained flow of new CDM projects so the demand for CERs is not constrained by a limited supply. The number of economically viable CDM projects will decline rapidly over the next few years unless domestic and/or international measures to give an economic value to post-2012 emission reductions are adopted soon. Failure to ensure a market value for post-2012 emission reductions soon would limit the CDM to an annual supply of 50 to 90 $MtCO_2e$ in 2010; a total supply of 250 to 450 $MtCO_2e$.

Possible ways to provide a market value for post-2012 reductions include: (i) inclusion of an option for post 2012 CERs in purchase contracts currently being negotiated by governments, (ii) commitments by Annex B Parties to continue domestic emission trading programs that allow the use of CERs beyond 2012, and (iii) international agreement that existing emission limitation commitments remain in effect until new commitments are negotiated.

The lead time for new CDM projects is four to five years, so project ideas initiated now will not yield emission reductions until 2008 or later. Under favourable conditions, the flow of new projects could accelerate in 2008 and require added capacity for the Executive Board.

To be economically viable a CDM project should reduce emissions by at least 100 000 tCO_2e per year. Project types large enough to be economically viable account for most of the CDM potential. These include: landfill gas capture; methane reductions in the oil and gas industry; renewable electricity generation; and afforestation and reforestation. Energy efficiency projects are also estimated to have significant potential, but the limited number of projects to-date suggests they face barriers not fully reflected in analyses of the achievable potential.

The larger the demand for CERs, the more important it becomes that the CDM potential in all countries be fully developed. Latin America currently has more CDM project activity relative to its estimated potential than any other region. Project activity relative to estimated CDM potential is low in all other regions. China's CDM potential is comparable to that of Latin America, Africa and the Middle East combined, so the scale of CDM activity in China will affect the total supply of CERs.

Executive Summary

The objective of this study is to estimate the market potential for the Clean Development Mechanism (CDM) based on the practical experience to date and developments that could affect the demand for and supply of Certified Emission Reductions (CERs) from CDM projects. This information is intended to help governments and private entities incorporate CERs into their greenhouse gas emission limitation compliance plans. And it should help host governments and project developers understand the forces that affect the demand for CERs from their CDM projects. Related policy implications are also discussed.

The study assumes that Russia ratifies the Kyoto Protocol so that it enters into force, but without the participation of Australia and the United States, which have announced their intention not to ratify. If the Kyoto Protocol does not enter into force, a market for CERs from CDM projects might still exist, but the market potential and price would differ from the estimates presented here.[1]

Analyses of the international market for Kyoto units are reviewed first. Next several issues that affect the supply of, or demand for, CERs are considered. The findings are then integrated to provide an estimate of the potential market for the CDM, the key factors that affect the market potential, and the associated policy implications.

Annual figures for 2010, rather than totals for 2008-2012, are used throughout this report unless stated otherwise. The CDM potential for 2008-2012 is approximately five times as large as the potential for 2010.

The International Market for Kyoto Units

CERs generated by CDM projects will compete with other Kyoto units in the international market. Thus an understanding of the international market for Kyoto units is crucial to an assessment of the potential for CDM. Demand for Kyoto units in 2010, excluding Australia and the United States, is estimated at about 925 $MtCO_2e$ (range about 600 to 1 150 $MtCO_2e$).

Almost all projections indicate that Russia and the Ukraine will have a surplus of low-cost Kyoto units that exceeds the projected demand. If the potential supply from these countries is fully available to the international market, the price of Kyoto units is likely to be low and the market demand for CERs will be very small.

Model results suggest that Russia and the Ukraine can increase the revenue from the sale of their Kyoto units by restricting sales to about 40% of their surplus units (approximately 540 $MtCO_2e$). Taking into account the supply of Kyoto units from other Annex B countries, that

[1] For example, if those countries that have ratified implement the treaty, CER demand could rise – as Russian allowances would no longer be available. Conversely, Kyoto obligations may be unmet, and countries may reduce CER purchases. Finally, new negotiations may ensue that could reinvigorate a market for offsets under some future agreement.

would create a demand for CERs of about 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$) and a market price for Kyoto units of about \$11.40/tCO_2e in 2010 (range \$1.00 to \$33.00/tCO_2e). This price is consistent with other data indicating a market price rising from US\$5.50/tCO_2e in 2003 to \$11/tCO_2e in 2010 with uncertainty range of $\pm$ 50%.

The model results must be used with care. The models are highly stylized representations of the international market for Kyoto units. They assume efficient domestic policies to limit emissions and enhance sinks in Annex B Parties, efficient domestic and international institutions for the CDM and efficient markets for Kyoto units. These conditions are unlikely to be realised fully in practice.

Issues that Affect the Potential Supply of CERs

Several estimates of the emission reductions and sink enhancements that could potentially be achieved by CDM projects are available. The most conservative of these estimates yields annual reductions in 2010 of 335 $MtCO_2e$ (range 215 to 405 $MtCO_2e$) at a price of \$11.00/CO_2e $\pm$ 50%.

CDM projects can earn CERs for emission reductions achieved prior to 2008. Pre-2008 reductions are likely to increase the annual supply of CERs during the commitment period by about 25%. Thus, the annual supply of CERs in 2010 would be 420 $MtCO_2e$ (range 270 to 505 $MtCO_2e$) at a price of \$11.00/CO_2e $\pm$ 50% given annual reductions of 335 $MtCO_2e$.

CDM projects incur relatively large fixed transaction costs prior to registration. This means that projects must be relatively large to be economically viable. Analytical studies suggest a minimum project size of 50 000 tCO_2e per year. Data from existing and identified projects suggest that the *minimum* size is about 100 000 tCO_2e per year. The *average* size of existing and identified projects is over 150 000 tCO_2e per year.

The minimum size of an economically viable project may decline over time as more approved baseline and monitoring methodologies become available. Those methodologies will reduce the fixed component for the transaction costs. However, the minimum size is likely to remain above 50 000 tCO_2e per year for regular CDM projects.

The simplified methodologies adopted by the Executive Board for small-scale CDM projects may reduce the transaction costs for those projects enough to make such projects economically viable. Small-scale CDM projects are likely to have annual emission reductions of less than 50 000 tCO_2e. At present there is no information on the potential number of small-scale projects nor on the aggregate emission reductions those projects might achieve.

Buyers currently have little interest in reductions achieved after 2012, so those reductions have virtually no market value at present. If a project is to recover its costs from the sale of CERs for the reductions achieved prior to 2013, it must begin to achieve emission reductions between 2001 and 2007. This means the number of economically viable CDM projects will decline rapidly over the next few years unless domestic and/or international measures to give an economic value to emission reductions beyond 2012 are adopted soon.

The large projects that account for most of the potential CDM supply have a lead time of four or five years. Thus new project ideas initiated now would only yield emission reductions after 2007. This means that emission reductions beyond those from currently identified projects depend heavily on new project ideas initiated now and implemented during 2008-2012. That could lead to a significant acceleration in the flow of new projects in 2008, which could strain the capacity of the designated operational entities and the Executive Board.

The project types that have an average size sufficiently large to be economically viable account for most of the CDM potential. These project types include: energy efficiency measures in the residential, commercial and institutional sectors; energy efficiency in industry; landfill gas capture and utilisation; methane reductions in the oil and gas industry; renewable electricity generation; and afforestation and reforestation. Other project types, such as recovery of coal-bed methane and reduction/destruction of non-methane GHGs, appear to be economically viable, but do not represent a large share of the total potential.

At present energy efficiency projects are under-represented relative to their estimated potential. This suggests the existence of factors, such as high administrative costs or other barriers that are not fully reflected in analyses of the achievable potential for these projects. On the other hand, renewable electricity generation and projects that involve non-CO_2 gases, such as methane, are over-represented. The higher global warming potential values of non-CO_2 projects tend to improve the project economics.

The geographic distribution of the estimated CDM potential is similar to the distribution of projected energy investment to 2010, projected energy-related CO_2 emissions in 2010 and projected growth of energy-related CO_2 emissions between 2000 and 2010. But it differs somewhat from the historic patterns of foreign direct investment (FDI) and official development assistance.

Latin America currently has more CDM project activity relative to its estimated potential than any other region, consistent with the pattern of FDI. Project activity relative to estimated CDM potential is low in all other regions. Due to its large share of the global CDM potential, the scale of CDM activity in Asia, and in particular China, could have a substantial impact on the total supply of CERs.

Annual emission reductions in 2010 of 400 MtCO_2e would require an annual investment of about \$10 billion. Foreign direct investment (FDI) in developing countries averaged \$140 billion per year during 1997-2002 and often varied by more than \$10 billion from one year to the next. The projected energy investment required for developing countries between 2001 and 2010 is \$192 billion per year.

Thus, it appears that the CDM will not cause major changes to existing and projected investment flows. However, the capital requirements for CDM projects during a given year, or for a few years, could be much larger. And higher prices for CERs could increase the capital requirements. On the other hand, the demand for CERs and investment in CDM projects could be lower. And the capital for CDM projects can come from domestic as well as foreign sources, so comparing the requirement only with international financial flows is too restrictive.

Issues that Affect the Potential Demand for CERs

Total demand by industry for Kyoto units in 2010 is estimated at 200 $MtCO_2e \pm 100$ $MtCO_2e$. The European Union (EU) represents 45 to 60% of the estimated industry demand. Purchases by European industry for compliance use will be governed by rules for exchanging Kyoto units for EU allowances. The draft EU Linking Directive allows CERs and ERUs, but not AAUs, to be exchanged for EU allowances. That would create an estimated industrial market for CERs and ERUs in 2010 of 110 $MtCO_2e \pm 65$ $MtCO_2e$.

The draft Linking Directive would also benefit the Clean Development Mechanism by and creating a demand for CERs and ERUs after 2012 and reducing the scope for JI projects in member states of the European Union.

Several Annex B governments have already purchased or announced plans to purchase ERUs or CERs. The announced plans represent an annualised demand of roughly 50 $MtCO_2e$ of CERs and ERUs. Government purchases are projected to represent between 45 and 75% of the total demand for Kyoto units. On that scale, government purchases could lead to market segmentation, such as the current preference for CERs and ERUs, and price differentiation for different categories of Kyoto units.

The minimum demand by industry in Europe (about 45 $MtCO_2e$) and the planned purchases by governments (about 50 $MtCO_2e$) yield an annual demand for CERs and ERUs of at least 100 $MtCO_2e$. The median demand by industry in Europe (110 $MtCO_2e$) combined with estimated government purchases by the European Union, Norway and Switzerland (about 120 $MtCO_2e$) yields a potential demand for CERs and ERUs of roughly 230 $MtCO_2e$ in 2010. The maximum demand by government and industry could be double the maximum supply of CERs of about 500 $MtCO_2e$ in 2010.

A greenhouse gas trading program in Australia or the United States, at the state or national level, could decide to allow the use of Kyoto units for compliance purposes. Such provisions could allow the use of any Kyoto units or be limited to specific types of units, such as CERs.

The Estimated Market Potential of CDM

Expressed preferences by buyer governments combined with the economic incentives for Russia and the Ukraine to limit sales of their Kyoto units ensure a market for CERs. All existing government initiatives to purchase Kyoto units are limited to CERs and/or ERUs. The draft Linking Directive would allow only CERs and ERUs to be exchanged for EU allowances. And model analyses indicate that Russia and the Ukraine have an economic incentive to limit sales of their surplus Kyoto units. Together these conditions ensure a demand for CERs.

The estimated market potential of the CDM is a demand for CERs in 2010 of 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$) at a price of \$11.00 /tCO_2e (range $\pm$ 50%). Virtually all of the estimates fall into this range for the demand. And the price is consistent with current prices and forecasts of the market price for Kyoto units in 2010. That potential assumes a continued preference for CERs and ERUs by buyers, a sustained flow of new CDM projects, and realisation of a substantial share of the potential emission reductions in Asia.

Failure to ensure a market value for post-2012 emission reductions quickly could have a major impact on the market potential for the CDM. With no market value for post-2012 reductions, the CDM would be limited to existing project ideas, which would yield an annual supply of 50 to 90 $MtCO_2e$. And there would be virtually no new CDM projects after 2007.

The estimates of the supply of CERs at the projected market price suggest that the estimated demand of 250 $MtCO_2e$ can be met. The maximum estimates of total supply and potential demand are equal at 500 $MtCO_2e$. The estimate of the potential supply of CERs in 2010 appears reasonable relative to projected emissions in 2010, emissions growth between 2000 and 2010, and the investment requirements. The number of projects involved, especially for the upper end of the range, appears to create more difficulties due to the lead time for new projects.

Key Factors Affecting the Market for CERs

The market potential for the CDM depends critically upon preferences by buyer governments for CERs and ERUs, proposed regulations that allow only CERs and ERUs to be exchanged for EU allowances, and economic incentives for Russia and the Ukraine to limit the sale of their surplus Kyoto units.

China represents 35 to 45% of the estimated total CDM potential in 2010, comparable to the estimated potential of Latin America, Africa and the Middle East combined. Thus the scale of CDM activity in China affects the total supply of CERs. While some CDM projects are being developed in China, the available data indicate that more projects accounting for a larger share of the estimated potential have been identified in India, Indonesia, Brazil and Mexico. The larger the demand for CERs, the more important it becomes that the CDM potential in all countries be fully developed.

Failure to ensure a market value for post-2012 emission reductions soon could have a major impact on the market potential for the CDM. The annual demand for CERs during 2008-2012 is estimated to be 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$). With no market value for post-2012 reductions, the CDM would be limited to existing project ideas, which would yield an annual supply of 50 to 90 $MtCO_2e$.

A continuous flow of new CDM projects is needed if the demand for CERs is not to be constrained by a limited supply. A market potential of up to 150 $MtCO_2e$ in 2010 could be supplied by maintaining a steady flow of new projects. A larger market potential in 2010 would require more new projects. But due to the lead time of four to five years, the flow of new projects is unlikely to increase before 2008. A significant acceleration in the flow of new projects in 2008 could strain the capacity of the designated operational entities and the Executive Board.

Policy Implications

Ensuring that post-2012 emission reductions have a market value soon is key to the market potential of the CDM. To ensure that the project types and sizes that account for most of the CDM potential are economically viable, emission reductions at least ten years into the future need to have a market value. Post-2012 emission reductions can be given a market value in any of several ways:

- Inclusion of an option to purchase post 2012 CERs in the contracts currently being negotiated by governments. Governments currently buying CERs could add an option to buy the post 2012 CERs under specified terms. The terms of the option could vary to suit the buyer and seller, but the option would indicate to the seller that post-2012 reductions have a market value.

- Commitments by Annex B Parties to continue domestic greenhouse gas emission trading programs that allow the use of CERs beyond 2012. The EU Emission Allowance Trading Directive establishes five-year phases continuously beyond 2012. Adoption of the draft Linking Directive would allow continued use of CERs after 2012. The market value of post-2012 CERs is still very uncertain since allocations for the 2005-2007 and 2008-2012, let alone 2013-2017, have not yet been determined. Other Annex B countries could adopt similar provisions for their domestic emissions trading programs.

- Negotiate national emission reduction commitments for some period after 2012 with the ability to use CERs for compliance. While negotiation of future emission limitation commitments is scheduled to begin in 2005 if the Kyoto Protocol enters into force, they could take several years to complete. In the interim it might be possible to agree that existing emission limitation commitments remain in effect until new commitments are agreed as a way to give a market value to post-2012 reductions.

The ability to shorten project lead times appears to be very limited. Project developers have an economic incentive to get their project into operation as quickly as possible. And, to date, the Executive Board has made decisions quite expeditiously. Thus, there is no obvious way to reduce project lead times, but a more detailed examination of this issue may be warranted. If the CDM is very successful it could lead to hundreds of new CDM projects per year, which could require strengthening the capacity of the Executive Board to ensure that lead times do not increase due to the larger volume of projects.

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1. Introduction

1.1 Objective

The objective of this study is to estimate the market potential for the Clean Development Mechanism (CDM) based on the practical experience to date and developments that could affect the demand for and supply of Certified Emission Reductions (CERs) from CDM projects. The estimated potential for the CDM is disaggregated both by geographic region and project type.

This information is intended to help governments and private entities of Annex B Parties incorporate CERs into their greenhouse gas emission limitation compliance plans.[2] And it should help non-Annex B governments and project developers understand the forces that affect the demand for CERs from their CDM projects.

The study also reviews the policy implications of these estimates for the implementation of the CDM and investments in different sectors, including the energy sector.

1.2 Background

The Kyoto Protocol to the United Nations Framework Convention on Climate Change, if it enters into force, would establish emission limitation commitments for 2008-2012 for the developed countries (Annex B Parties) that ratify the Protocol. The Protocol includes three mechanisms that would enable an Annex B Party to meet its commitment, in part, through emission reductions in other countries. The three mechanisms are:

- Joint Implementation (JI, Article 6): A project to mitigate climate change in an Annex B Party can earn emission reduction units (ERUs) that can be used by another Annex B Party to help meet its emission limitation commitment.

- Clean Development Mechanism (CDM, Article 12): A project to mitigate climate change in a non-Annex B Party can generate certified emission reductions (CERs) that can be used by an Annex B Party to help meet its emission limitation commitment.[3]

[2] The Kyoto Protocol specifies emission limitation commitments for 38 countries (plus the European Community), expressed as a fraction of each country's base year (usually 1990) emissions, in its Annex B. Hence, a country that would have an emission limitation commitment under the Protocol is called an Annex B country. An Annex B country that ratifies the Protocol is called an Annex B Party. Developing countries would not have emission limitation commitments. A developing country that ratifies the Protocol is called a non-Annex B Party. To help meet its commitment, an Annex B Party may impose emission limitation obligations on domestic sources.

[3] 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.

- International Emissions Trading (IET, Article 17): One Annex B Party can transfer some of its allowable emissions, assigned amount units (AAUs), or acquired ERUs, CERs and Removal Units (RMUs), to another Annex B Party.[4] This increases the allowable emissions in the recipient country and reduces those of the seller country.

Parties may allow their legal entities to participate in these mechanisms.

The Kyoto Protocol will enter into force once it has been ratified by at least 55 countries accounting for 55% of Annex I 1990 CO_2.[5] In 2001 the US Administration decided to withdraw from the Kyoto Protocol. In 2002 the Australian government decided not to ratify the Protocol until it is in Australia's economic interest, but to meet its emissions limitation commitment nevertheless.[6] To enter into force without ratification by the United States and Australia, the Russian Federation must ratify the Kyoto Protocol.[7]

Although the Kyoto Protocol has not yet entered into force, activity under the Clean Development Mechanism is underway. Detailed rules for the CDM were adopted in November 2001 as part of the Marrakech Accords. Members of the Executive Board, which administers the CDM, were elected at that time.

The Marrakech Accords stipulate that an emission reduction project activity under the CDM must, among other things:

- use an approved methodology to define the baseline emissions, i.e., the emissions that would have occurred in the absence of the project, from which reductions are calculated;
- use an approved monitoring methodology to monitor actual emissions and collect other information needed to calculate the emission reductions achieved; and
- be reviewed by an accredited "designated operational entity" which confirms that the proposed baseline and monitoring methodologies are appropriate and that other eligibility requirements are met.

Thus, before a CDM project can be registered, the Executive Board must approve baseline and monitoring methodologies and accredit "designated operational entities". As of 30 November 2003, 36 proposed baseline and monitoring methodologies had been submitted to

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[4] Removal Units are issued for verified increases in carbon stocks resulting from eligible forestry and land use activities in Annex B Parties.

[5] Entry into force occurs 90 days after the Protocol has been ratified by at least 55 Parties to the United Nations Framework Convention on Climate Change which account for at least 55% of the 1990 CO_2 emissions by Parties listed in Annex I of the Convention.

[6] Australia (2002), pp. 1-2 "The Commonwealth Government decided in July 2002 … not to ratify the Kyoto Protocol unless and until it is demonstrated that it is in the national interest to do so. …shorter term focus upon development and investment of funding in domestic programs to meet Australia's target under the Kyoto Protocol of limiting greenhouse emissions to 108% of 1990 emissions levels over the period 2008 – 2012."

[7] As of 26 November 2003, the Protocol had been ratified by 120 countries accounting for 44.2% of the 1990 CO_2 emissions by Annex I Parties. In the absence of the United States and Australia, the only way to achieve the 55% of 1990 CO_2 emissions threshold is ratification by the Russian Federation.

the Executive Board. Of these, 9 methodologies had been approved and 20 were still under review. As of the same date, 19 organizations had submitted an application to be accredited as a designated operational entity. It is expected that the first designated operational entities could be accredited and the first projects could be registered during the first quarter of 2004.

Despite the fact that the formal registration process is not yet fully operational, initiatives to develop projects for registration as CDM projects have been underway for several years and are accelerating.

- The Prototype Carbon Fund (PCF) was launched by the World Bank in January 2000 to develop CDM and JI projects on behalf of the investors. Canada, Finland, Japan, Netherlands, Norway and Sweden as well as 17 private firms have subscribed US$180 million to the PCF. As of September 2003, it had signed emission reduction purchase contracts for 12 projects and had an additional 17 under preparation to purchase 43.987 million tonnes of CO_2 equivalent ($MtCO_2e$) at a cost of US$160.2 million.[8] These totals include 22 potential CDM projects with emission reduction purchases of 38.871 $MtCO_2e$ at a cost of US$139.1 million.

- The government of the Netherlands launched the CERUPT tender to acquire CERs in December 2001 and announced the selection of 18 projects with a total reduction of 16.551 $MtCO_2e$ in March 2003. The Netherlands is also buying ERUs and CERs through several other arrangements.

- The World Bank launched a Community Development Carbon Fund in July 2003 to invest in small-scale CDM projects with sustainable development benefits and has plans to launch a BioCarbon Fund following adoption of the rules for afforestation and reforestation projects under the CDM in December 2003.

- The governments of Austria, Belgium, Denmark, Finland, Germany, Italy, Japan, Norway, Sweden and Switzerland have announced programs to purchase emission reductions from CDM and/or JI projects.

- The Asian Development Bank has established a fund to help finance CDM projects in Asia. Several other funds to invest in CDM and/or JI projects have been proposed by international agencies, national governments and private sector organisations and are at various stages of implementation.

- In addition to investing in the PCF and other funds, some private sector entities are starting to participate in potential CDM projects. Japanese utilities, in particular, started to purchase CERs in 2003 (Lecocq and Capoor, 2003).

As mentioned earlier, the CERs generated by a CDM project can be used by an Annex B Party to help meet its emission limitation commitment for 2008-2012. An Annex B Party can

[8] PCF (2003b). The total emission reductions estimated for these 29 projects is 112.214 $MtCO_2e$; the Prototype Carbon Fund is buying 39.2% of the projected reductions.

also implement, or require domestic entities to implement, emission reductions and sink enhancements.[9] And an Annex B Party may acquire AAUs, ERUs and RMUs to help meet its emission limitation commitment. Thus, the demand for CERs depends upon the emission reductions Annex B Parties need to make to meet their commitments as well as competition from the other options for meeting these commitments.

The demand for CERs could be significantly affected by several recent developments:

- The American and Australian decisions not to ratify the Kyoto Protocol significantly reduce the demand for CERs because they were projected to be large net buyers of Kyoto units (AAUs, CERs, ERUs and RMUs).

- Due to a substantial decline in its emissions since 1990, the Russian Federation is projected to have a surplus of AAUs that is large relative to the projected demand for Kyoto units. The same is true, on a smaller scale, for the Ukraine, and on an even smaller scale, for several Eastern European countries with economies in transition. Given its large surplus, Russia may be able to raise the market price for Kyoto units by restricting sales of its surplus AAUs.

- The European Union will implement an emission allowance trading program covering CO_2 emissions by specified industrial sources in member states beginning in 2005. This will become the world's largest emission allowance trading program covering greenhouse gas emissions by industrial sources. The Commission has released a proposal to allow CERs and ERUs (but not AAUs or RMUs) to be exchanged for EU allowances that participants can use for compliance beginning in 2008.[10] The proposal would also reduce the scope for potential JI projects in member states.[11] The proposal must be approved by the European Parliament and the Council and may be amended before it is adopted.[12]

The withdrawal of Australia and the United States will tend to lower the demand and price for CERs. Strategic behaviour by Russia, or other restrictions on the sale of their surplus AAUs, would raise the demand and price for CERs. The ability of participants in the EU trading

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[9] An Annex B Party could adopt domestic policies that require specified entities to implement emission reduction or sink enhancement measures. An emission allowance trading program that caps the emissions of specified sources is an example of such a policy. An emission allowance trading program may allow participants to use Kyoto units for compliance purposes. Thus both Annex B governments and entities are potential buyers of Kyoto units including CERs.

[10] European Commission (2003b).

[11] The restrictions on potential JI projects are intended to prevent possible double crediting of emission reductions. Electricity generators will be covered by the emissions trading program. Any reduction in their emissions means they need fewer allowances to achieve compliance. Awarding ERUs for energy efficiency or electricity generation projects that reduce the emissions of electricity generators would mean the reductions are credited twice -- the ERUs issued for the project and the allowances saved by the generator.

[12] European Parliament (2004).

programs to exchange CERs and ERUs for EU allowances that can be used for compliance helps establish the market for CERs while limiting competition from AAUs and RMUs.[13]

1.3 Approach

The study first reviews analyses of the international market for Kyoto units. The CERs generated by CDM projects compete with other units in this market. Then several issues that affect the supply of, or demand for, CERs are considered. These findings are integrated to provide an estimate of the potential market for the CDM, the key factors that affect the market potential, and the associated policy implications.

The study assumes that the Russian Federation ratifies the Kyoto Protocol so that it enters into force, but without the participation of Australia and the United States, which have announced their intention not to ratify. If the Kyoto Protocol does not enter into force, a market for CERs from CDM projects might still exist, but the market potential and price would differ from the estimates presented in this report.

Emission projections for Annex B Parties provide an estimate of the international market for Kyoto units. Comparing the emission projection for a country, after implementation of its expected emission reduction and sink enhancement measures, with its emission limitation commitment indicates whether it is expected to be a net buyer or net seller of Kyoto units. The net purchases of the Annex B Parties, adjusted for possible limits on sales of Kyoto units by Russia, represent the market potential for CERs. This provides no information on the supply of CERs or on the market price.

Several global models produce estimates of emissions by Annex B Parties, their demand for Kyoto units, the supply of AAUs, CERs, ERUs and RMUs under different assumptions, and the price of Kyoto units under these different assumptions. These models make highly stylized assumptions regarding the supply of CERs and other Kyoto units. But they yield estimates of the market price for Kyoto units and are well suited to analysis of restrictions on the sale of surplus Russian AAUs. Published model results are summarised and model runs undertaken for this study are reported.

The potential supply of CERs will be affected by the lead time needed to implement CDM projects and the transaction costs for CDM projects. The cost of getting a CDM project registered is roughly the same regardless of the size of the project and represents a large fraction of the total transaction cost. This relatively fixed portion of the transaction cost influences the minimum size of an economically viable project. Early experience with existing and proposed projects provides information on the time required to implement a project, minimum and average project size and expected project life. Such information is available for proposed CDM projects selected by the PCF and CERUPT, proposed CDM

[13] Of course, should the Protocol fail to enter into force, the analysis of the CDM market would clearly change substantially. This analysis does not treat that scenario.

projects submitted to the Executive Board, and projects implemented under the Activities Implemented Jointly (AIJ) initiative.[14]

These existing and proposed projects also provide a profile of the potential supply of CERs by project type and region. Those distributions are compared with estimates of the CDM potential by project type and region. Information on the regional distribution of the CDM is compared with the regional distribution of foreign direct investment (FDI), official development assistance (ODA), and projected energy sector investments. Implicit in each estimate of the CDM potential is the number of projects (based on the average project size) and the associated investment (based on the cost per tonne of emissions reduced). The investment requirements are compared with the scale of FDI, ODA and projected energy sector investments.

The potential supply of CERs during 2008-2012 will also be affected by activity prior to 2008. CDM projects can earn CERs for reductions achieved after 1 January 2000. Thus projects implemented prior to 2008 will build an inventory of CERs that can be used by Annex B Parties for compliance with their 2008-2012 commitments. The effect of this inventory on the potential supply is estimated.

As indicated above, a number of Annex B governments have announced or launched initiatives to purchase CERs and/or ERUs. In addition, the European Commission has proposed that participants in the EU emission allowance trading scheme be permitted to exchange CERs or ERUs, but not AAUs or RMUs, for EU allowances that can be used for compliance. These actions segment the international market for Kyoto units, making CERs and ERUs less vulnerable to competition from AAUs and RMUs. Thus, these actions affect the potential demand for CERs.

In summary, the analyses of the international market for Kyoto units provide relatively good information on aggregate demand and the market price under different behavioural assumptions. These analyses are reviewed in Chapter 2. The project data and other information reviewed in Chapter 3 provide much richer detail on the potential supply of CERs. Additional perspectives on the demand for CERs are presented in Chapter 4. Chapter 5 draws this material together to provide an assessment of the potential market of the CDM, an understanding of the key factors that affect the potential market for CERs and the associated policy implications.

[14] Activities Implemented Jointly (AIJ) is a voluntary pilot phase of JI and CDM launched in 1995. AIJ projects can not be used to comply with emission limitation commitments. However, AIJ projects that meet the eligibility requirements for CDM projects can be registered as CDM projects and can then earn CERs for emission reductions achieved after January 1, 2000.

2. The International Market for Kyoto Units

This chapter reviews analyses of the international market for Kyoto units for 2008-2012. First, projections of Annex B emissions prepared by countries/institutions are compared with the emission limitation commitments. This net demand by Annex B Parties for Kyoto units is an estimate of the potential market for CERs. Second, the analyses of the international market for Kyoto units produced by several global models are reviewed. These models yield estimates of the market price for Kyoto units as well as the supply of CERs under different assumptions. Third, model runs undertaken for this study are reported. Finally, current market prices for Kyoto units are related to price forecasts for 2010.

Results are adjusted, where possible, to cover all greenhouse gases and ratification of the Kyoto Protocol by all Annex B countries except Australia and the United States.

2.1 Methodology: Annual or Total Figures?

Annex B Parties have emission limitation commitments for the five years from 2008 through 2012, so the aggregate demand for CERs is the total demand for this five-year period. However, virtually all projections and model results are available only for selected years. Almost without exception the only year of the 2008-2012 period for which projections and model results are available is 2010.

Annual figures for 2010, rather than totals for 2008-2012, are used throughout this report unless stated otherwise. The reasons for this choice are that:

- annual figures for 2010 are familiar since they are widely reported; and
- calculation of annual values for 2008 through 2012 by linear interpolation of projections for 2005, 2010 and 2015 yields a total that is only marginally different from five times the 2010 figure.[15]

This report, then, discusses the market potential for the CDM in 2010 and the market potential for 2008-2012 would be approximately five times as large.

Also, all emissions are reported in metric tonnes of carbon dioxide emissions equivalent (tCO_2e) or millions of metric tonnes of carbon dioxide emissions equivalent ($MtCO_2e$).

2.2 Emission Projections by Countries/Institutions

This section reviews emission projections for Annex B countries.[16] The review covers projections prepared by the countries themselves as part of their national communications

[15] Using the data from the national communications, five times the 2010 projection is less than 0.1% lower than the total of the interpolated values for 2008-2012 for all Annex B countries, for all Annex B countries except the United States, and for all Annex B countries except Australia and the United States.

submitted to the United Nations Climate Change Secretariat. It also covers emission projections prepared by the International Energy Agency (IEA) and the Energy Information Administration (EIA) of the United States Department of Energy.[17]

2.2.1 National Emission Inventories and Projections

Annex B countries are required to submit annual emission inventories and periodic "national communications" to the Climate Change Secretariat. The inventories, prepared using procedures and guidance developed by the Intergovernmental Panel on Climate Change (IPCC), include all gases and sources covered by the Kyoto Protocol. The national communications include projections of emissions for 2005, 2010 and 2015.

These inventories and projections provide the most comprehensive emission information for Annex B countries. Unfortunately they are not current or complete for all countries. Base year emissions are available for all 38 Annex B countries.[18] Emissions during 2000 are available for 29 countries. Emission projections are available for 36 countries although in a number of cases there are multiple projections (e.g., low and high), the projection(s) does not cover all gases and/or sources, and the projection(s) may not cover all of the years 2005, 2010 and 2015. Extrapolation, interpolation and other assumptions were used to construct a complete set of emission estimates for 2000 and projections for 2010.[19]

The emission estimates for the base year and 2000 and the projection for 2010 are shown in Table A-1 (Appendix A). The table also shows the annualized assigned amount for each country.[20] Finally, the table shows the projected purchases or sales of Kyoto units in 2010 by each Annex B country. The purchases/sales are calculated by subtracting the projected emissions in 2010 from the annualized assigned amount. Implicitly this assumes the projected 2010 emissions for each country reflect the effects of its existing and future policies, as well as specific projects, aimed at reducing its greenhouse gas emissions and increasing its eligible sinks.

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[16] The 38 Annex B countries are listed in Table A-1. It is assumed that all of them except Australia and the United States ratify the Kyoto Protocol, so the remaining 36 countries are Annex B Parties.

[17] BP publishes energy statistics that can be used to estimate energy-related CO_2 emissions for 31 of the 38 Annex B countries, but it does not publish a forecast so that information is not used here.

[18] The base year is 1990 for all countries except Bulgaria (1988), Hungary (1985-87), Poland (1988), and Romania (1989).

[19] If the projection for 2010 covers only energy-related CO_2 emissions, for example, it would be assumed that the ratio of total greenhouse gas emissions to energy-related CO_2 emissions is the same in 2010 as in 2000.

[20] Each country's assigned amount covers the period 2008 through 2012. The table shows 20% of the total assigned amount to facilitate comparison with the annual emissions. The assigned amounts for the current members of the European Community reflect their burden sharing agreement, which redistributes the assigned amount among the member states.

If the emission reduction measures reflected in the 2010 projection for an Annex B Party are less effective than anticipated, its demand for Kyoto units would be higher or its supply of Kyoto units would be lower. If an Annex B Party implements additional emission reduction or sink enhancement measures domestically, it would reduce that country's demand for, or increase its supply of, Kyoto units.

The market potential for CDM is estimated from these projections by subtracting the supply of Kyoto units available from Annex B Parties from the demand for Kyoto units. The annual demand for Kyoto units in 2010, excluding Australia and the United States, is shown as 869 $MtCO_2e$ in Table A-1. The annual supply of Kyoto units from Annex B Parties is projected at 689 $MtCO_2e$, consisting of 520 $MtCO_2e$ from Russia and the Ukraine and 169 $MtCO_2e$ from other Annex B Parties. When this supply is subtracted from the demand, it leaves a market potential of 180 $MtCO_2e$ for the CDM in 2010.[21]

This calculation assumes that Kyoto units from Annex B Parties have a lower cost than CERs and so are sold first. Most of the Kyoto units from Annex B Parties are surplus AAUs, which cost nothing to generate. Surplus AAUs do have an "opportunity cost" because they can be "banked" for use after 2012.[22] Developers of CDM projects incur costs to achieve the emission reductions for which CERs are issued. Thus, the costs of CERs are usually assumed to be higher than the costs of surplus Kyoto units from Annex B Parties.

The estimated market potential for the CDM of 180 $MtCO_2e$ in 2010 is sensitive to the assumption that the emission projection for each Annex B Party reflects the effects of its existing and future actions to reduce its greenhouse gas emissions and increase its eligible sinks. It is also sensitive to the assumption that surplus Kyoto units from Annex B Parties are used first. If the aggregate emissions in 2010 of Annex B Parties are higher than the total projected in Table A-1, the market potential for CERs would be higher and *vice versa*. If Annex B sellers decide to bank some of their surplus Kyoto units or Annex B buyers choose CERs rather than surplus AAUs, the market potential for CERs would be higher than 180 $MtCO_2e$ in 2010.

Lower emissions by Annex B Parties would reduce the market potential for the CDM. The projections for several transition economy countries -- Bulgaria, Lithuania, Poland, Romania, Russia and Slovakia -- indicate significant increases in emissions over the next decade. A smaller increase in the projected emissions of any of these countries would increase the supply of Kyoto units and reduce the market potential for the CDM.

To assess the impact of lower projected emissions in transition economy countries on the potential market for CDM, a sensitivity scenario for Russia, the country with by far the largest supply potential in this group, is considered. The sensitivity scenario is Moe and Tangen's

[21] Given the assumptions underlying this calculation, the total supply of ERUs and surplus AAUs available is 689 $MtCO_2e$. These units are assumed to have a lower cost than CERs and so are used first, leaving the remaining demand of 180 $MtCO_2e$ to be supplied by CERs.

[22] The opportunity cost is the value of the surplus Kyoto units in their most valuable alternative use. If the surplus units are not sold, they can be kept ("banked") for compliance use after 2012.

sustained decline scenario.[23] This scenario, which is the lowest emissions scenario we found in the literature, projects energy-related CO_2 emissions for 2010 at 1 305 $MtCO_2e$ or total greenhouse gas emissions at 1 877 $MtCO_2e$.[24] This is about 35% lower than the projection of 2 912 $MtCO_2e$ in 2010 from the Russian national communication.

The sensitivity scenario for Russia does not affect the demand, but increases the supply of Kyoto units from Annex B Parties to 1 724 $MtCO_2e$, which is almost double the 869 $MtCO_2e$ demand for Kyoto units. Russia's surplus of 1 164 $MtCO_2e$ alone would exceed the total demand. It is important to remember, however, that this surplus reflects the lowest emissions scenario we found in the literature. Given the assumption that surplus AAUs are sold before CERs, there would be no market for CERs under this sensitivity scenario unless Russia decided to bank some of its surplus units or Annex B buyers decided to choose CERs rather than surplus AAUs.

In summary, national emission projections for Annex B Parties yield an estimated market potential for the CDM of 180 $MtCO_2e$ in 2010. This estimate is sensitive to the assumption that the effects of existing and future actions to reduce greenhouse gas emissions and increase eligible sinks are reflected in the emission projection for each country. It is also sensitive to the assumption that surplus Kyoto units from Annex B Parties are used before CERs.

A sensitivity case with much lower emissions for Russia, as a proxy for lower emissions in transition economy countries, indicates no market for CERs if surplus Kyoto units from Annex B Parties are used first. In the sensitivity case, Russia would need to bank some of its surplus AAUs or Annex B buyers would need to choose CERs over surplus AAUs to generate a market for the CDM. Thus, the supply of Kyoto units from Annex B Parties, especially Russia as the largest potential seller, can have a significant impact on the potential market for the CDM. Model analyses of the effects of restricted sales by Russia are reviewed in section 2.3.2 below.

2.2.2 The International Energy Agency (IEA) Projection

The International Energy Agency (IEA) compiles energy-related CO_2 emissions supplied by member countries to facilitate its in-depth reviews of their energy policies as reported in *Energy Policies of IEA Countries*. Total energy-related CO_2 emissions for the 24 member countries in Annex B during 2000 were 11 130 $MtCO_2e$.[25] The energy-related CO_2 emissions

[23] Moe and Tangen (2000), Table 3.4, p. 41. The "sustained decline" scenario assumes that GDP declines at 1% per year from 1999 through 2010. Energy intensity increases at 0.5% per year thus offsetting part of the emissions reduction due to the economic decline.

[24] Based on the historic relationship between energy-related CO_2 emissions and total greenhouse gas emissions in Russia.

[25] IEA (2003a).

during 2000 reported by these countries in their national inventories were 11 266 $MtCO_2e$, a difference of less than 1.5%.[26]

In its *World Energy Outlook 2002*, the IEA projects "business as usual" energy-related CO_2 emissions for groups of Annex B countries.[27] The IEA projections for 2010 are shown in Table A-2. Total energy-related CO_2 emissions for Annex B countries in 2010 are projected at 16 070 $MtCO_2$. Total greenhouse gas emissions are estimated by multiplying the energy-related CO_2 emissions by 1.25. This is the ratio of total greenhouse gas emissions to total energy-related CO_2 emissions for Annex B countries in 2000 as calculated from the national communications. The resulting estimate of total greenhouse gas emissions in 2010 is 20 088 $MtCO_2e$, virtually identical to the projection of 20 054 $MtCO_2e$ in Table A-1.

Comparing the projected emissions for a group with the assigned amount for the group yields the net purchases or sales by the group. Since some regional groups include both likely buyers and sellers, it is not possible to estimate the demand for and supply of Kyoto units by Annex B Parties from the IEA projection. But it is possible to estimate the potential market for CERs by comparing the projected emissions for Annex B countries with the annualised assigned amount. As shown in Table A-2 the market potential for the CDM in 2010, excluding Australia and the United States, is 214 $MtCO_2e$.

The estimated market potential of 214 $MtCO_2e$ in 2010 assumes that the "business as usual" emission projection for each group of Annex B Parties reflects the effects of its existing and future actions to reduce its greenhouse gas emissions and increase its eligible sinks. It also assumes that surplus Kyoto units from Annex B Parties are used before CERs. As noted in the previous section, higher aggregate emissions by Annex B Parties in 2010 would increase the market potential for CERs and *vice versa*. And actions to limit sales of surplus AAUs or give preference to CERs would increase the market potential for the CDM. The estimated market potential of 214 $MtCO_2e$ based on the IEA projections compares reasonably well to the figure of 180 $MtCO_2e$ derived from the national communications in Table A-1.

2.2.3 The U.S. Energy Information Administration (EIA) Projection

The Energy Information Administration (EIA) of the United States Department of Energy provides estimates of energy-related CO_2 emissions for 36 of the 38 Annex B countries.[28] Total energy-related CO_2 emissions for these countries during 2000 were 14 008 $MtCO_2e$. As mentioned earlier, energy-related CO_2 emissions during 2000 are available for only 29 of these countries from their national inventories. The 2000 energy-related CO_2 emissions for

[26] These differences may be due to the use of different conversion factors by the IEA and the member countries, reporting different projections to the IEA and the UN Climate Change Secretariat, or other reasons.

[27] IEA (2002). The IEA uses a model to make these projections. The model calculates the CO_2 emissions associated with the projected energy demand. The supply of, and demand for, Kyoto units are not part of the model.

[28] EIA (2003a), Table H-1, pp. 233-234. The two Annex B countries not reported are Liechtenstein and Monaco.

those 29 countries totaled 11 635 $MtCO_2e$ in the national inventories and 11 880 $MtCO_2e$ in the EIA estimates, a difference of just over 2%.

The EIA reference case projects energy-related CO_2 emissions individually for eight of the Annex B countries and for four regional groups covering the remaining Annex B countries.[29] The projection, presented in Table A-2, yields total energy-related emissions for Annex B countries in 2010 of 16 397 $MtCO_2$. The total greenhouse gas emissions of 20 496 $MtCO_2e$ in 2010 are estimated by multiplying the energy-related emissions by 1.25.[30] This projection is about 2% higher than the corresponding figures from the national communications and IEA projection.

The *International Energy Outlook: 2003* includes a comparison with the IEA "business as usual" emission projection.[31] Over the 2000-2010 decade both the EIA reference case and IEA "business as usual" projection feature world energy demand growth of 1.9% per year and demand growth of 1.1% per year in industrialised countries. The EIA reference case has relatively more demand growth in transition economy countries (2.4%/year vs. 1.8%/year) and less demand growth in developing countries (2.7%/year vs. 3.2%/year) than the IEA projection. The EIA reference case also has relatively more coal (1.7%/year vs. 1.4%/year) and less natural gas (2.5%/year vs. 3.0%/year) than the IEA projection.

Comparing the projected emissions for Annex B countries, excluding Australia and the United States, with the annualised assigned amount yields an estimate of the market potential for the CDM in 2010 of 622 $MtCO_2e$ in the reference case. The EIA also projects emissions for low and high economic growth cases. The energy-related CO_2 emissions for these cases are also shown in Table A-2. In the low economic growth case, the demand for Kyoto units is lower and the supply available from Annex B Parties is higher with the result that there is no market potential for the CDM given the assumption that surplus AAUs are used before CERs. In the high economic growth case features more demand and less supply from Annex B Parties, resulting in a market potential for the CDM of 2 259 $MtCO_2e$ in 2010.

These estimates of the market potential assume that the emission projection for each group of Annex B Parties reflects the effects of its existing and future actions to reduce its greenhouse gas emissions and increase its eligible sinks. They also assume that surplus Kyoto units from Annex B Parties are used before CERs. The three cases illustrate the sensitivity of the market potential estimates to differences in aggregate emissions by Annex B Parties in 2010. As stated in the previous section, actions to limit sales of surplus AAUs or give preference to CERs would increase the market potential for the CDM.

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[29] EIA (2003b), Table A-10, p. 191. Like the IEA, the EIA uses a model to make these projections. The EIA model calculates the CO_2 emissions associated with the projected energy demand. The supply of, and demand for, Kyoto units are not part of the EIA model.

[30] This is the ratio of total greenhouse gas emissions to total energy-related CO_2 emissions for Annex B countries in 2000 as calculated from the national communications.

[31] EIA (2003b), pp. 18-22, Tables 4 and 7.

The estimated market potential of 180 $MtCO_2e$ derived from the national communications and of 214 $MtCO_2e$ based on the IEA projection are substantially lower than the estimate of 622 $MtCO_2e$ based on the EIA reference case, but they fall into the lower end of the range of 0 to 2 259 $MtCO_2e$ obtained from the low and high economic growth cases. The higher estimate of the market potential for CDM in the EIA reference case relative to the national communications and the IEA projection is due to the EIA's higher emissions projection.[32]

2.3 Model Analyses of the International Market for Kyoto Units

There is an extensive literature on analyses of the international market for Kyoto units. Most of the analyses use global models. Springer (2003) provides a useful survey of the models used and key results. Unfortunately, most of the results apply to analyses that assume ratification of the Kyoto Protocol by the United States and Australia.

Results from eleven studies that assume the United States does not ratify the Kyoto Protocol are summarised in Table A-3 (Appendix A).[33] The models used for these analyses differ in several ways, including their structure, the emissions covered (energy related CO_2 only to all greenhouse gases), the coverage of sinks (none to maximum allowable sinks), the potential scale of CDM activity (none to all reductions from business as usual emissions in developing countries), and transaction costs for project-based mechanisms (none to 30%). All of the models assume efficient domestic policies and no restrictions on domestic or international trade of Kyoto units except those explicitly modeled.

The projected greenhouse gas emissions of all Annex B countries in 2010, adjusted to cover all greenhouse gases, for the studies fall into a relatively narrow range of 19 610 to 21 620 $MtCO_2e$, which covers the estimates from Tables A-1 and A-2 as well. Larger differences are found in the projected demand for Kyoto units, the supply of Kyoto units by Russia and the Ukraine, and the potential demand for CERs.

Some of the analyses assume a "perfectly competitive" international market for Kyoto units where Russia and other transition economy Parties are willing to sell their surplus Kyoto units even if the market price is very low and buyers always purchase the lowest cost units. The cost of surplus AAUs to Annex B Parties is assumed to be zero, Surplus AAUs are assumed to have a zero cost, as a result there is no demand for CERs in most of these analyses.[34] These results are reviewed in section 2.3.1.

[32] The emissions projection for 2010 is 21 496 $MtCO_2e$, which is 442 $MtCO_2e$ higher than the 20 054 $MtCO_2e$ in Table A-1. If the emissions projection were the same as in the national communications, the demand would be 620 - 442 = 178 $MtCO_2e$, which is similar to the estimates of 180 and 212 $MtCO_2e$ from the national communications and the IEA projections.

[33] All of analyses reported assume that the United States does not ratify the Kyoto Protocol. Most of them assume all other Annex B countries, including Australia, ratify the Protocol. The exceptions are Holtsmark (2003), which assumes that Australia also does not ratify the Protocol, and Jakeman, et al. (2001), which assumes that Canada also does not ratify the Protocol. Canada ratified the Protocol in December 2002.

[34] The models assume that surplus AAUs have zero cost but that costs must be incurred to generate CERs. Thus surplus AAUs always have a lower cost than CERs and are assumed to be sold before any CERs are sold.

Other analyses assume strategic behaviour by Russia, and possibly other transition economy Parties. Since Russia's projected surplus is large relative to the anticipated demand for Kyoto units, it can increase the total revenue it receives by limiting the quantity it sells and thus raising the market price. Limiting sales of surplus Kyoto units by Annex B Parties increases the market for CERs. Results of these analyses are reviewed in section 2.3.2.

In addition to these highly stylized representations of the international market for Kyoto units, the models assume efficient domestic policies to limit emissions and enhance sinks in Annex B Parties as well as efficient domestic and international institutions for the CDM. These conditions are unlikely to be realised fully in practice so the results need to be interpreted with care. Despite these limitations, models are the only way to analyse the impact on the market potential of the CDM of different assumptions regarding the sale of surplus Russian AAUs.

2.3.1 Unrestricted Sales of Russian/Ukrainian AAUs

When the United States is excluded (Australia is usually part of a larger region and so is not excluded from the results) and there are no restrictions on the sales of Russian and Ukrainian AAUs, the models' projected demand for Kyoto units by Annex B Parties averages 1 220 $MtCO_2e$ (range 807 to 2 312 $MtCO_2e$).[35] Taking out the Australian demand of about 122 $MtCO_2e$ (see Table A-1), would reduce the average demand to about 1 098 $MtCO_2e$, 25% higher than the estimate of 869 $MtCO_2e$ from Table A-1. The lower projection in Table A-1 may reflect existing and planned emissions reduction and sink enhancement policies, the impacts of recent economic conditions, and other factors not embodied in the models.

The supply of Kyoto units from Annex B Parties other than Russia and the Ukraine averages 277 $MtCO_2e$ (range of 75 to 600 $MtCO_2e$). The estimate of 169 $MtCO_2e$ from Table A-1 is about 40% below the models' average, due mainly to higher projected emissions in 2010 associated with more rapid economic growth than is reflected in the models. The estimated supply of Kyoto units from Russia and the Ukraine averages 1 144 $MtCO_2e$ (range 500 to 1 562 $MtCO_2e$). The low end of the range matches the 520 $MtCO_2e$ for Russia and the Ukraine reported in Table A-1. The high end of the range is almost identical to the total for Russia and the Ukraine (1 556 $MtCO_2e$) under the Russian sensitivity scenario in Table A-1. Thus the ranges are consistent.

There is no potential market for CERs in most of the analyses. The Annex B Parties are able to meet their commitments through domestic actions to reduce emissions and enhance sinks together with purchases of surplus Kyoto units from other Annex B Parties, especially Russia and the Ukraine. Surplus AAUs are assumed to have zero cost and so are assumed to be sold before CERs generated by CDM projects.[36] The demand for Kyoto units is less than the

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[35] In most models Russia and the Ukraine are grouped with other Annex B countries of the former Soviet Union.

[36] The models assume that surplus AAUs have zero cost but that costs must be incurred to generate CERs. Thus surplus AAUs always have a lower cost than CERs and are assumed to be sold before any CERs are sold.

supply of surplus Kyoto units from Annex B Parties so there is no potential market for CERs. In contrast to the general pattern, two studies indicate a potential market for the CDM with Grütter (2000) suggesting that the demand could be as high as 500 $MtCO_2e$ in 2010.

Table A-4 shows that estimates of the market price for Kyoto units, after withdrawal of the United States and with no restrictions on the sale of Russian/Ukrainian AAUs, are relatively low. The average is about $2.35/$tCO_2e$ with a range of $0 to $13.50/$tCO_2e$.

In summary, with a perfectly competitive international market for Kyoto units the models show a higher demand for Kyoto units than suggested by the projections in Table A-1. The models also indicate significant uncertainty in the supply of Kyoto units available from Russia and the Ukraine due to uncertainty about economic growth and associated greenhouse gas emissions. The models yield a range for the supply of Kyoto units from Russia and the Ukraine almost identical to that presented in Table A-1. In most studies the supply of Kyoto units from Russia and the Ukraine exceeds the net demand by other Annex B Parties with the result that there is no market for the CDM. Under these assumptions the international market price for Kyoto units is low.

2.3.2 Restricted Sales of Russian/Ukrainian AAUs

Sales of surplus AAUs by Russia and the Ukraine might be restricted for any of several reasons. Russia and the Ukraine could decide to restrict sales to increase the market price for Kyoto units and so raise the total revenue from the sale of their AAUs, ERUs and RMUs. Russia and the Ukraine might not meet the eligibility conditions to participate in international emissions trading, and hence be restricted to sales of ERUs from JI projects implemented under the international review process.[37] Or Annex B buyers might decide to limit their purchases of surplus AAUs from Russia and the Ukraine.

Table A-4 shows that restricting the sale of Russian/Ukrainian AAUs after withdrawal of the United States increases the market price for Kyoto units from $2.35 to $11.40/$tCO_2e$ (range $1.00 to $33.00/$tCO_2e$). The results suggest that Russia and the Ukraine can maximise their revenue by selling about 40% of their surplus AAUs and banking the remaining 60%.[38]

Model results for the demand and supply of Kyoto units assuming restrictions on the sale of Russian/Ukrainian AAUs are shown in Table A-3. The demand by Annex B buyers falls by almost 15% to 1 047 $MtCO_2e$ (range 688 to 1 298 $MtCO_2e$) with restricted supplies because they implement more emission reduction and sink enhancement measures domestically due to the higher international market price for Kyoto units. Subtracting the Australian demand reduces the average to about 925 $MtCO_2e$, about 6% higher than the estimate of 869 $MtCO_2e$ in Table A-1.

[37] The eligibility requirements are specified in paragraph 2 of the Annex to Decision 18/CP.7. They include having a national system for estimating greenhouse gas emissions, having submitted the most recent required emissions inventory, and having a national registry.

[38] The Kyoto Protocol allows unused AAUs to be banked for use during future periods.

The sales by Annex B countries other than Russia and the Ukraine rise by about 10% to 300 $MtCO_2e$ (range 73 to 399 $MtCO_2e$) again due to the higher international market price for Kyoto units. Sales of surplus AAUs by Russia and the Ukraine drop by more than half to 539 $MtCO_2e$ (range 250 to 1 100 $MtCO_2e$). Despite selling fewer Kyoto units, the total revenue received by Russia and the Ukraine more than doubles from $2.7 billion to $6.1 billion per year due to the higher international price for Kyoto units.[39] Without the Australian demand, the sales by Russia, the Ukraine and other Annex B Parties are likely to differ a little from the above averages, but still fall within the specified ranges.

Restrictions on sales of Russian/Ukrainian AAUs increase the market potential for the CDM. All of the models that include developing countries show a potential market for CERs when sales of Russian/Ukrainian AAUs are restricted with the average quantity being 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$). The CDM would supply between 5% and 35% of total demand for Kyoto units if sales of Russian/Ukrainian AAUs are restricted. Eliminating the Australian demand would reduce the market for the CDM somewhat from 250 $MtCO_2e$, but the demand would still lie within the range defined by the different analyses.

Jotzo and Michaelowa (2002) undertake sensitivity analyses of the demand for CERs. Their basic assumption is that annual sales of surplus AAUs by Russia and the Ukraine are limited to 500 $MtCO_2e$, just under one-third of the total available. In that case CDM sales amount to 465 $MtCO_2e$ or a 45% market share.[40] Jotzo and Michaelowa conduct sensitivity analyses for the quantity of surplus AAUs sold, the Annex B economic growth, the stringency of project baselines, and CDM transaction costs. The resulting range of potential demand for CERs is 217 to 640 $MtCO_2e$ with a CDM market share between 17% and 64%. The demand for CERs is most sensitive to the quantity of surplus AAUs sold by Russia and the Ukraine.

The model results confirm the significant impact of restrictions on the sale of surplus Russian and Ukrainian AAUs on the potential market for the CDM. Indeed, the model results suggest that such a restriction is critical to the establishment of a market for the CDM. The restriction could be due to a desire by the sellers to maximise their revenue, actions by the buyers, or the eligibility of the sellers to participate in international emissions trading. With such a restriction, the market for the CDM is likely to be between 50 and 500 $MtCO_2e$ per year in 2010.

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[39] The studies rarely report total revenue, but the order of magnitude can be estimated using the average sales and the average price. With no restrictions on sales, annual sales of Kyoto units by Russia and the Ukraine would average 1 144 $MtCO_2e$ at an average price of $2.35/t CO_2e yielding total revenue of roughly $2.7 billion. With restricted sales, the volume drops to 539 $MtCO_2e$ but the average price rises to $11.40/t CO_2e yielding total revenue of more than $6.1 billion per year.

[40] Jotzo and Michaelowa (2002) report the market share (Tables 2 and 9) as 32%. They calculate the market share as a percentage of the total action implemented by Annex B Parties (1 169 $MtCO_2e$), which includes domestic reductions by Annex B buyers of 337 $MtCO_2e$. Here the domestic actions are removed from the total to get the CDM market share of the total Kyoto units traded of 372/(1 169-337) = 372/832 = 44.7%. This same adjustment accounts for the differences between the CDM market shares reported here as compared with those reported by Jotzo and Michaelowa. The quantities in the text are the Jotzo and Michaelowa figures multiplied by 1.25 to convert the energy-related CO_2 emissions to emissions of all greenhouse gases.

2.4 Model Runs for this Study

The Carbon Emission Reduction Trade (CERT) model, version 1.2 without the United States, was used to confirm the above assessment of the market potential for the CDM. The model covers only energy-related CO_2 emissions. Australia was removed from the "Other OECD" region in the model to reflect its non-ratification. The emission projections for 2010 are the 2001 reference scenario of the Energy Information Administration (EIA) of the United States Department of Energy.[41] Excluding the United States and Australia, the 2010 energy-related CO_2 emissions for Annex B Parties are 8 661 $MtCO_2e$. This corresponds to total greenhouse gas emissions of approximately 10 827 $MtCO_2e$, which is about 5% lower than the estimate of 11 359 $MtCO_2e$ in Table A-1.[42]

The model allows a choice of cost curves for reducing CO_2 emissions in each region. Runs were performed using:

- the marginal abatement cost curves from the Emissions Prediction and Policy Assessment (EPPA) model developed at the Massachusetts Institute of Technology (MIT); and

- the marginal abatement cost curves from the Global Trade and Environment Model (GTEM) developed by the Australian Bureau of Agricultural and Resource Economics (ABARE).

Sink enhancement actions allowed by the Marrakech Accords are available in each Annex B region at zero cost.

The analyses assume that sales of surplus Kyoto units ("hot air") are restricted to maximise the profits of the Annex B countries of the former Soviet Union.[43] With no restriction on the sale of Kyoto units by the Annex B countries of the former Soviet Union, the market price is zero and there is no market for CERs under either set of cost curves.

The model requires an assumption about the fraction of emission reduction potential in non-Annex B countries that generates CERs. Only part of the emission reduction potential can be realised through the CDM because CERs must be generated by emission reduction projects and must bear the associated transaction costs.[44] CDM activity is assumed to range from a

[41] EIA (2003a), Table H-1, pp. 233-234.

[42] For Annex B countries as a group, total greenhouse gas emissions are approximately 1.25 times the energy-related CO_2 emissions.

[43] In the model eastern European countries also have "hot air" and a restriction on the sale of "hot air" applies equally to the eastern European and former Soviet Union countries. A restriction on the sale of "hot air" does not constrain the sale of ERUs generated by emission reductions in these regions. Profits are calculated as the revenue from the sale of ERUs and AAUs less the cost of the emission reductions that generate the ERUs.

[44] Some emission reductions can be realised more easily through regulations or other policies than through emission reduction projects; reducing emissions by improving the fuel efficiency of new vehicles for example.

minimum of 5% to a maximum of 100% of the emission reduction potential at each market price.[45]

The results of the analyses are summarised in Table 1. A larger potential for the CDM reduces the market power of the countries with surplus Kyoto units and causes them to sell a larger share of their “hot air”. The result is a lower market price and larger total market for Kyoto units. Conversely, a limited potential for the CDM leads to more of the “hot air” being banked, a higher market price, reduced sales and more domestic emission reductions by Annex B countries.[46]

Table 1
Results of Model Runs Undertaken for this Study

	EPPA Cost Curves		**GTEM Cost Curves**	
	Min. CDM[a]	**Max. CDM[a]**	**Min. CDM[a]**	**Max. CDM[a]**
Market price (2000US$/t$CO_2$e)	$6.62	$0.82	$13.57	$1.96
Share of “hot air” sold (%)[b]	12%	35%	0%	28%
CERs sold in 2010 (MtCO_2e)	101	421	106	435
ERUs sold in 2010 (MtCO_2e)	459	154	826	290
AAUs sold in 2010 (MtCO_2e)	139	411	0	327
Total market in 2010 (MtCO_2e)	700	986	932	1 051

Notes: a: The minimum CDM cases assume 5% of the emission reduction potential of non-Annex B countries at each price is achieved through CDM projects while the maximum CDM cases assume 100% of the emission reduction potential of non-Annex B countries at each price is achieved through CDM projects.
b: This is the share of the “hot air” of the eastern European and former Soviet Union countries that maximises the profits of the former Soviet Union countries.

The total demand for Kyoto units ranges from 700 to 986 MtCO_2e with the EPPA cost curves and from 932 to 1 051 MtCO_2e with the GTEM cost curves.[47] These estimates are comparable to those presented in Tables A-1 and A-3. But the CERT estimates are for energy-related CO_2 emissions only while those presented in Tables A-1 and A-3 apply to all greenhouse gases. So the CERT estimates correspond to a larger total market.

[45] Several of the model analyses summarised in the previous section assume that the CDM is limited to 15% of the emission reduction potential.

[46] The domestic emission reductions by Annex B countries are not shown in the table. The higher market price makes more domestic emission reductions economically attractive.

[47] These results are for energy-related CO_2 emissions only. Multiplying them by 1.25 to get the corresponding figures for all greenhouse gases is tempting, but would not be correct.

The share of the "hot air" of the eastern European and former Soviet Union countries that maximises the profits of the former Soviet Union countries is between 12% and 35% for the EPPA cost curves and between 0% and 28% for the GTEM cost curves. For the studies summarised in Table A-4, the share ranges between 10% and 75% with an average of 41%. Except for the GTEM minimum CDM case, the CERT results fall in the lower half of this range.

The market price in 2010 is between \$0.82 and \$6.62/tCO_2e using the EPPA cost curves and between \$1.96 and \$13.57/tCO_2e using the GTEM cost curves. These results are consistent with the range of \$1.00 to \$33.00/tCO_2e for the studies reported in Table A-4, although they fall into the lower half of the range and are generally lower than the average of \$11.40/tCO_2e.[48]

The estimates of the potential market for CERs in 2010 are very similar using the EPPA and the GTEM cost curves -- from 100 to 435 MtCO_2e. The minimum is somewhat higher than the low end of the range (50 MtCO_2e) reported in Table A-3 bearing in mind that the CERT estimate applies to energy-related CO_2 emissions only. The maximum is very similar to the high end of the range (500 MtCO_2e) reported in Table A-3 taking into account that the CERT estimate applies to energy-related CO_2 emissions only.

In summary, the CERT results are generally consistent with those from other models as presented in the previous section. This is not surprising since many of the models use the same source data and have similar structures. As well, results from the CERT model (Grütter) and GTEM (Jakeman, et al.) are already included in Table A-3.

2.5 Observed and Projected Prices for Kyoto Units

Trades of Kyoto units are already being contracted.[49] Prices for projects selected through the ERUPT, CERUPT and Swedish CDM tenders and prices negotiated by the PCF have been in the range of US\$3 to US\$6/tCO_2e.[50] As of December 2003 Evolution Markets reports that CERs continue to be offered at prices in the US\$3.50 to \$8.00 range, ERUs are offered at prices ranging from €4.90 to 6.80, and "green" AAUs are available at prices between € 3.00 and 8.00.[51] A market survey by Lecocq and Capoor (2003) reports prices of US\$3.00 to

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[48] The price reported for the GTEM model in Table A-4 (Jakeman, et al.) is \$12.50/tCO_2. This is within the range of \$1.96 to \$13.57 obtained when the GTEM cost curves are used in the CERT model.

[49] Since no Kyoto units have yet been issued, the seller contracts to deliver the specified units to the buyer at an agreed future date.

[50] Point Carbon (2003a), p.1 and Mathias (2003), p. 8.

[51] Evolution Markets, (2003), p. 1. Green AAUs are AAUs linked to emission reduction or sink enhancement actions. For example, revenue from the sale of the AAUs could be put into a fund that finances emission reduction and/or sink enhancement actions. Unlike a JI project, specific AAUs would not be associated with a specific emission reduction or sink enhancement action.

$4.25/$tCO_2e$ when the buyer takes the registration risk and US$3.00 to $6.50/$tCO_2e$ when the seller takes the registration risk.[52]

Prices for 2005-2007 EU allowances ranged between €9 and €13/tCO_2 over the last few months of 2003.[53] Under the draft Linking Directive (European Commission, 2003a) CERs and ERUs can not be used for compliance during that period, so these allowance prices are not related to prices for Kyoto units.[54] Prices for UK allowances have ranged between £2.20 and £2.50/tCO_2e during the last few months of 2003. Since Kyoto units can not be used for compliance in the UK program, these prices also are not related to prices for CERs.

Current prices for risk-free Kyoto units suggest an average market price of approximately US$5.50 ± 50%/$tCO_2e$.[55] Using a discount rate of 10% per year, a price of $5.50/$tCO_2e$ in 2003 is equivalent to almost US$11/$tCO_2e$ in 2010. This is close to the average of $11.40 estimated by models (Table A-4) under the assumption that sales of Kyoto units by Russia and the Ukraine are restricted. A poll taken at the annual meeting of the International Emissions Trading Association in October 2003 indicated an average price of US$14.30/$tCO_2e$ at the end of 2010. Point Carbon estimated the carbon price in 2010 at US$9.90/$tCO_2e$ (25th percentile $5.00 and 75th percentile $13.70 /$tCO_2e$) in September 2003.[56] All of this information suggests an average market price for risk-free Kyoto units rising from US$5.50/$tCO_2e$ in 2003 to $11/$tCO_2e$ in 2010 with uncertainty range of ± 50%.

The price of Kyoto units will fluctuate and price differences among units are likely. CERs from reforestation projects, for example, might be discounted relative to the prices of CERs from other projects.[57] Similarly, it is likely that the price of CERs purchased from project developers will remain below the price of AAUs due to differences in delivery risks. The AAUs from a country that may not meet its commitment may command a lower price than those from a country expected to meet its commitment. And governments are likely to look for characteristics other than the lowest price (Natsource, 2003). Since governments are expected to be substantial buyers, their preferences may lead to price differences in the market, especially in the short-term. Private sector buyers have not yet been very active in the

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[52] Lecocq and Capoor (2003), Figure 7, p. 19.

[53] Allowances have not yet been allocated to participants. These are prices for test trades involving relatively small quantities of allowances to be delivered at an agreed future date.

[54] An amendment being proposed by the Committee on the Environment, Public Health and Consumer Policy of the European Parliament would allow CERs to be exchanged for EU allowances beginning in 2005 (European Parliament, 2004). If that amendment is adopted, the prices of CERs and EU allowances would be linked.

[55] As discussed below, a range of prices for Kyoto units with different characteristics is more likely than a single market price.

[56] IETA (2003), p. 3.

[57] The CERs for afforestation and reforestation projects -- tCERs and lCERs -- have only a limited life, so they are likely to command a lower price than other CERs.

CDM market so it is difficult to assess how selective they might be in their purchases of Kyoto units.

2.6 Summary of the Review of the International Market for Kyoto Units

The CERs generated by CDM projects will compete with other Kyoto units in the international market. Thus, an understanding of the international market for Kyoto units is crucial to an assessment of the potential for CDM. The review assumes that the Kyoto Protocol is ratified by all Annex B countries, except Australia and the United States, and hence that it enters into force. If the Kyoto Protocol does not enter into force a market for CERs from CDM projects might still exist, but the market potential and price would differ from the estimates presented here.[58]

Several projections of the market demand for Kyoto units in 2010 were reviewed. Market demand for Kyoto units based on projections for individual Annex B Parties is 869 $MtCO_2e$ in 2010. Model results suggest a market demand for Kyoto units in 2010 of about 925 $MtCO_2e$ (range about 600 to 1 150 $MtCO_2e$) excluding Australia and the United States.[59]

Russia and the Ukraine are projected to have a large surplus of Kyoto units. Almost all projections indicate that the potential supply of Kyoto units from Russia and the Ukraine exceeds the projected demand. If the potential supply from these countries is fully available to the international market, the price of Kyoto units is likely to be low and the market demand for CERs is likely to be very small.

The market potential for CDM then depends critically on restriction of the sale of surplus Kyoto units by Russia and the Ukraine. Sales of their surplus Kyoto units might be restricted for any of several reasons. Russia and the Ukraine could decide to restrict sales to increase the revenue from the sale of their Kyoto units. Russia and the Ukraine might not meet the eligibility conditions to participate in international emissions trading, and hence be restricted to the sale of ERUs from JI projects implemented under the international review process. Or Annex B buyers might decide to purchase CERs and ERUs rather than surplus AAUs from Russia and the Ukraine.

Model results suggest that Russia and the Ukraine can raise their profits from the sale of Kyoto units by restricting sales to about 40% (range 10% to 75%) of their surplus units. That would raise the market price for Kyoto units to about \$11.40/tCO_2e in 2010 (range \$1.00 to \$33.00/tCO_2e). Under these assumptions the models estimate a market potential for CERs of 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$) and the CDM would represent 5% to 35% of the international trade in Kyoto units.

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[58] For example, if those countries that have ratified implement the treaty, CER demand could rise – as Russian allowances would no longer be available. Conversely, Kyoto obligations may be unmet, and countries may reduce CER purchases. Finally, new negotiations may ensue that could reinvigorate a market for offsets under some future agreement.

[59] The average (1 047) range (688 to 1 298) from Table A-3 have been adjusted to exclude Australia.

Most models assume that Australia ratifies the Kyoto Protocol and is a net buyer of Kyoto units. While it is easy to adjust the total demand for the Australian withdrawal, the impact on the market price, revenue-maximising sales of Kyoto units by Russia and the Ukraine, and the demand for CERs can not be calculated without restructuring the models.[60] However, it is likely that the market price for Kyoto units and the demand for CERs would be lower, but still within the ranges reported, due to the Australian withdrawal.

The model results must be used with care. The models are highly stylized representations of the international market for Kyoto units. They assume efficient domestic policies to limit emissions and enhance sinks in Annex B Parties as well as efficient domestic and international institutions for the CDM. These conditions are unlikely to be realised fully in practice.

Is a CDM market of 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$) per year during the commitment period realistic? This question will be addressed in chapter 5. First the study reviews issues that affect the potential supply of, and demand for, CERs based on early experience with CDM projects (chapters 3 and 4). That information will permit a better assessment of the market potential for the CDM in chapter 5.

[60] Based on the projections in the national communications, Australia would represent about 12% of the total demand for Kyoto units in the absence of the United States.

3. Issues that Affect the Potential Supply of CERs

This chapter reviews a number of issues that affect the potential supply of CERs during the 2008-2012 commitment period under the Kyoto Protocol. It begins with a review of estimates of the potential scale of CDM activity and the most likely types of CDM projects in 2010. Transaction costs for CDM projects are considered next because they affect the minimum economic project size and so can reduce the potential supply of CERs. Then the lead times for projects are reviewed because they affect the number of projects that can be implemented prior to 2012. The impact of CDM projects initiated prior to 2008 on the supply of CERs available during the commitment period is then assessed. The regional distribution of CDM activity is considered. Finally, the investment required by CDM projects is assessed.

Several sections of this chapter present data on the characteristics of potential CDM projects. The data relate to the following groups of potential CDM projects:

- 54 AIJ projects for which information was available in October 2003. This covers all AIJ projects except projects in Annex B countries and forest protection projects in non-Annex B countries;
- 22 projects by the World Bank Prototype Carbon Fund in non-Annex B countries for which emission reduction purchase contracts have been signed or that were under preparation as of September 2003;
- 18 projects selected by the Netherlands government through the CERUPT tender;
- 15 potential CDM projects that had been submitted to the Executive Board as of October 2003;[61] and
- 50 electricity generating projects in non-Annex B countries identified by Ellis (2003) not included in the other sets of potential CDM projects.[62]

Relevant data may not be available for all of the projects in a group. When results are reported for a given group of projects, the number of projects for which the relevant data were available is also reported. Thus, a reference to, for example, 48 AIJ projects means that the relevant data were available for 48 of the 54 AIJ projects.

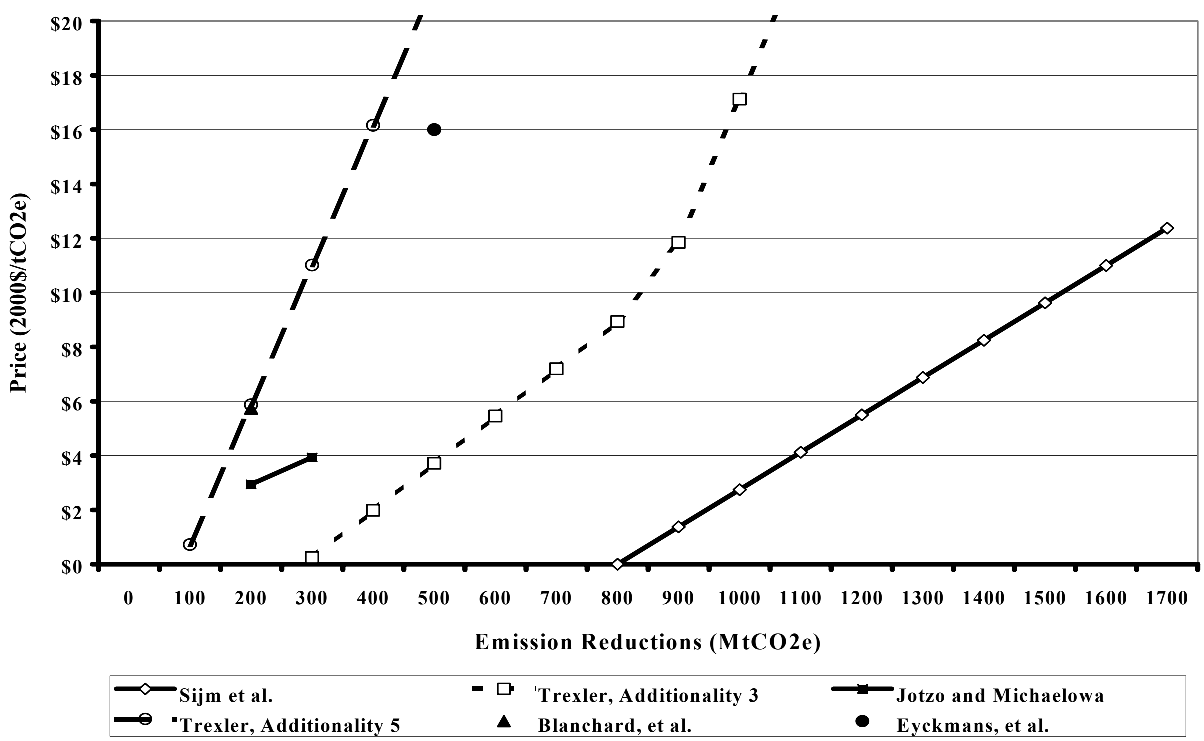
[61] Three of the CERUPT projects had been submitted as well. Those projects are included with the other CERUPT projects and not included with the projects submitted to the Executive Board.

[62] Ellis (2003), Annex I, pp. 36-38. The PCF projects, CERUPT projects, projects submitted to the Executive Board and projects in Annex B countries have been excluded from the list.

3.1 Estimates of Potential CDM Supply in 2010

A few estimates of the potential CDM supply in 2010 are available. Some of the estimates of potential supply also provide information on the mix of project types and/or the geographic distribution of projects that are useful for an understanding of the market potential of the CDM. The estimates of potential CDM supply in 2010 at different prices are shown in Figure 1.

Figure 1
Estimates of Potential CDM Supply in 2010



Sijm, et al. (2000) estimate that potential "no regret" emission reductions of 800 $MtCO_2e$ per year would be available in developing countries during 2008-2012 and that approximately 1 700 $MtCO_2e$ of emission reductions would be available at a marginal cost below 1990\$10/tCO_2e. The latter estimate becomes roughly 1 675 $MtCO_2e$ at \$12/tCO_2e in 2000 dollars as shown in Figure 1. This estimate includes all emission reductions judged to be technically and economically feasible. This estimate is much higher than the others.

Trexler and Associates (TAA) has developed supply curves by project type and region drawing mainly on data from the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (TAR), which reports a wide range of technical potentials for annual reductions in 2010. Data for sectors not covered in the TAR -- particularly oil and gas industry methane reductions and forestry options -- are based on technical potential studies by a variety of authors. See the note to Table A-7 for a description of Trexler and Associates' GHG Supply Tool© and the uncertainties inherent in the estimates.

The technical potential estimates are discounted to reflect the achievable potential based on IPCC qualitative assessments and TAA's analysis of project-based reductions. The achievable potential is partitioned into five levels of additionality stringency. These additionality assessments do not correspond to specific baseline policies or additionality criteria; rather they are qualitative assessments of the degree to which the emissions reductions are likely to be judged to arise from activities that go beyond "business as usual." A rank of 1 implies "poor" additionality, meaning that the reduction in question probably would have happened anyway. A rank of 5 implies "unquestioned" additionality, meaning that the reduction would likely receive credit under almost any screening standard. Transaction costs further reduce the potential supply for a given price and additionality ranking.

For Additionality 3, the mid-level stringency, the potential supply of CERs in 2010 rises from 254 MtCO_2e at US\$0/tCO_2 (the "no-regret" potential) to 1 054 MtCO_2e at US\$20/tCO_2e.[63] The TAA estimates for Additionality 3 at \$10 and \$20/tCO_2e have been adjusted to exclude soil sequestration and to cap forest sequestration at 1% of the base year emissions for Annex B Parties excluding Australia and the United States (117.2 MtCO_2e).[64] While well below the Sijm, et al. estimates, the Additionality 3 estimates are still substantially larger than those from other sources.[65]

Under TAA's most stringent additionality standard, Additionality 5, the achievable potential supply of CERs in 2010 rises from 83 MtCO_2e at US\$0/tCO_2e (the "no-regret" potential) to 448 MtCO_2e at US\$20/tCO_2e. This is the most conservative of the estimates of the CDM potential. The estimates by Blanchard, Criqui and Kitous (2002) and Eyckmans, Van Regemorter and van Steenberghe (2001) are respectively about 15% and 25% higher than the TAA Additionality 5 estimates.

Jotzo and Michaelowa (2002) calibrate the CDM supply to 10% of the economy-wide abatement potential projected under the MIT EPPA model parameters for each country or region and add 25% of current emissions from flared gas (at US\$3/tCO_2e). Their estimate of the potential supply in 2010 rises from 206 MtCO_2e at US\$3/tCO_2e to 307 MtCO_2e at US\$4/tCO_2e. At the lower price their estimate is about one-third higher than the corresponding TAA Additionality 5 figure.

[63] The potential projects include some that yield net revenue or cost savings even after incurring the transaction costs associated with CDM projects; for example, some projects for landfill gas recovery to generate electricity, leakage reduction in natural gas pipelines, and energy efficiency improvement. Thus there is some potential supply even if the market price is zero. The CDM additionality requirement would eliminate many, but probably not all, such projects.

[64] These adjustments are not necessary for Additionality 5 because the potential for soil sequestration is zero and the potential for forest sequestration is less than the cap.

[65] A fairer comparison is the TAA estimate for Additionality 1 (no additionality restrictions) of 1 649 MtCO_2e at a price of \$20/tCO_2e with the Sijm, et al. estimate of 1 675 MtCO2e at \$12/tCO_2e.

At a price of \$11.00/tCO_2e ± 50% in 2010, the most conservative estimate of the potential supply, TAA's Additionality 5 stringency, indicates potential annual emission reductions in 2010 of 335 MtCO_2e (range 215 to 405 MtCO_2e based on the price range of \$5.50/tCO_2e to \$16.50/tCO_2e). A comparison of the Sijm, et al. and TAA Additionality 5 estimates suggests that only a small fraction of the achievable potential at a given price may meet the additionality requirements for the CDM.

3.2 Estimates of CDM Potential by Project Type

Estimates of the distribution of CDM potential in 2010 by project type are available from Trexler and Associates and Sijm, et al. These estimates can be compared with the distribution of project types for groups of existing and identified projects.

Trexler and Associates' estimates of the CDM potential by project type in 2010 are shown in Table A-5. Table A-5 shows the distribution of potential for the lowest estimate (Additionality 5, \$0/tCO_2e) and for the highest estimate (Additionality 3, \$20/tCO_2e). Under the low estimate of CDM potential three categories of projects account for over 80% of the total potential -- (i) building and appliance energy efficiency in the residential, commercial and institutional sectors; (ii) methane reductions in the oil and gas industry; and (iii) energy efficiency in industry.

Under the high estimate of CDM potential many more project types become attractive. The five project types with the largest potential together comprise just under 60% of the total -- (i) building and appliance energy efficiency in the residential, commercial and institutional sectors; (ii) afforestation and reforestation; (iii) energy efficiency in industry; (iv) landfill gas capture and utilisation; and (v) methane reductions in the oil and gas industry.

Sijm, et al. (2000) report that energy efficiency measures in the power sector and demand-side energy efficiency measures together represent 66% of the total CDM emission reduction potential.[66] Most of the balance comes from renewable energy (14%) and fuel switching from coal or oil to natural gas (17%).

The distributions of emission reductions by project type for different estimates of the potential CDM supply and for various groups of existing and identified projects are compared in Table 2. The distributions for the groups of existing and identified projects can be significantly affected by one or two large projects. The distributions for the groups of existing and identified projects sometimes are based on a common time period (annual or contracted emission reductions) and sometimes are based on different time periods (project lifetimes or crediting periods that vary by project). And the classifications are not consistent across the different sources. Thus, the variation in distributions should not be surprising.

[66] Sijm, et al. (2000), p. 27.

Table 2
Estimated Distribution by Project Type
(percentage of emission reductions)

	CDM Potential		**Existing and Identified Projects**					
	TAA[a]	**Sijm, et al.**	**AIJ**	**PCF**	**CERUPT**	**CDM**	**Ellis**[b]	**Point Carbon**[h]
Energy efficiency (commercial and residential)	20%	66%	18%					
Energy efficiency (industrial)	11%			11%	5%	4%		
Landfill gas recovery[c]	13%		66%	15%	10%	23%	4%	21%
Fugitive methane (oil and gas)	11%					16%		
Coal bed methane	12%			28%				
Destruction of other GHGs								11%
Renewable electricity	4%	14%	11%	41%	85%	10%	96%	36%
Biomass including bagasse				*20%*	*10%*	*7%*	*23%*	
Hydro				*17%*	*29%*	*3%*	*32%*	
Wind				*4%*	*13%*		*25%*	
Geothermal, solar					*33%*		*16%*	
Fuel switching	2%	17%				45%		30%
Afforestation and reforestation	15%		6%	2%		2%		
Other projects	13%	3%		4%				1%
Emission reductions ($MtCO_2e$)			234.5[d]	102.5[d]	16.6[e]	45.8[f]	8.9[g]	
Number of projects			54	22	18	15	45	45

Notes: a Based on Additionality 5, $10.
b Electricity generation projects only.
c Some landfill gas projects involve only recovery and flaring while others involve use of recovered methane to generate electricity and so could be classified as renewable electricity projects.
d Lifetime emission reductions.
e Contracted emission reductions.
f Emission reductions over the crediting periods of the projects.
g Annual emission reductions.
h Reported by Point Carbon (2003b).

Renewable electricity generation and fugitive methane recovery, including landfill gas, projects appear to be well represented compared to their estimated potential. Energy efficiency projects, on the other hand, appear to be under represented relative to their estimated potential.

Methane recovery projects are attractive because methane has a global warming potential (GWP) value of 21, so that each tonne of emissions reduced yields 21 CERs.[67] In addition, the methane can often be used to displace other energy sources and so earn additional CERs. The PCF observes that the sale of CERs increases the internal rate of return for landfill gas to energy projects by more than five percentage points at current prices.[68] The internal rate of return for renewable energy projects, on the other hand, increases by one to three percentage points depending on the type of fuel displaced.

Residential and commercial energy efficiency programs need a large number of participants to achieve substantial emission reductions. This means such projects have unique institutional requirements and, possibly, higher administrative costs than other CDM projects. As well, additionality may be considered to be difficult to demonstrate for energy efficiency projects given that some installations of most energy efficiency measures are likely to be cost-effective due to the energy savings. In addition, the literature identifies numerous reasons why implementation of cost-effective energy efficiency measures is often less than the estimated potential.[69] Such considerations help explain why there are fewer energy efficiency projects than suggested by the estimates of potential CDM supply.

The current distribution of projects may not be representative of the mature CDM market. A diversity of project types provides a hedge against the regulatory risk for early participants. The PCF, for example, had a mandate to explore as many technologies as possible. Later participants may concentrate on proven project types to generate CERs at minimum risk. Such projects would rely on approved methodologies and technologies demonstrated to be cost-effective. Such a pattern is already evident in the concentration by Japanese firms on landfill gas to energy projects.

3.3 CDM-related Transaction Costs

A project must incur various costs to be registered as a CDM project and to receive CERs for the emission reductions or sink enhancements achieved. Those costs are CDM-related transaction costs. They include the cost of preparing a Project Design Document that conforms to the requirements established by the Executive Board and having this document reviewed by a Designated Operational Entity prior to registration of the project. The

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[67] The global warming potential (GWP) of a gas represents its impact on the climate over a specified time period relative to an equal mass (e.g., 1 tonne) of CO_2. The 100 year GWP for methane adopted for 2008-2012 is 21. This is sometimes called the "methane kick."

[68] The internal rate of return (IRR) is a measure of the economic viability of a project. Investors look for projects with an IRR greater than a specified threshold, such as 15%. Thus, if the revenue from the sale of CERs raised the IRR from 10% to 16%, it might make the project viable.

[69] There is an enormous literature that estimates potential cost savings, energy savings and emission reductions for various energy efficiency measures. In practice only a fraction of the cost-effective measures are implemented. The reasons for the low implementation rate are also the subject of a large literature. The under representation of energy efficiency CDM projects relative to the estimated potential for such projects simply reflects this broader pattern.

transaction costs also include monitoring the emission reductions or sink enhancements achieved and verification and certification of those achievements by a Designated Operational Entity prior to issuance of the CERs.[70]

To be attractive as a CDM project, the revenue expected from the sale of the CERs must exceed the costs of the emission reduction component of the project, including the transaction costs. Thus, the transaction costs affect the viability of potential projects -- the higher the transaction costs, the fewer projects are economically attractive --and so affect the potential supply. This section reviews estimates of the transaction costs for CDM projects and their implications for the supply of CDM projects. Only the CDM-related transaction costs -- costs incurred to register the project and to obtain CERs for the reductions achieved -- are considered.

3.3.1 Transaction Costs by Project Size

Michaelowa, et al. (2003) provides a thorough analysis of transaction costs for CDM projects. Their data on transaction costs are summarised in Table A-6.[71] They estimate the minimum fixed costs for a CDM project at €150 000. Due to this large fixed cost, the significance of transaction costs varies dramatically with project size as shown in Table A-6. With current and projected prices for CERs only projects classified by Michaelowa, et al. as “large” (20 000 to 200 000 tCO_2e/year) or “very large” (over 200 000 tCO_2e/year) are viable.[72]

According to Michaelowa, et al. wind power, energy efficiency in large industry, and solar thermal projects typically would fall into the “large” category while large hydro, gas power, large CHP, landfill methane capture, pipeline methane capture, cement plant efficiency, large scale afforestation and geothermal projects typically would fall into the “very large” category. Solar thermal and geothermal projects tend to have relatively high abatement costs so they may not be attractive despite low transaction costs.

Trexler and Associates estimates transaction costs ranging from a few cents to several dollars per tonne of emission reductions. Those costs are similar to the estimates by Michaelowa, et al. for “large” and “very large” projects. The project types identified by Trexler and Associates as having a large emission reduction potential -- energy efficiency, afforestation and reforestation, landfill gas capture and utilisation, and methane reductions in the oil and gas industry -- match those identified by Michaelowa, et al. as likely to have relatively low transaction costs quite well.

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[70] See Michaelowa, et al. (2003) for a discussion of the transaction costs associated with CDM projects. Components of the overall transaction cost identified by Michaelowa, et al., are listed in Table A-6.

[71] Bosi (2001), p. 10 and de Gouvello and Coto (2003) Appendix 4 also provide estimates of transaction costs for CDM projects. Those estimates are consistent with the estimates provided by Michaelowa, et al.

[72] The Netherlands established a minimum size of 100 000 tCO_2e over the term of the contract (usually 7 years) for CERUPT projects and 500,000 tCO_2e over the term of the contract for ERUPT projects to cover its transaction costs as a buyer.

Fichtner, et al. (2003) presents an analysis of the transaction costs for 64 AIJ projects that provided detailed information on both production and transaction costs. Transaction costs range from \$0.05 to \$261/tCO_2e and represent from 6% to 53% of the total project cost. The analysis finds that both production costs and transaction costs per tonne of CO_2 reduced are much lower for larger projects. AIJ projects with total costs likely to be viable as CDM projects were energy efficiency projects with total reductions greater than 20 000 tCO_2e per year and renewable energy projects with total reductions over 50 000 tCO_2e per year. Since the transaction costs for CDM projects are higher than for AIJ projects, the minimum viable size for CDM projects probably would be higher.

The Prototype Carbon Fund estimates the transaction costs at approximately \$250 000. Shell believes transaction costs should not exceed 25% of the price.[73] Fichtner, et al. finds that transaction costs for 59 AIJ projects represent 13% of the total cost for energy efficiency projects and 20% for renewable energy projects. Based on analysis of 51 Swedish AIJ projects Michaelowa, et al. finds that transaction costs average 20.5% for energy efficiency projects and 14.4% for renewable projects with some decline over time.

It is important to remember that these transaction costs reflect the early stages of the CDM market. The transaction costs are likely to be lower for projects that use baseline and monitoring methodologies already approved by the Executive Board. Thus as more methodologies are approved, the fixed component of the transaction costs should fall.

3.3.2 Transaction Costs for Small-Scale CDM Projects

The Executive Board has approved simplified baseline and monitoring methodologies for small-scale projects -- projects with a capacity of less than 15 MW, annual energy production of less than 15 GWh, or annual emissions and emission reductions of less than 15 000 tCO_2e. These simplified methodologies should reduce the transaction costs of registering a small project significantly. Small projects may also be "bundled" up to the maximum size for a small-scale project for validation, registration and verification, to further reduce transaction costs.

De Gouvello and Coto (2003) estimates that the simplified modalities and procedures for small-scale projects reduce the transaction costs to between \$8 000 and \$80 000, compared with estimated transaction costs of \$100 000 to \$1 100 000 for regular CDM projects.[74] Since a large component of the transaction cost is fixed, this is a major reduction. But it only reduces the transaction costs per tonne of CO_2 equivalent for small-scale projects to the same order of magnitude as those for regular CDM projects.[75] The PCF estimates the transaction

[73] Reported by Michaelowa, et al. (2003).

[74] De Gouvello and Coto (2003), p. 9.

[75] Assume that the annual emission reductions average 15 000 tCO_2e for small-scale projects and 150 000 tCO_2e for regular CDM projects (see section 3.4.2). Assume both have an average crediting period of 15 years (see

costs for small-scale projects at $105 000, a reduction from $250 000 for regular CDM projects.[76] Although, this is a substantial reduction in the fixed transaction costs, the transaction costs per tonne of CO_2 equivalent are substantially higher for a small-scale project than for a regular CDM project.[77] Nevertheless, these estimates suggest that small-scale projects may be economically viable at current market prices.[78]

The economic viability of small-scale CDM projects is confirmed by evidence of a potential supply of such projects. As of April 2003 the World Bank's Community Development Carbon Fund (CDCF), which will concentrate on small-scale projects, had received about 30 project ideas representing projects between 0.6 and 1.2 $MtCO_2e$ of total reductions.[79] Finland is expected to sign contracts to purchase about 500 000 tCO_2e of CERs from three or four small-scale projects at prices from €2.70 to €6.30/tCO_2e.[80] Those prices are comparable to the prices for CERs from larger CDM projects, suggesting that the simplified methodologies reduce the transaction costs enough to keep small-scale projects competitive in the market.

3.3.3 Sensitivity of Supply to Transaction Costs

Jotzo and Michaelowa (2002) find that the scale of CDM activity is relatively insensitive to changes to transaction costs and marginal abatement costs; the impact is smaller than that due to changes in the rate of Annex B emissions growth and the share of the "hot air" sold. Their base case has transaction costs of about 20% ($0.75 with a price of $3.78/$tCO_2e$) leading to annual CER sales of 372 $MtCO_2e$ and a market share of 45%.[81]

When the transaction costs double (to $1.50/$tCO_2e$) and the slopes of the marginal abatement cost curves double, the price rises to $5.08/$tCO_2e$ (transaction costs of 30%), CER sales fall almost 25% to 286 $MtCO_2e$, and the CDM market share declines to 38%. When the transaction costs are reduced to $0.50/$tCO_2e$ and the slopes of the marginal abatement cost curves are halved, the price falls to $2.70/$tCO_2e$ (transaction costs of 19%), CER sales rise almost 22% to 453 $MtCO_2e$, and the CDM market share rises to 50%.

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section 3.4.1). Then the transaction cost is 4 to 36¢/tCO_2e for small-scale projects and 4 to 49¢/tCO_2e for regular CDM projects.

[76] PCF (2003a).

[77] Using the same assumptions as in footnote 72, the transaction cost is 47¢/tCO_2e for small-scale projects and 11¢/tCO_2e for regular CDM projects.

[78] Using more conservative assumptions of a 10 000 tCO_2e per year emission reduction and a life of 10 yields total reductions of 100 000 tCO_2e for a small-scale CDM project. With transaction costs of $100 000, the transaction costs are $1/$tCO_2e$. At a market price of $5.50/$tCO_2e$, the transaction costs are 18% of the price.

[79] Point Carbon (2003b).

[80] Mathias (2003), p. 8.

[81] Annual sales of "hot air" are assumed to be 400 $MtCO_2e$ per year, just under one-third of the total available.

3.3.4 Summary

In summary, CDM-related transaction costs include a large fixed component prior to project implementation. This means that regular CDM projects will need to be large, at least 50 000 tCO_2e per year, to reduce the transaction costs to an affordable level, less than 25% of the market price.[82] Fortunately, the project types expected to meet these conditions are estimated to account for a large share of the total potential. Once a methodology is approved it can be used by many projects. This should lead to a reduction of the fixed component of the transaction costs over time.

The simplified methodologies adopted by the Executive Board for small-scale CDM projects appear to reduce the transaction costs for those projects enough to make such projects economically viable. Evidence as to whether the transaction cost per CER is higher or lower than for a regular CDM project is mixed. But indications of a supply of potential small-scale CDM projects suggest that the transaction costs for the simplified methodologies are sufficiently low to make some small projects economically viable at the current market price for Kyoto units.

3.4 Project Size and Lifetime

The previous section noted that transaction costs have a large fixed component. To be economically viable a project must spread the fixed transaction costs over a large emission reduction. Thus, the fixed transaction costs create a minimum size for an economically viable CDM project. That size can be expressed in terms of the total emission reduction over the life of the project, which is equal to the average annual emission reduction multiplied by the life of the project. This section reviews available data on project lifetime as well as average and minimum project size by project type.

3.4.1 Project Lifetime

Under the CDM rules an emission reduction project may choose a crediting period of up to ten years or of up to seven years renewable twice for a maximum of 21 years.[83] The project life may be shorter than the crediting period. If a project reaches the end of its life before the end of its crediting period, it ceases to generate emission reductions and no longer earns CERs.

Data on the expected lifetime are available for 27 of the 54 AIJ projects. The projects have forecast lifetimes ranging from 6 to 37 years with an average of 20 years. AIJ projects can

[82] Over five years a 50 000 tCO_2e/year project yields 250 000 CERs. At a price of $5.50 /$CO_2e$ it yields revenue of $1.375 million. Fixed transaction costs of $250 000 then represent 18% of the revenue.

[83] The crediting period is the maximum period during which a CDM project can earn CERs for the emission reductions achieved. Afforestation and reforestation projects can choose a crediting period of 30 years or of 20 years renewable twice for a maximum of 60 years.

not earn credits for the emission reductions achieved and so are not affected by the crediting period for CDM projects. However, AIJ projects that meet the eligibility requirements can register as CDM projects and earn CERs for emission reductions achieved after 1 January 2000. When a maximum crediting period of 21 years is imposed, the average for these 27 projects falls to 18 years.

The 15 projects submitted to the Executive Board as of October 2003 have forecast lifetimes ranging from 10 to 25 years with an average life of 22.3 years. The crediting period is either an initial period of 7 years or a total of 10 years. Assume the projects that choose a 7 year crediting period initially renew the crediting period to a maximum of 21 years as long as the renewed period is shorter than the project life. Then one project would have a crediting period of 7 years, six projects would have crediting periods of 10 years, and eight projects would have crediting periods of 21 years. The average crediting period for these 15 projects would be 15.7 years.

In short, the average crediting period based on this small sample is 15 to 18 years. There are currently not enough projects to determine whether there are meaningful differences in the project lifetimes for different project types.

3.4.2 Project Size for Regular CDM Projects

The average project size by project type for each group of potential CDM projects analysed is shown in Table 3. The data are a mix of estimated total reductions over the contract period, crediting period, or project lifetime and estimated annual reductions. All figures are thousands of metric tonnes of CO_2e. The data reveal substantial variations in project size for a given project type. There are currently not enough projects of each type to determine whether there are project types whose average size is significantly larger or smaller than the overall average.

The average emission reduction per project ranges between 130 000 and 180 000 tCO_2e per year for four of the groups analysed -- the AIJ, CERUPT, CDM and Ellis. The weighted average reduction for the projects in these four groups is 160 200 tCO_2e per year; the average annual reduction for PCF projects, at 310 000 tCO_2e per year, is almost twice as large.

The minimum project size for the CERUPT and CDM groups is 100 000 tCO_2e per year, while the minimum for the PCF is twice as high at 215 000 tCO_2e per year. The minimum project size for each of these groups of projects is well above the minimum project size of 20 000 tCO_2e per year for energy efficiency projects and 50 000 tCO_2e per year for renewable energy projects identified by Fichtner, et al. (2003). The minima also lie well within the range of 20 000 to 200 000 tCO_2/year for “large” projects as defined by Michaelowa, et al., which they find to be the smallest economically viable project size category.

In summary, the available data suggest a minimum size of about 100 000 tCO_2e for regular CDM projects and an average project size of about 150 000 tCO_2e for such projects. That corresponds to a minimum emission reduction of about 1.5 $MtCO_2e$ over the crediting period of a typical project. The available data do not reveal any systematic differences in the minimum or average project size by project type.

Table 3
Estimated Project Size by Project Type
(average emission reductions, 000 tCO_2e)

	Reduction over the Contract Period, Crediting Period or Project Lifetime				Annual Reduction Ellis[a]	
	AIJ	**PCF**	**CERUPT**	**CDM**	**Regular Projects**	**Small Scale**
Energy efficiency (commercial and residential)	2 443					
Energy efficiency (industrial)		11 000	409	531		
Landfill gas recovery[b]	25 713	5 112	824	10 731	133	32
Fugitive methane (oil and gas)				7 270		
Coal bed methane		29 000				
Destruction of other GHGs						
Renewable electricity	1 014					
Biomass including bagasse		6 697	553	751	101	27
Hydro		2 423	1 190	1 560	220	40
Wind		1 023	443		200	41
Geothermal, solar			2 766		403	0
Fuel switching				10 298		
Afforestation and reforestation	2 223	1 775		441		
Other projects		2 103				
Average for all projects	2 380	4 657	924	3 055		
Average annual reduction (000 tCO_2e/year)	159[c]	310[c]	32[d]	168[e]	180	34
Minimum size (000 tCO_2e/year)	13	215	100	104	0[f]	0[f]
Number of projects	54	22	18	15	23	22

Notes: a Electricity generation projects only. Projects with a capacity of less than 15 MW are classified as small-scale. The data needed to determine whether they qualify on the basis of output (<15 GWh) or emissions (emissions and emission reductions of <15 $ktCO_2e$/year) are not available.

b Some landfill gas projects involve only recovery and flaring while others involve use of recovered methane to generate electricity and so could be classified as renewable electricity projects.

c Estimated assuming an average project crediting period of 15 years.

d Estimated using the average purchase commitment of 7 years.

e Estimated using the calculated crediting period of 15.7 years.

f The minimum project size is less than 1 000 tCO_2e.

As noted in section 3.3.2, projects that meet the criteria for small-scale CDM projects may use simplified methodologies which reduces the transaction costs for those projects. To meet the eligibility requirements as small-scale CDM projects the annual emission reductions are likely to be less than 50 000 tCO_2e, well below the minimum size of about 100 000 tCO_2e for regular CDM projects.[84] The average reduction for small-scale projects in Table 3 is 34 000 tCO_2e per year.

3.5 Project Start Date and Economic Viability

Buyers currently have little interest in reductions achieved after 2012, so the project costs must be recovered from the sale of CERs for the reductions achieved prior to 2013. Figure 2 shows the present value of the revenue received through 2012 relative to the project cost by project start date. The project start date is defined as the first year that CERs are received. Results are shown for a marginal project (annual emission reduction of 50 000 tCO_2e) and an average project (annual emission reduction of 150 000 tCO_2e) using discount rates of 10% and 15%.

The project cost is the cost of the emission reduction component, which is estimated at $1.5 million and $4.0 million respectively for a marginal and an average project.[85] The project is assumed to contract the sale of half of the CERs generated at a fixed price of $4.00//$tCO_2e$ and to sell the other half at the market price, which rises from $4.00/$tCO_2e$ in 2000 to $13.00/$tCO_2e$ in 2012.[86] An average crediting period of 15 years is assumed.[87]

The figure shows that with a discount rate of 15% a marginal project would need to begin generating CERs in 2001 to recover the full project cost from the revenue generated through 2012.[88] A 10% discount rate delays this "breakeven" date to 2003. Larger projects have a later "breakeven" date because their transaction costs are proportionally lower. With a discount rate of 15% an average project would need to begin generating CERs in 2002 and

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[84] Bosi (2001), Figure 1.

[85] See section 3.8 for a discussion of the cost of CDM projects. The cost of a project is estimated at $25 per tonne of CO_2 emissions reduced annually plus $250 000 for transaction costs. This yields a total cost of $1.5 million for a marginal project with annual emission reductions of 50 000 tCO_2e ($25 * 50 000 + $250 000 = $1 500 000) and $4 million for an average project with an annual emission reduction of 150 000 tCO_2e.

[86] This is a price increase of 10% per year, which results in a price of $5.50 in 2003 and $10.75 in 2010.

[87] The crediting period assumption does not affect the revenue earned prior to 2013 as long as it is more than 12 years. However, the length of the crediting period does affect the total revenue earned and hence the share earned post 2012. The results are not very sensitive to a longer crediting period because the extra revenue occurs at the end of the period and so is heavily discounted.

[88] For an average project with a start date of 2003, the present value of the revenue is calculated by multiplying the annual emission reductions (150 000 tCO2e) for each year from 2003 through 2012 by the assumed price for that year. The present value of the revenue in 2003 is calculated and divided by the project cost of $4 million. A ratio greater than 1 indicates that the present value of the revenue through 2012 exceeds the emission reduction component of the project cost.

with a 10% discount rate the "breakeven" date is almost 2004. Under the more favourable assumption that all of the CERs are sold at the market price delays the "breakeven" date with a discount rate of 10% to 2006 for marginal projects and 2007 for average projects.

Figure 2
Project Start Date and Economic Viability

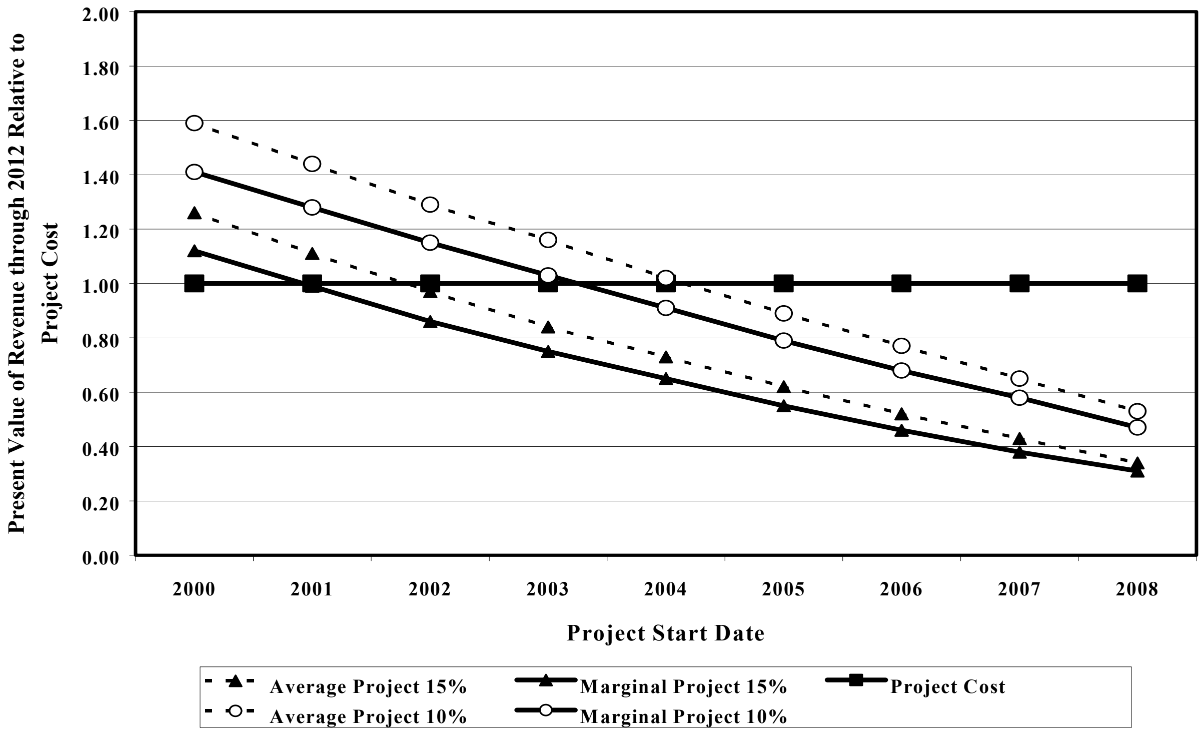

Figure 2 suggests that projects with a start date after 2004 will not be able to recover their costs from the revenue received for emission reductions achieved through 2012. The reason is simple. The project cost does not change, but each year that the start of a project is delayed reduces the revenue earned prior to 2012. Thus, the ability to recover the project cost from pre-2013 revenue is reduced. The total revenue does not change, only the portion earned prior to 2013.

Thus the limited market value of post-2012 emission reductions affects the economic viability of potential CDM projects. This means that commitments to give a market value to emission reductions beyond 2012 are needed soon to sustain CDM activity over the next few years. Ideally, those commitments would be internationally agreed national emission limitation commitments for some period after 2012. Other possibilities include options to purchase post 2012 CERs and commitments to continue domestic greenhouse gas emission trading programs that allow participants to use CERs beyond 2012.

3.6 Project Lead Times

Projects of the type and size of likely CDM projects can take several years to implement. Meeting the requirements for approval as a CDM project can increase this time. The lead time for a project is defined as the period from the time a potential project is identified until it becomes operational. The date at which a potential project is identified is rarely documented, thus accurate data on project lead times are not available. Some data are available on components of the lead time, such as construction time, but they understate the lead time.

3.6.1 Project Lead Times

The types of projects that are likely to be economically viable as CDM projects include: energy efficiency in large industrial plants, cement plant efficiency, landfill methane recovery, pipeline methane capture, destruction of greenhouse gases, electricity generation using biomass, hydroelectricity, wind, geothermal, fuel switching, large combined heat and power (cogeneration), and afforestation and reforestation projects.

Given the size needed to be economically viable as a CDM project, implementation of such projects typically would require 9 to 60 months. The International Energy Agency, for example, uses the following assumptions for average construction times for electricity generation projects: onshore wind 12 to 24 months, combined cycle gas turbines 24 to 36 months, offshore wind 36 months, biomass 36 months, geothermal 48 months, and large hydroelectric projects 60 months.[89] Other project types, such as landfill gas recovery projects, might require less time for construction. The time required for feasibility studies, financing, engineering design, host country approval, and registration by the Executive Board could add a year or two to these construction times. Thus, the time needed to transform an idea into an operational CDM project might well be four or five years.

Data on lead times for actual projects are very scarce. For 27 of the AIJ projects the time from the earliest date specified in the project description (usually project approval or a feasibility study) until the start of the project ranges from 2 to 54 months and averages 26 months. Data for three PCF projects yield an average lead time of 31 months. Since a CDM project needs host country approval and registration by the Executive Board, the lead time for CDM projects would be longer still. Thus, four or five years may be a reasonable estimate of the total time needed to turn an idea into an operational CDM project.

Since the approvals required to implement a project differ and the time needed to secure the required approvals differ by country, the lead time for a proposed project can vary significantly from country to country. As mentioned below, there could be hundreds of new CDM projects each year, which could cause delays in getting projects registered and so increase lead times.

[89] Based on IEA (2002) assumptions.

3.6.2 Implications for the Flow of Projects

Potential projects identified today that take four or five years to implement will not earn CERs until 2008 at the earliest. As discussed in the previous section, unless the market places a value on post-2012 reductions soon, projects that start after 2007 are likely to be economically unattractive given current CER price expectations. Under those circumstances, the CDM might be limited to projects already identified. Point Carbon (2003b) estimates that 450 to 500 ideas currently exist for CDM projects.

Assume that commitments that give a value to post-2012 reductions are implemented soon. Then the existing project ideas might be implemented through 2007 with the projects from new ideas beginning operation in 2008. The existing 500 project ideas would represent an average of 125 new projects implemented each year year. With an average project size of 150 000 tCO_2e per year, they would yield 75 $MtCO_2e$ of emission reductions per year during 2008-2012.

The assumption that all of the project ideas become CDM projects is very optimistic. The PCF (2003) reports that it had received a total of 420 project ideas as of September 2003, of which it has only taken 94 to the Project Concept Note stage, the next stage in the PCF project pipeline, and only 30 to PDD development. Since the PCF has limited funds and a mandate to pursue geographic and project type diversity, it does not proceed with all projects that may ultimately become CDM projects. Registration of 20% of the project ideas appears to be a reasonable estimate of the success ratio. Then 500 existing project ideas would generate 100 CDM projects (25 projects per year) with annual emission reductions of 15 $MtCO_2e$ during 2008-2012. The actual emission reductions might be smaller still since some projects are likely to fail to deliver all of their anticipated reductions.

To obtain, for illustrative purposes, average annual reductions from CDM projects of 250 $MtCO_2e$ during 2008-2012 -- the market potential for the CDM estimated in chapter 2 if sales of surplus AAUs are restrained -- would then require annual reductions of 175 to 235 $MtCO_2e$ from new projects that begin operation in 2008 or later.[90] With an average project size of 150 000 tCO_2e per year, that would require some 475 to 625 new projects per year between 2008 and 2012.[91] If all of the existing project ideas become CDM projects, the project flow would rise from 125 per year prior to 2008 to 475 per year during 2008-2012. If only 20% of the existing project ideas become projects, the project flow would increase from 25 per year prior to 2008 to 625 per year during 2008-2012. A larger average project size would, of course, reduce the number of projects needed to supply the market potential.

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[90] The 250 $MtCO_2e$ is used for illustrative purposes only. It is the average demand for CDM assuming sales of Kyoto units by Russia and the Ukraine are restricted as reported in Table A-3.

[91] To get an average annual reduction of 175 $MtCO_2e$, the total reduction for 2008-2012 must be 875 $MtCO_2e$. Each project will yield annual reductions for 2.5 years during the period for a project average of 2.5* 150 000 tCO_2e = 0.375 $MtCO_2e$. That implies a total of 875/0.375 = 2,333 projects over five years or about 475 new projects per year. An average annual reduction of 235 $MtCO_2e$ implies an average of 625 new projects per year by the same calculation.

The existing project ideas have the potential to generate a pre-2008 project flow that could lead to emission reductions of 15 to 75 $MtCO_2e$ per year during 2008-2012. A market potential of 30 to 150 $MtCO_2e$ in 2010 could be supplied by maintaining roughly the same flow of new projects. Maintaining a flow of new projects past 2007 requires that a value for post-2012 emission reductions be established soon. A larger market potential in 2010 would require more new projects each year. But due to the lead time, the flow of new projects is unlikely to increase significantly before 2008. And it will only happen if there is a market value for post-2012 reductions. A significant acceleration in the flow of new projects in 2008 could strain the capacity of the designated operational entities and the Executive Board to validate proposed projects.

3.7 The Effect of Pre-2008 Emission Reductions

The Kyoto Protocol stipulates that CDM projects can generate CERs for eligible emission reductions from 1 January 2000. Although no projects have yet been registered, some projects may still earn CERs for reductions achieved between 1 January 2000 and the date they are registered. Other projects will earn CERs for reductions they generate from the date of implementation.

The result will be an inventory of CERs that accumulates prior to 2008. Those CERs can be used to meet the 2008-2012 commitments of Annex B Parties. The estimates of the potential annual supply of CERs should be adjusted to reflect this pre-2008 inventory. The inventory will include new CDM projects and may include AIJ projects that qualify as and seek CDM project status.

There are 54 AIJ projects, excluding forest protection projects, in non-Annex B countries that could qualify as CDM projects. Data on annual emission reductions are available for only 17 of these AIJ projects. Those 17 projects account for about 57% of the lifetime emission reductions of the 54 AIJ projects. The total emission reduction forecast for the 17 projects during 2000-2007 is 53.4 $MtCO_2e$. Extrapolating that total to all 54 AIJ projects yields a total reduction of 100 $MtCO_2e$ for 2000-2007. On an annual basis the pre-2008 inventory of emission reductions by AIJ projects that may qualify as CDM projects is 20 $MtCO_2e$. In addition these projects would achieve a further 13 $MtCO_2e$ of emission reductions annually during 2008-2012. These are maximum figures since the AIJ projects might choose not to seek CDM status, might not qualify as CDM projects, or might be registered with a more stringent baseline.

To estimate the pre-2008 inventory due to new CDM projects, assume that the first new CDM projects begin to generate CERs during 2005 and that the scale of CDM activity increases linearly to the estimated annual potential for 2010. Then the CERs issued for 2005 reductions are one-sixth of the 2010 annual total because CDM activity ramps up linearly over the six years from 2005 through 2010. Since the 2005 projects are underway, those reductions occur during 2006 and 2007 as well. In addition, new projects with annual reductions equal to those during 2005 begin operation in 2006 and again in 2007. These assumptions produce a pre-2008 inventory equal to the estimated 2010 annual supply.[92]

These two categories of pre-2008 inventory can increase the supply of CERs available during the commitment period appreciably. If the annual CDM potential in 2010 is 75 $MtCO_2e$, the pre-2008 inventory would be 75 $MtCO_2e$ for new CDM projects plus up to 100 $MtCO_2e$ for AIJ projects for a total of 75 to 175 $MtCO_2e$; the equivalent of 15 to 35 $MtCO_2e$ per year for the five years of the commitment period. The pre-2008 inventory, then, would increase the quantity of CERs available to 90 to 110 $MtCO_2e$ per year from the 75 $MtCO_2e$ per year actually achieved during the commitment period, an increase of 20 to 45%.

Similarly, if the annual CDM potential in 2010 is 250 $MtCO_2e$, the pre-2008 inventory would include 250 $MtCO_2e$ from new CDM projects plus up to 100 $MtCO_2e$ for AIJ projects for a total of 250 to 350 $MtCO_2e$, which would raise the quantity of CERs available annually by 50 to70 $MtCO_2e$.[93] The pre-2008 inventory, then, would increase the quantity of CERs available to 300 to 320 $MtCO_2e$ per year from the 250 $MtCO_2e$ per year actually achieved during the commitment period, an increase of 20 to 30%.[94]

The foregoing calculations assume that the pre-2008 flow of new projects is maintained for 2008-2012. If the flow of new projects stops after 2007 due to uncertainty about the market value of post-2012 emission reductions, the supply of CERs available during 2008-2012 would be lower but the pre-2008 inventory would be a larger share of the total available.[95] On the other hand, if post-2012 reductions have a market value and the project flow accelerates after 2007 due to the lead times involved in implementing projects, the pre-2008 inventory could be a smaller share of the 2008-2012 reductions.

In summary, eligible AIJ projects and new CDM projects can earn CERs for emission reductions achieved prior to 2008. Those CERs can be used for compliance with the 2008-2012 emission limitation commitments of Annex B Parties. The effect is to increase the quantity of CERs available relative to the emission reductions achieved during 2008-2012 by approximately 25%.

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[92] The 2005 CERs are 1/6 of the 2010 annual total, the 2006 CERs are 2/6 of the 2010 annual total (half from new projects and half from 2005 projects), and the 2007 CERs are 3/6 of the 2010 annual total (one-third each from new projects, 2006 projects and 2005 projects) for a total of 6/6 = 1 of the 2010 annual total.

[93] The pre-2008 inventory would consist of 100 $MtCO_2e$ from AIJ projects plus 500 $MtCO_2e$ from new CDM projects beginning in 2005.

[94] Point Carbon (2003b) reports the emission reductions for 45 proposed CDM projects for 2002 through 2006. Extrapolating that project flow and the emission reductions through 2012 indicates that the pre-2008 reductions would increase the supply of CERs during the commitment period by about 24%.

[95] Assume that the annual potential in 2010 was 250 $MtCO_2e$ but that the flow of new projects ceases after 2007. The projects implemented yield reductions of 125 $MtCO_2e$ per year during 2008-2012 plus a total of 250 $MtCO_2e$ in pre-2008 reductions. The pre-2008 inventory, then, would increase the quantity of CERs available by 40% to 175 $MtCO_2e$ per year from the 125 $MtCO_2e$ per year actually achieved each year.

3.8 Estimates of CDM Potential by Region

Information on the regional distribution of the CDM potential in 2010 for the estimates reviewed in section 3.1 is summarised in Table A-7. The distributions for those estimates are compared with the distributions of projected emission reductions for groups of existing and identified projects in Table 4.

Table 4
Geographic Distribution of CDM Potential
(percentage of emission reductions)

	CDM Potential[a]				Existing and Identified Projects				
	Jakeman, et al.	**TAA[b]**	**Jotzo + Michaelowa**	**Sijm, et al.**	**AIJ**	**PCF**	**CERUPT**	**CDM**	**Ellis[c]**
Asia	62%	63 to 75%	72%	71 to 78%	4%	64%	52%	23%	37%
Latin America	12%	7 to 15%	6%	10 to 13%	64%	24%	48%	77%	38%
Africa	4%	5 to 14%	11%	5 to 8%	31%	11%			25%
Middle East	9%	9 to 13%	11%	4 to 11%	0%[d]				0%[d]
Projects					54	22	18	15	45

Notes: a From Table A-7.
b Based on Additionality 5, $0 to $20. The potential includes some project types that yield net revenue or cost savings even after incurring the transaction costs associated with CDM projects, for example, projects for landfill gas recovery to generate electricity, leakage reduction in natural gas pipelines, and energy efficiency improvement. Thus there is some potential supply even if the market price is zero. The CDM additionality requirement would eliminate many, but probably not all, such projects.
c Electricity generation projects only.
d The estimated reductions for projects in this region represent less than 0.5% of the total.

Asia dominates the estimated CDM potential. Under different assumptions, its share of the total potential ranges between 62% and 78%.[96] The large share reflects the large size of the region (including China, India, Indonesia, and Korea) and the relatively high consumption of coal and oil. In contrast, the estimated share of each of the other three regions -- Latin America, Africa and the Middle East -- ranges between 5% and 15%. Furthermore, Asia dominates the estimated low cost potential. As the price rises, Asia's share of the estimated total potential declines as more projects in other regions become economically viable.[97] The

[96] The geographic distribution is not sensitive to the inclusion of afforestation and reforestation projects. They are included in the Jakeman, et al, and the Trexler and Associates estimates of CDM potential but not in the Sijm, et al. and Jotzo and Michaelowa estimates.

[97] See the Trexler and Associates estimates in Table A-7.

same is true on a smaller scale for the Middle East. Conversely, the share of the estimated total potential in Latin America and Africa rises as the price increases.

The distributions of projected emission reductions for the groups of existing and identified projects vary widely. The PCF has a distribution most similar to the estimates of the CDM potential, but with a larger share of its reductions in Latin America and no reductions in the Middle East. The other groups of projects all have a relatively large share of their projected reductions in Latin America and almost no projects in the Middle East. The share of projects intended for Kyoto compliance (PCF, CERUPT and CDM) is lower relative to the estimated potential in the Middle East and Africa than in Asia and Latin America.[98]

Is Asia's large share of the projected global CDM potential realistic? There is no definitive answer to this question. Table 5 compares the geographic distributions of CDM potential with those of Official Development Assistance (ODA), Foreign Direct Investment (FDI), projected energy investment, 2010 energy-related CO_2 emissions, and 2000-2010 growth of energy-related CO_2 emissions.

Table 5
Comparison of the Geographic Distributions of CDM Potential, ODA, FDI, Projected Energy Investment, Emissions and Emissions Growth

<table>
<tr><th></th><th>CDM Potential 2010[a]</th><th>Official Development Assistance 1997-2001[b]</th><th>Foreign Direct Investment 1997-2002[c]</th><th>Projected Energy Investment 2001-2010[d]</th><th>Energy-Related CO_2 Emissions 2010[e]</th><th>CO_2 Emissions Growth 2000 to 2010[e]</th></tr>
<tr><td>Asia</td><td>60 to 80%</td><td>37%</td><td>41%</td><td>56%</td><td>65%</td><td>71%</td></tr>
<tr><td>Latin America</td><td>5 to 15%</td><td>13%</td><td>50%</td><td>18%</td><td>14%</td><td>13%</td></tr>
<tr><td>Africa</td><td>5 to 15%</td><td rowspan="2">50%</td><td rowspan="2">9%</td><td>13%</td><td>8%</td><td>5%</td></tr>
<tr><td>Middle East</td><td>5 to 15%</td><td>14%</td><td>13%</td><td>10%</td></tr>
</table>

Notes: a Based on Table 4.
b Calculated from Table A-8 excluding Europe and Central Asia and Unspecified.
c Calculated from Table A-8 excluding Europe and Central Asia.
d Calculated from IEA (2003b) Table 2.3, p. 47. The total investment is $1 923 billion (2000US$). China represents 30% of the total or 54% of the Asian share.
e Calculated from the EIA Reference Case (EIA (2003b), Table A10, p.191) energy-related CO_2 emissions with Mexico added to the Central/South America region.

The distribution of CDM potential is quite similar to the distribution of projected energy investment, projected energy-related CO_2 emissions in 2010 and projected growth of energy-

[98] The PCF, CERUPT, and CDM projects are explicitly intended to generate CERs for Kyoto Protocol compliance. While the AIJ and Ellis projects may qualify as CDM projects, it is not clear that the proponents of those projects plan to submit them for validation as CDM projects.

related CO_2 emissions between 2000 and 2010 for all regions. Africa's large share of ODA is a response to the social and economic development needs of that region. As a result the distribution of ODA is quite different from that of the estimated CDM potential.

Latin America was the recipient of half of all FDI during 1997-2002. This is due both to a relatively good environment for foreign investment and specific events such as privatisation of a number of government-owned enterprises. To the extent that a good foreign investment environment is conducive to CDM projects it helps explain the relatively high level of project activity in Latin America. The limited project activity to-date in the Middle East, and to a lesser extent Africa, is consistent with their relatively low share of FDI.

The relative attractiveness of Asia to foreign investors as reflected in its share of FDI may be one reason why CDM project activity is lagging relative to the estimated potential of the region. In addition, some authors claim that China lags other developing countries in implementing a system for identification, approval and implementation of CDM projects.[99] Due to its large share of the estimated global CDM potential, the scale of CDM activity in China could have a substantial impact on the total supply of CERs.[100]

These comparisons, then, suggest that estimates of the CDM potential are closely related to projected emissions and emissions growth. But the institutional and human capacity to handle investment in CDM projects appears not to be fully reflected in the estimates of CDM potential. At present Latin America appears to have an advantage over other regions in terms of the capacity to handle foreign investment in CDM projects.

3.9 Potential CDM Investment

CDM projects require investments in land, equipment, buildings, and other items that will reduce emissions for up to 20 years or enhance sinks for up to 60 years. This section examines the scale of investment associated with the CDM. The analysis will use the upper end of the range of CDM demand from the models; 500 $MtCO_2e$ which will be assumed to be met by 400 $MtCO_2e$ of reductions during 2010 and 25% (100 $MtCO_2e$) banked pre-2008 CERs.

For some project types the emission reduction or sink enhancement investment constitutes virtually the entire project. That is the case for a landfill gas recovery and flaring system and for most afforestation projects. But the emission reduction component of a project that replaces a proposed coal-fired generating plant with a biomass plant is only a fraction of the total investment. Where data on project cost are provided it is usually not clear whether they apply to the entire project or only to the emission reduction component.

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[99] See Tangen and Heggelund (2003) and Michaelowa, et al. (2000).

[100] Using 2010 emissions and 2000-2010 emissions growth as indicators of its CDM potential, China represents 35 to 45% of the total CDM potential in 2010. This is discussed further in section 5.2.2.

Data on project costs are very scarce. For 20 AIJ projects the cost per tCO_2e reduced over the life of the project is \$11.16 with a range of \$3.88 to \$1,658.60.[101] Data for 7 proposed CDM projects show an average cost of \$22.78 per tCO_2e reduced over the life of the project with a range of \$3.61 to \$54.69.[102] The costs of AIJ projects are likely to be lower than the costs of CDM projects. This is because AIJ projects could not earn credits for the emission reductions achieved, so developers had an incentive to implement low cost projects or small projects if the cost per tonne reduced was high. And since AIJ projects faced less stringent additionality tests than CDM projects they are more likely to include "no regret" projects.

On the basis of the very limited data available, an investment cost of \$25/tCO_2e reduced over the life of a project is assumed for the analysis.[103] The investment typically would need to be made before the project begins operation. But if a steady stream of new projects is implemented, the investment required during a given year is approximately equal to the investment cost of the reductions achieved that year. So the investment implied by a 400 $MtCO_2e$ reduction in 2010 is roughly \$10 billion.

This estimated annual CDM investment of \$10 billion is based on the maximum demand for CERs. Foreign direct investment (FDI) in developing countries averaged \$140 billion per year during 1997-2002. The projected energy investment required for developing countries between 2001 and 2010 is \$192 billion per year. The CDM investment is only 5 to 7% of these totals. Total foreign direct investment in developing countries often fluctuates by more than \$10 billion from year to year.[104]

The capital required for CDM projects can come from domestic as well as foreign sources, so comparing the requirement with FDI is too restrictive.[105] The foreign CDM funding, whether it is an investment in the project or a contract to purchase CERs, is usually a strong currency (dollars, euros, yen). That funding can be used to reduce the cost of capital from other sources or to leverage additional financing. The PCF has explored such financial structures for various projects.

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[101] This is a weighted average -- the total cost for the 20 projects divided by the lifetime emission reductions for the 20 projects. If the cost per tCO_2e is calculated for each of the 20 projects and each project is given equal weight, the average is \$158.68/tCO_2e. This is because the sample includes some relatively small, high-cost projects.

[102] If the cost per tCO_2e for each project is weighted equally, the average is \$25.70/tCO_2e.

[103] The \$25/tCO_2e reflects the costs of CDM projects currently being proposed. Those projects presumably were evaluated using current price forecasts for Kyoto units. Current prices are \$3.00 to \$6.50/tCO_2e. The 500 $MtCO_2e$ demand for CERs reflects a market price in 2010 of about \$11/tCO_2e. At that higher price more costly projects would be economically viable, so the capital requirements could be higher.

[104] See Table A-8.

[105] The CDM rules allow "unilateral" projects, projects implemented entirely by entities based in the host country. In such cases some or all of the capital might come from domestic sources. Projects with participation by foreign entities could also raise some or all of the required capital domestically. The fact that the projected annual investment requirement for energy projects is about 35% higher than the annual FDI confirms that at least some of the capital for energy projects will be raised domestically.

It appears, then, that the CDM will not cause major changes to existing and projected investment flows, but that conclusion needs to be interpreted cautiously. The investment requirements for CDM projects during a given year, or for a few years, could be much larger than the \$10 billion estimated above. Higher prices for CERs could make more costly projects economically viable and so increase the capital requirements. On the other hand, the market potential could be much lower than assumed for the above calculations. Finally, the capital required for CDM projects can come from domestic as well as foreign sources.

3.10 Summary of Issues that Affect the Potential Supply of CERs

Several estimates of the emission reductions and sink enhancements that could potentially be achieved by CDM projects are available. Using the most conservative of these estimates, Trexler and Associates Additionality 5, and the price projection of \$11.00/CO_2e $\pm$ 50% in 2010 from the previous chapter yields annual reductions in 2010 of 335 MtCO_2e (range 215 to 405 MtCO_2e). Pre-2008 reductions are likely to increase the annual supply of CERs during the commitment period by about 25%. Thus, the annual supply of CERs in 2010 could be on the order of 420 MtCO_2e (range 270 to 506 MtCO_2e).

CDM projects incur relatively large fixed transaction costs prior to registration. This means that regular CDM projects must be relatively large to be economically viable. Analytical studies suggest a minimum project size of 50 000 tCO_2e per year. Data from existing and identified projects suggest that the minimum size is close to 100 000 tCO_2e per year for regular CDM projects. The average size of existing and identified projects is over 150 000 tCO_2e per year. The minimum and average for PCF projects are roughly twice as large.

The simplified methodologies adopted by the Executive Board for small-scale CDM projects appear to reduce the transaction costs for those projects enough to make some small projects economically viable. Small-scale CDM projects are likely to have annual emission reductions of less than 50 000 tCO_2e. At present there is no information on the potential number of small-scale projects nor on the aggregate emission reductions those projects might achieve.

Buyers currently have little interest in reductions achieved after 2012, so those reductions have virtually no market value at the present time. This means that the project costs must be recovered from the sale of CERs for the reductions achieved prior to 2013. Analyses suggest that a project must begin to achieve emission reductions between 2001 and 2007 to be able to recover the cost prior to 2013. This means that the number of economically viable CDM projects likely will decline rapidly over the next few years unless international or domestic measures to give an economic value to emission reductions beyond 2012 are adopted soon.

The large projects that account for most of the estimated potential CDM supply have a lead time of four or five years. Thus new project ideas initiated now would only yield emission reductions after 2007. Few of those projects would be implemented unless post-2012 emission reductions have an economic value. Assuming that post-2012 emission reductions have a market value, the lead time could limit the project flow prior to 2008. That would make the supply of CERs during 2008-2012 heavily dependent upon the implementation of new projects during that period.

The existing project ideas will generate a pre-2008 project flow that could lead to emission reductions of 15 to 75 $MtCO_2e$ per year during 2008-2012. A market potential of 30 to 150 $MtCO_2e$ in 2010 could be supplied by maintaining roughly the same flow of new projects. Maintaining a flow of new projects past 2007 requires that a value for post-2012 emission reductions be established soon. A larger market potential in 2010 would require more new projects each year. But due to the lead time, the flow of new projects is unlikely to increase before 2008. A significant acceleration in the flow of new projects in 2008 could strain the capacity of designated operational entities and the Executive Board to validate new projects.

The project types that have an average size sufficiently large to be economically viable account for most of the estimated CDM potential. These project types include: energy efficiency measures in the residential, commercial and institutional sectors; energy efficiency in industry; landfill gas capture and utilisation; methane reductions in the oil and gas industry; renewable electricity generation; and afforestation and reforestation. Other project types, such as recovery of coal-bed methane and reduction/destruction of non-methane GHGs, also appear to be economically viable, but do not account for a large share of the total CDM potential. Renewable electricity generation and fugitive methane recovery are well represented in known projects compared to their estimated potential. Energy efficiency projects, on the other hand, are under represented relative to their estimated potential.

Most of the estimated potential supply, especially the low cost supply, occurs in Asia. The geographic distribution of the estimated CDM potential is similar to the distribution of projected energy investment to 2010, projected energy-related CO_2 emissions in 2010 and projected growth of energy-related CO_2 emissions between 2000 and 2010. But it differs somewhat from the historic patterns of foreign direct investment and official development assistance.

Latin America currently has more CDM project activity relative to its estimated potential than any other region, consistent with the pattern of FDI. Project activity relative to estimated CDM potential is low in all other regions. Due to its large share of the estimated global CDM potential, the scale of CDM activity in Asia, and in particular China, could have a substantial impact on the total supply of CERs.

Annual emission reductions in 2010 of 400 $MtCO_2e$ would require an annual investment of $10 billion. This is less than 7% of the annual foreign direct investment in developing countries during 1997-2002 and projected energy investment required for developing countries between 2001 and 2010. Thus, it appears that the CDM will not cause major changes to existing and projected investment flows. However, the capital requirements for CDM projects during a given year, or for a few years, could be much larger. And higher prices for CERs could increase the capital requirements. On the other hand, the demand for CERs and investment in CDM projects could be lower. And the capital for CDM projects can come from domestic as well as foreign sources, so comparing the requirement only with international financial flows is too restrictive.

4. Issues that Affect the Potential Demand for CERs

This chapter reviews issues that affect the potential demand for CERs. First, the implications of the draft Linking Directive by the European Commission on the use of CERs and ERUs by participants in the emissions trading programs of Member States is discussed. Then estimates of the demand for CERs and ERUs by governments and industry are reviewed. Finally, the possible demand for Kyoto units by non-Parties is considered.

4.1 The Draft EU Linking Directive

The Emission Allowance Trading Directive of the European Union became law on October 25, 2003 (European Commission, 2003b). It requires each member state to establish an emission allowance trading program that covers the CO_2 emissions of specified industrial sources beginning in January 2005.[106] The Directive specifies many of the design features of the trading programs, but leaves some choices, primarily the allocation of allowances, to each member state.[107] The programs of the 25 member states are expected to have a total of 10 000 and 15 000 participants and to account for about 45% of their total CO_2 emissions.

In July 2003 the European Commission released a proposal, the draft Linking Directive, to amend the Emission Allowance Trading Directive to allow participants to use CERs and ERUs beginning in 2008 (European Commission, 2003a). Under the proposal, a CER or ERU could be exchanged for a new EU allowance that could be traded or used for compliance. The European Parliament has proposed several amendments to the draft Linking Directive including one that would allow CERs to be exchanged for EU allowances beginning in 2005 (European Parliament, 2004). Assuming the draft Linking Directive is adopted, it will affect the market potential for CDM in several ways.

First, the Linking Directive would create a large market for CERs and ERUs. Any participant in a trading program established under the Emission Allowance Trading Directive could exchange CERs or ERUs for EU allowances and use them for compliance.[108] Estimates of the annual compliance demand by these sources in 2010 range from 45 $MtCO_2e$ to 243 $MtCO_2e$.[109] The estimated compliance demand for CERs and ERUs will be affected by the national allocation plans for 2005-2007 and 2008-2012.

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[106] The Commission may recommend that coverage be extended to other gases at the end of 2004 and any member state may propose expansion of the programs to additional gases and sources beginning in 2008.

[107] The allocation plans must meet specified criteria and may be rejected by the Commission. Further harmonisation of the trading program designs is specified after 2008.

[108] The government can use the CER or ERU to cover the extra emissions as part of its compliance with its Kyoto Protocol commitment.

[109] Sijm et al., (2002) estimate the demand at 45 $MtCO_2e$ for the sectors covered by the Emission Allowance Trading Directive in the current 15 member states with no use of CERs or ERUs. Criqui and Kitous (2003) estimate the demand for the covered sectors at 243 $MtCO_2e$. The draft Linking Directive (European

The draft Linking Directive proposes that a review be triggered if the total quantity of CERs and ERUs exchanged for allowances reaches 6% of the total allowances allocated for 2008-2012; annual purchases of 91 $MtCO_2e$ by trading program participants.[110] Such a review might, but need not, lead to the introduction of restrictions on the use of CERs and ERUs. Analyses performed for the Commission suggest that with no restriction purchases of CERs and ERUs could exceed the 6% level by approximately 10%.[111] Point Carbon argues that the supply of CERs and ERUs will not be large enough to exceed the 6% threshold due to institutional barriers and the low price implied by that volume of CERs and ERUs.[112]

In short, despite a possible limit on the quantity of CERs and ERUs that may be exchanged for EU allowances, the Linking Directive is expected to create a large demand for CERs and ERUs on the part of industry participants in the EU Emission Allowance Trading programs.

Second, the draft Linking Directive reduces the quantity of ERUs that can be generated by Joint Implementation projects in member states. To avoid double counting the draft Directive proposes that no ERUs be issued for reductions that directly or indirectly affect emissions at installations covered by the emission allowance trading programs.[113] Furthermore, baselines for Joint Implementation projects in member states must reflect the standards of the *Acquis Communautaire* rather than existing practice, thus reducing the quantity of ERUs generated by many projects.[114] These restrictions on JI projects in member states reduce the potential supply of ERUs and so increase the potential market for CERs.

Third, the draft Linking Directive does not allow the exchange of AAUs for EU allowances. This increases the market potential for the CDM because the surplus AAUs held by Russia and the Ukraine can not be used for compliance by participants in the EU emission allowance

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Commission, 2003a) states that the emissions of trading program participants would be 111 $MtCO_2e$ higher than without linking.

[110] The draft Linking Directive (European Commission, 2003a, p. 30) states that in the absence of limits on conversion, the CERs and ERUs used will amount to an estimated 7% of initially allocated allowances for 2008-2012. Six percent of the total allowances allocated corresponds to industry purchases of 91 $MtCO_2e$ per year. Member state governments would purchase an additional 117 $MtCO_2e$ per year.

[111] With unrestricted use of CERs and ERUs the market price of allowances is estimated to be €12.40/tCO_2e in 2010. If use of CERs and ERUs is capped at 6% of the allowances allocated, the price of EU allowances rises to €14.50/tCO_2e and the international price of CERs and ERUs drops to €12.00/tCO_2e (Criqui and Kitous, 2003).

[112] Point Carbon (2003c) *CDM Monitor*, October 2, p. 1.

[113] Since electricity generating units are covered by the emissions trading program, actions by customers to reduce electricity use would not be not eligible as JI projects.

[114] The *Acquis Communutaire* sets out the transition to full implementation of European Union laws and regulations by a new member state. Using the *Acquis Communutaire* to set baselines for JI projects generally results in a more stringent baseline than current practice. For example, EU law requires capture of landfill gas for large landfills, so landfill gas recovery at such landfills would not qualify for as a JI project.

trading programs. In other words, the draft Linking Directive reduces the potential market for "hot air" and so increases the potential market for the CDM.

Finally, the Emission Allowance Trading Directive establishes successive five-year phases beginning in 2008. This will create a demand for CERs from emission reductions achieved by CDM projects after 2012. This demand currently is not evident in the market because the participants in the emission allowance trading programs do not yet know their allocations for 2005-2007 or for 2008-2012 and so do not know whether they will be a buyer or seller in during those periods, let alone in 2013.

During their deliberations on the draft Linking Directive, the Council (member state governments) and the European Parliament will consider amendments that could affect the demand for CERs. The European Parliament has proposed amendments to allow CERs to be exchanged for EU allowances beginning in 2005 rather than in 2008 and to allow the establishment of links with emission trading programs in countries that are not Parties to the Kyoto Protocol (European Parliament, 2004). Several alternatives, ranging from tighter control to no limit, have been proposed to the quantitative restriction on the exchange of CERs and ERUs for EU allowances.

In summary, if the proposals in the draft Linking Directive are adopted it will allow entities covered by the emission allowance trading programs in at least 25 Annex B countries to use CERs and ERUs indirectly for compliance.[115] This creates a market for CERs and ERUs where AAUs are excluded. In addition, the scope for JI projects in these countries is reduced, thus increasing the market for CERs. It also creates a demand for CERs and ERUs after 2012.

4.2 Estimated Demands by Government and Industry

As noted in Chapter 1 a number of Annex B governments have announced programs to purchase emission reductions from CDM and/or JI projects. Two recent studies attempt to segment the demand for Kyoto units between industry and government. This affects the demand for different types of Kyoto units. As discussed in the previous section the draft Linking Directive would limit the industrial demand for Kyoto units of the 25 European Union member states to CERs and ERUs. And almost all of the government purchase programs announced to-date are limited to CERs or ERUs. This section reviews the estimates of the industrial and government demands for Kyoto units and the implications for the CDM.

[115] Additional countries -- Bulgaria, Romania and possibly Turkey -- may join the European Union before 2012 and thus would be required to implement emission allowance trading programs. In addition, Annex B Parties that are not members of the European Union, such as Norway, Switzerland, Canada, New Zealand and Japan, can negotiate links with the EU trading programs. And, if the amendment proposed by the European Parliament is adopted, trading programs in countries that are not Parties to the Kyoto Protocol could negotiate links with the EU trading programs.

4.2.1 Industry Demand for Kyoto Units

As part of a recent estimate of the potential demand for Kyoto units by governments, Natsource (2003) has estimated the demand for Kyoto units by industry. Their estimates of the annual demand by industry in 2010 as well as estimates by Criqui and Kitous (2003) are summarised in Table 6.

Table 6
Estimates of Industrial Demand for Kyoto Units in 2010

	Natsource		**Criqui and Kitous** ($MtCO_2e$)
	Low ($MtCO_2e$)	**High** ($MtCO_2e$)	
Australia and New Zealand			23
Canada	22.4	22.4	20
European Union 25	45.0	173.7	111
Japan	34.8	92.4	34
Norway and Switzerland			10
Total	**102.2**	**288.5**	**198**

The average industrial demand in 2010 is expected to be almost 200 $MtCO_2e$ with a range of $\pm$ 100 $MtCO_2e$. The European Union, which represents 45% to 60% of the total expected industry demand, plans to restrict industry purchases to CERs and ERUs. That would represent an annual demand for CERs and ERUs of 110 $MtCO_2e$ with a range of $\pm$ 65 $MtCO_2e$. It appears likely that other countries will allow the use of all Kyoto units by industry (Point Carbon, 2003d).[116]

4.2.2 Government Demand for Kyoto Units

A number of Annex B governments have indicated that they plan to purchase Kyoto units to help comply with their commitment under the Kyoto Protocol (Point Carbon, 2003d). The Netherlands plans to purchase a total of 67 $MtCO_2e$ and has already committed to purchase about 25 $MtCO_2e$ of CERs and ERUs through various purchase tenders and other processes. Other countries that have announced national initiatives to purchase Kyoto units include: Austria (up to €36 million, 20-30 $MtCO_2e$), Belgium, Denmark (about US$125 million budgeted and planned, 6.25 $MtCO_2e$), Finland (approximately 0.5 $MtCO_2e$), Italy (at least 60 $MtCO_2e$), Norway (0-13 $MtCO_2e$), Sweden (about 2.5 $MtCO_2e$), and Switzerland (about 5 $MtCO_2e$).[117] All of these initiatives involve purchases of CERs and/or ERUs.

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[116] Canada, for example, has indicated that it plans to allow the large final emitters in its proposed emissions trading program to use all types of Kyoto units for compliance purposes.

[117] Based on Natsource (2003) and Point Carbon (2003d).

Canada, Finland, Japan, the Netherlands, Norway and Sweden have invested in the PCF and will receive a share of the Kyoto units purchased by the fund. In addition, Canada, Italy, and the Netherlands have invested in the Community Development Carbon Fund.

Natsource (2003) has recently estimated the potential demand for Kyoto units by governments in 2010. The Natsource estimates, summarised in Table A-9, as well as estimates by Criqui and Kitous (2003) are presented in Table 7.

Table 7
Estimates of Government Demand for Kyoto Units in 2010

	Natsource		**Criqui and Kitous** ($MtCO_2e$)
	Low ($MtCO_2e$)	**High** ($MtCO_2e$)	
Australia and New Zealand			12
Canada	12.0	81.8	74
European Union 25	53.9	462.8	113
Japan	17.7	217.6	26
Norway and Switzerland			16
Total	**83.6**	**762.2**	**241**

Natsource did not reconcile its estimates of industry and government purchases to compliance with Annex B national commitments. The sum of the high estimates, 1 050.7 $MtCO_2e$, is higher than most estimates of the total demand for Kyoto units. And the sum of the low estimates, 185.8 $MtCO_2e$, is only a fraction of the estimated total demand for Kyoto units.

Government purchases are estimated to represent between 45% (83.6 of 185.8 $MtCO_2e$) and 73% (762.2 of 1 050.7 $MtCO_2e$) of all Kyoto unit purchases in 2010 by the Natsource estimates and 55% of all Kyoto unit purchases by the Criqui and Kitous estimates. The European Union accounts for 60% to 65% of the total government demand by the Natsource estimates and 45% of the total by the Criqui and Kitous estimates.

As indicated above several countries are already in or entering the market. Point Carbon (2003d) tried to estimate the current and potential demand for CERs, but could not separate the demand for CERs from the demand for Kyoto units. The current commitments and plans to purchase CERs and ERUs are 50 $MtCO_2e$ for Canada (all Kyoto units), 150 $MtCO_2e$ for the European Union, 95 $MtCO_2e$ for Japan and 5-18 $MtCO_2e$ for Norway and Switzerland. This total of 300-313 $MtCO_2e$ represents actual and planned purchases at the present time rather than an annualised demand. If Canada is removed from this total because its demand covers all Kyoto units, the total purchases of 250-263 $MtCO_2e$ represent an annualised demand of just over 50 $MtCO_2e$ for CERs and ERUs.

4.2.3 Summary

Governments are already buying Kyoto units to help meet their emission limitation commitments for 2008-2012. All of the announced initiatives involve purchases of CERs or ERUs. The available estimates indicate that governments will be the predominant buyers in international GHG markets, representing 45 to 75% of the total demand.[118] Government purchase decisions usually include considerations in addition to lowest cost. If governments are the predominant buyers, their preferences could lead to market segmentation and price differentiation for different categories of Kyoto units.[119]

Governments will also influence the demand by industry by regulating the types of Kyoto units they will accept for compliance with domestic emission limitation obligations. The draft Linking Directive, for example, would limit compliance demand for Kyoto units by participants in the EU greenhouse gas emission allowance trading programs to CERs and ERUs. Other countries, such as Canada, may allow participants in their emissions trading programs to use all types of Kyoto units for compliance purposes.

Summing the minimum demand by industry in Europe (about 45 $MtCO_2e$) and the planned purchases by governments (about 50 $MtCO_2e$) gives an annual demand for CERs and ERUs of at least 100 $MtCO_2e$. The median demand by industry in Europe (110 $MtCO_2e$) combined with the Criqui and Kitous estimates of government purchases by the European Union, Norway and Switzerland (about 120 $MtCO_2e$) yields a potential demand for CERs and ERUs of roughly 230 $MtCO_2e$ in 2010. The maximum demand by government and industry could be double the maximum supply of CERs of about 500 $MtCO_2e$ in 2010.

4.3 Possible Non-Party Demand for Kyoto Units

Despite the decisions by Australia and the United States not to ratify the Kyoto Protocol, they might allow the use of Kyoto units for compliance by firms with obligations under domestic emissions trading programs. Thus, there could be a demand for Kyoto units, including CERs, by sources in countries that are not Parties to the Protocol. [120]

A few American states have adopted limits on CO_2 emissions by coal-fired electricity generating stations. Other states are considering emission trading programs for greenhouse gas emissions by industrial sources. National limits on CO_2 emissions are part of some bills in the Congress to regulate emissions by electricity generators. Those requirements and proposals all allow emissions trading. A bill introduced by Senators McCain and Lieberman

[118] Natsource (2003), p. 14.

[119] Natsource (2003), p. 8.

[120] It might be noted that while this study does not evaluate expectations for project-based offsets markets in the absence of Kyoto, demand may continue even if the Kyoto Protocol does not enter into force. Most countries that have ratified the agreement have enshrined commitments into national laws, and are proposing to allow international offsets in their national and regional trading programs.

(2003) would establish a comprehensive greenhouse gas emissions trading program in the United States by 2010.

The McCain-Lieberman bill was rejected in the Senate by a vote of 43 to 55 on October 30, 2003. The bill is interesting in that it would have allowed the use of emission permits from countries that meet specified conditions. Annex B Parties eligible to engage in international emissions trading probably would have been the only countries to meet those conditions. Thus, under the McCain-Lieberman bill the United States could have been a buyer of Kyoto units, even if it did not ratify the Protocol. Of course, it would only have made sense to buy Kyoto units if the price of American allowances was higher than the price for Kyoto units.

The key point is that American legislators are aware that they can decide unilaterally whether to allow the use of Kyoto units for compliance with domestic emission limitation obligations even if the United States does not ratify the Kyoto Protocol. Thus any greenhouse gas emissions trading program in the United States, at the state or federal level, could decide to allow the use of Kyoto units for compliance purposes. Such provisions could allow the use of any Kyoto units or be limited to specific types of units, such as CERs.

Australia plans to meet its commitment domestically despite not ratifying the Protocol. That could be interpreted to mean that it will not be a buyer of Kyoto units. But emissions trading programs are being considered in various states. A state or national program could decide unilaterally to allow the use of Kyoto units for compliance.

As noted in section 4.1 above, the European Parliament is proposing an amendment to the EU emission allowance trading scheme that would permit links with trading programs in non-Parties. If such programs are net buyers of EU allowances, it would stimulate the demand for CERs and ERUs. If such programs are net sellers of allowances to the EU scheme, it could reduce the demand for CERs and ERUs unless the non-Party allowances had to be accompanied by Kyoto units.[121]

In short, emission trading programs in non-Parties could affect the market potential for the CDM. No estimates of the potential demand for CERs by non-Party trading programs are available at the present time.

4.4 Summary of Issues that Affect the Potential Demand for CERs

Total industry demand for Kyoto units is estimated at 200 $MtCO_2e$ with a range of $\pm$ 100 $MtCO_2e$. The European Union represents 45 to 60% of the estimated industry demand. Purchases by European industry will be governed by rules for exchanging Kyoto units for EU allowances. The draft Linking Directive would allow only CERs and ERUs to be exchanged

[121] If the non-Party allowances are not accompanied by Kyoto units they impose an added compliance burden on the EU member states that accept them. Use of the non-Party allowances in an EU member state means higher emissions there. Since the EU member state can not use the non-Party allowances toward compliance with its Kyoto Protocol obligations, this would increase its compliance burden.

for EU allowances. That would create a total industrial market for CERs and ERUs of 110 $MtCO_2e$ with a range of $\pm$ 65 $MtCO_2e$.

The draft Linking Directive would also reduce the scope for JI projects in member states of the European Union and create a demand for CERs and ERUs after 2012.

Government purchases are estimated to represent between 45 and 75% of the total demand for Kyoto units. Several Annex B governments have already purchased or announced plans to purchase ERUs or CERs. The announced plans represent an annualised demand of roughly 50 $MtCO_2e$ of CERs and ERUs. Government purchases on the scale projected could lead to market segmentation and price differentiation for different categories of Kyoto units.

The minimum demand by industry in Europe (about 45 $MtCO_2e$) and the planned purchases by governments (about 50 $MtCO_2e$) gives an annual demand for CERs and ERUs of at least 100 $MtCO_2e$. The median demand by industry in Europe (110 $MtCO_2e$) combined with the Criqui and Kitous estimates of government purchases by the European Union, Norway and Switzerland (about 120 $MtCO_2e$) yields a potential demand for CERs and ERUs of roughly 230 $MtCO_2e$ in 2010. The maximum demand by government and industry could be double the maximum supply of CERs of about 500 $MtCO_2e$ in 2010.

Any greenhouse gas trading program in Australia or the United States, at the state or federal level, could decide to allow the use of Kyoto units for compliance purposes. Such provisions could allow the use of any Kyoto units or be limited to specific types of units, such as CERs. It may also be possible to link such trading programs with the EU emission allowance trading program.

5. Market Potential of CDM

This chapter draws together the material reviewed in the previous three chapters to assess the market potential of CDM. It also summarises the key factors that will affect the market for CDM and discusses the associated policy implications.

5.1 The Market Potential of CDM

This section assesses the market potential of CDM. It reviews estimates of the demand for CERs and compares them with estimates of the potential supply. Next it examines whether the estimates of potential supply are realistic. Then the characteristics of the supply -- the types of projects and geographic distribution -- are described. [122]

5.1.1 Will there be a Market for CERs?

Emissions projections and model results suggest that there may be no market for CERs unless sales of Kyoto units by Russia and the Ukraine are restricted. Will sales of Kyoto units by Russia and the Ukraine be restricted? The answer is almost certainly yes. Annex B governments will segment the market for Kyoto units to ensure a demand for CERs. In addition, Russia and the Ukraine have an economic incentive to limit the sales of their surplus units.

Several Annex B governments have announced or launched initiatives to purchase CERs or ERUs. These initiatives represent an annualised demand of about 50 $MtCO_2e$. The European Union is also considering a draft Linking Directive that would limit the Kyoto units that could be exchanged for EU allowances by industry participants in member state emission trading programs to CERs and ERUs. That represents a demand of 110 $MtCO_2e \pm 65$ $MtCO_2e$ for CERs and ERUs. In short, there is likely to be a market for at least 100 $MtCO_2e$ per year for CERs and ERUs.

Model analyses suggest that Russia and the Ukraine have an economic incentive to limit sales of their Kyoto units. Given their market power, reducing the quantity sold drives up the market price. Profits from the sale of Kyoto units are maximised when sales are restricted to

[122] Entry into force of the Kyoto Protocol will also clearly have implications for the estimated size of the CER market and on the estimated CER price. However, even without entry-into force, a market could still exist as long as domestic commitments continue to generate a demand and CERs (or CER-like credits) are recognized for domestic compliance purposes. For example, Annex B countries that have ratified the Protocol could keep their GHG commitments and continue to recognize emission reductions achieved through project-based activities undertaken in developing countries. Such a scenario might in fact lead to a greater market for CERs (or CER-like credits) as there would no longer be competing surplus AAUs from Russia available on the market. Conversely, Annex B countries could modify their emissions commitments if the Kyoto Protocol does not enter into force, leading to a reduction in overall demand.

about 40% of their surplus units, about 539 $MtCO_2e$ (range 250 to 1 100 $MtCO_2e$), leading to a price of about \$11.40/tCO_2e (range \$1.00 to \$33.00/tCO_2e) in 2010. The models estimate an average demand for CERs of 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$) when Russia and the Ukraine seek to maximise their profits from the sale of Kyoto units.

The rules governing the Kyoto mechanisms may also restrict sales of Kyoto units by Russia and the Ukraine. If Russia and/or the Ukraine do not meet the eligibility conditions to participate in international emissions trading, they would not be able to sell their surplus AAUs. This would limit Russia and the Ukraine to selling ERUs from JI projects implemented under the international review process. That would reduce the supply of Kyoto units from Russia and the Ukraine significantly and so increase the market for CERs.[123]

In summary, expressed preferences by buyer governments and economic incentives for Russia and the Ukraine combine to ensure a market for CERs.

5.1.2 What is the Potential Demand for CERs?

Model analyses assuming that Russia and the Ukraine maximise their profits from the sale of Kyoto units suggest a demand for CERs in 2010 of 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$) at a price of \$11.40 /tCO_2e (range $\pm$ 50%). This price is consistent with current prices and other forecasts of the market price for Kyoto units in 2010.

Other information is consistent with this range. Projections from Annex B national communications and the IEA yield estimated demands of 180 and 214 $MtCO_2e$ respectively. CERT model runs yield demands of 145 to 165 $MtCO_2e$ when the CDM is limited to 15% of the total potential emissions reductions and 398 to 418 $MtCO_2e$ when the CDM is not limited.[124] Projections of the demand for CERs and ERUs by Annex B governments and industry in the European Union total at least 100 $MtCO_2e$ and may reach 230 $MtCO_2e$.

The only estimate not fully consistent with the range from the models is the 622 $MtCO_2e$ (range 0 to 2 259 $MtCO_2e$) derived from the EIA emissions projection. The higher estimate is due to the relatively high EIA emissions projection for 2010, which apparently incorporates fewer emission reduction measures than the national communications and IEA projections.

The available evidence then indicates a minimum demand for CERs of 100 $MtCO_2e$ in 2010 and a potential demand in 2010 of 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$) at a price of \$11.40 /tCO_2e (range $\pm$ 50%).

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[123] Table A-3 calculates that when Russia and the Ukraine maximise their profits from the sale of Kyoto units, the average annual sales are 539 $MtCO_2e$. A model run using CERT that prohibits the sale of AAUs by the former Soviet Union leads to annual sales of 139 $MtCO_2e$ of ERUs.

[124] Recall that most analyses limit the share of the total emissions reductions that can be achieved by the CDM because of the need to structure the emission reduction activities as projects.

5.1.3 Will the Supply of CERs be Sufficient to Meet this Demand?

The supply of CERs available in 2010 consists of CERs issued for emission reductions during that year plus one-fifth of the CERs issued for emission reductions achieved prior to 2008. The pre-2008 CERs increase the annual supply in 2010 by about 25%. In other words to meet a demand for 250 $MtCO_2e$ in 2010 would require emission reductions during 2010 of 200 $MtCO_2e$.

The models used to analyse the market for Kyoto units assuming that Russia and the Ukraine maximise their profits from the sale of Kyoto units do not include a supply of pre-2008 CERs. Thus an estimated demand for CERs of 250 $MtCO_2e$ also means a supply of 250 $MtCO_2e$ of CERs in 2010 at \$11.40 /tCO_2e. This means the models understate the supply of CERs by about 25%.

The most conservative estimate of the potential emission reductions by CDM projects in 2010, Trexler and Associates' Additionality 5, is 335 $MtCO_2e$ (range 215 to 405 $MtCO_2e$) at a price of \$11.00 /tCO_2e $\pm$ 50%. Adding the pre-2008 reductions yields a total supply in 2010 of 420 $MtCO_2e$ (range 270 to 500 $MtCO_2e$).

Thus, the estimates of the supply of CERs at the projected market price suggest that the projected demand (250 $MtCO_2e$) can be met. The maximum estimates of total supply and potential demand are equal at 500 $MtCO_2e$. In short, the evidence suggests that the supply should be sufficient to meet the projected demand. But the supply will be realised only if a steady flow of new projects is sustained and if a substantial share of the potential emission reductions in Asia, especially China, is implemented.

5.1.4 What is the Minimum Potential Market for the CDM?

The estimates of potential supply assume a steady flow of new CDM projects. The continued absence of a market value for post-2012 emission reductions could stop the flow of new projects after 2007. And the four to five year lead time for many projects means that the supply of CERs depends heavily on projects that begin operation after 2007.

What is the minimum potential market for the CDM if the value of post-2012 reductions is not resolved quickly? Under those circumstances only projects already identified are likely to be implemented. Table 8 shows two estimates of the emission reductions through 2012 for potential CDM projects.

The low estimate sums the projected emission reductions through 2012 for various groups of potential CDM projects. It assumes that 20% of the reductions from AIJ projects that might be registered as CDM projects and 20% of potential projects identified by Point Carbon are implemented. The high estimate assumes that all of the potential projects identified by Point Carbon are implemented, but that this included all of the known projects. The low estimate is 236 $MtCO_2e$ or about 50 $MtCO_2e$ per year and the high estimate is 450 $MtCO_2e$ or about 90 $MtCO_2e$ per year.

The projected emission reductions may exceed the reductions actually achieved by some CDM projects due to operational, technical or other problems. On the other hand, some of the figures are contracted amounts, which usually cover only part of the projected emission reductions. And a registered project has an incentive to maximise the emission reductions achieved.

The low estimate of 50 $MtCO_2e$ per year is consistent with the low end of the range of model results when sales of surplus AAUs by Russia and the Ukraine are restricted. The high estimate is similar to the estimated demand by governments and European industry of about 100 $MtCO_2e$ per year of ERUs and CERs.

Table 8
Estimates of the Minimum Potential Market for the CDM

	Total Emission Reductions through 2012 ($MtCO_2e$)	
	Low Estimate	**High Estimate**
PCF Projects	70[a]	
CERUPT projects[b]	17[b]	
CDM projects[c]	26[c]	
AIJ projects[d]	33[c]	
Project ideas[e]	90[e]	450[e]
Total	236	450
Annual supply during 2008-2012[f]	50[f]	90[f]

Notes: a The PCF has contracted for 44 MtCO2e from projects that are expected to achieve total reductions of 112 MtCO2e, but most of the non-contracted reductions are expected to occur after 2012.
b The amount contracted from the 18 CERUPT projects.
c The 15 potential CDM projects that had been submitted to the Executive Board as of October 2003.
d Section 3.7 calculates the potential emission reductions for AIJ projects as 100 $MtCO_2e$ prior to 2008 plus 13 $MtCO_2e$ per year thereafter for a total of 165 $MtCO_2e$, of which 20% is assumed to be registered as CDM reductions.
e Section 3.7 calculates the potential emission reductions for 500 potential CDM projects identified by Point Carbon as 75 $MtCO_2e$ prior to 2008 plus 75 $MtCO_2e$ per year thereafter for a total of 450 $MtCO_2e$ by 2012. The low estimate assumes that 20% of these potential reductions are additional to the other projects identified and are implemented. The high estimate assumes that all of these potential projects are implemented, but that the other projects identified are part of the total.
f The total emission reduction through 2012 divided by 5 to get an annualized amount for 2008-2012.

Failure to ensure a market value for post-2012 emission reductions quickly could have a major impact on the market potential for the CDM. The annual demand for CERs during 2008-2012 is estimated to be 250 MtCO_2e (range 50 to 500 MtCO_2e). With a very low market value for post-2012 reductions, the CDM would be limited to existing project ideas, which would yield an annual supply of 50 to 90 MtCO_2e. And there would be virtually no new CDM projects after 2007.

5.1.5 Is the Estimate of the Potential Supply of CERs Realistic?

The potential supply of CERs reflects emission reductions during 2010. Relating the emission reductions to the projected emissions during 2010 and to the emissions growth during 2000 to 2010 provides a perspective on the magnitude of the effort implied. Relating the capital cost of the CDM projects to FDI and energy related investments yields another perspective on the implied scale of CDM activity.

These comparisons are provided for annual emission reductions of 200 and 400 MtCO_2e in 2010. Annual reductions of 200 MtCO_2e correspond to an annual supply of 250 MtCO_2e, which is the projected demand. Annual reductions of 400 MtCO_2e correspond to an annual supply of 500 MtCO_2e, which is the maximum estimated supply and demand.

Table 9 compares annual emission reductions of 200 and 400 MtCO_2e to the projected 2010 emissions and the 2000-2010 emissions growth. The maximum CDM potential of 400 MtCO_2e represents a reduction of about 2.7% of projected 2010 emissions. The reduction ranges between 1.9% and 3.3% depending upon the region. Naturally, the maximum CDM potential represents a substantially larger share of the 2000-2010 emissions growth, averaging about 12% but ranging from 9% in Latin America to 22% in Africa.

The emissions projections incorporate "business as usual" emission reductions. So the emission reductions implied by the estimated CDM potential are reductions in excess of "business as usual". Nevertheless, the magnitude of the reductions implied, especially for a reduction of 200 MtCO_2e, which corresponds to the projected demand, appears manageable. A reduction of 200 MtCO_2e per year via the CDM would imply an average reduction of 1.4% from non-Annex B countries' projected 2010 "business as usual" emissions and an average reduction of 6.0% of their projected 2000-2010 "business as usual" emissions increase.

As discussed in section 3.9, the investment implied by a 400 MtCO_2e reduction in 2010 is roughly $10 billion, so the investment needed for a 200 MtCO_2e reduction is roughly $5 billion. Foreign direct investment (FDI) in developing countries averaged $140 billion per year during 1997-2002 and often varied by more than $10 billion from one year to the next. The projected energy investment required for developing countries between 2001 and 2010 is estimated at $192 billion per year. The CDM investment for 200 MtCO_2e is only 3 to 4% of these totals and for 400 MtCO_2e is only 5 to 7% of the totals. The investment implied, especially for a reduction of 200 MtCO_2e, which corresponds to the projected demand, appears manageable. This also implies that the estimated CDM investments would not materially alter "business as usual" FDI and energy investments.

With an average annual reduction of 150 000 tCO_2e per project, 200 $MtCO_2e$ of reductions through the CDM in 2010 implies about 1 300 active projects. This means roughly 200 new projects per year. The only estimate of the number of potential CDM projects is 450 to 500 by Point Carbon. The current lack of a market value for post-2012 emission reductions means that projects that begin to reduce emissions after 2007 may not be economically viable.[125] The four to five year lead time for projects may result in a smaller number of projects being implemented prior to 2008 requiring a larger number of projects thereafter to achieve the target supply in 2010.

Table 9
Estimated CDM Potential Relative to Projected Emissions and Emissions Growth

Region	**2010 Emissions** ($MtCO_2e$)[a]	**2000-2010 Emissions Increase**[a] ($MtCO_2e$)	**CDM Potential of 200 $MtCO_2e$/yr as % of**[b]		**CDM Potential of 400 $MtCO_2e$/yr as % of**[c]	
			2010 Emissions	**2000-2010 Emissions Increase**	**2010 Emissions**	**2000-2010 Emissions Increase**
Asia	9 519	2 376	1.6%	6.3%	2.9%	11.8%
Latin America	2 096	440	1.0%	4.5%	1.9%	9.1%
Africa	1 197	184	0.8%	5.4%	3.3%	21.7%
Middle East	1 927	349	1.0%	5.7%	2.1%	11.5%
Total	**14 740**	**3 349**	**1.4%**	**6.0%**	**2.7%**	**11.9%**

Notes: a Calculated from EIA (2003b) TableA10, p. 191 by multiplying the energy-related CO_2 emissions by 3.67 to convert them from MtC to $MtCO_2$ and then multiplying them by 1.25 to get estimated total greenhouse gas emissions. Mexico is included with Latin America.
b Regional distribution of achievable potential assumed to be Asia 75%, Latin America 10%, Africa 5%, Middle East 10%.
c Regional distribution of achievable potential assumed to be Asia 70%, Latin America 10%, Africa 10%, Middle East 10%.

For a CDM supply of 400 $MtCO_2e$ of reductions in 2010, about 2 700 active projects would be needed in 2010. The lead time for new projects would make it much more difficult to achieve that total. A supply of this magnitude might require a focus on larger projects, projects with average annual reductions of 300 000 or more as in the case of the PCF portfolio. This volume of projects might also tax the capacity of the institutions involved in the assessment and approval of CDM projects.

To conclude, the estimate of the potential supply of CERs in 2010 appears reasonable relative to projected emissions in 2010, emissions growth between 2000 and 2010, and projected

[125] The Linking Directive for the EU emission allowance trading scheme will give a value to post-2012 reductions, but that value is likely to be uncertain -- albeit positive -- until the EU governments provide some indication of post-2012 allocations.

"business as usual" investment. The number of projects involved, especially for annual reductions of 400 $MtCO_2e$, appears to be more difficult to achieve due to the lead time for new projects and the capacity of the Executive Board to approve new methodologies, register the new projects, accredit designated operational entities, and issue CERs for the emission reductions achieved.

5.1.6 Characteristics of the Potential CDM Supply

Regular CDM projects are likely to have a minimum size of about 100 000 tCO_2e per year initially. This may decline over time as more approved baseline and monitoring methodologies become available. Those methodologies will reduce the fixed component for the transaction costs. However, the minimum size for regular CDM projects is likely to remain above 50 000 tCO_2e per year as suggested by Fichtner, et al. (2003) and Michaelowa, et al. (2003).

The average size of regular CDM projects will be somewhat larger than the minimum. Current projects average over 150 000 tCO_2e per year although those in the PCF portfolio average over 300 000 tCO_2e per year. A decline in the transaction costs due to the availability of more approved methodologies should also lower the average size of an economically viable project.

Some small-scale projects that can use the simplified methodologies approved by the Executive Board appear to be economically viable at current market prices. The average size of small-scale CDM projects will be substantially less than 50 000 tCO_2e per year. At present there is no information on the potential number of small-scale projects nor on the aggregate emission reductions those projects might achieve.

Project types likely to be economically viable include: energy efficiency in large industry, cement plant efficiency, large CHP, landfill methane capture, pipeline methane capture, coal bed methane, destruction of other GHGs, biomass, hydro, wind, geothermal, gas power, and afforestation projects. These project types account for a large share of the estimated total CDM potential. Thus most of the potential can be realised with economically viable projects.

At present energy efficiency projects are under-represented relative to their estimated potential. This may be due to higher administrative costs, the difficulty of establishing additionality, or other barriers that are not fully reflected in analyses of the achievable potential for energy efficiency projects. On the other hand, renewable electricity generation and projects that involve non-CO_2 gases, such as methane, are over-represented. The higher global warming potential values of non-CO_2 projects tend to improve the project economics. Those patterns are expected to persist.

The estimated geographic distribution of CDM potential in 2010 is: Asia - 60 to 80%, Latin America - 5 to 15%, Africa - 5 to 15%, and Middle East - 5 to 15%. Current experience and the pattern of recent foreign direct investment suggest a relatively higher level of activity in Latin America and correspondingly lower levels in other regions. As will be discussed in the next section, the level of CDM activity in China will affect both the total and the regional distribution.

In summary, current CDM activity differs from the estimated CDM potential in 2010 in terms of the mix of project types and the geographic distribution of emission reductions. With the possible exception of the geographic distribution, the characteristics of the CDM supply are not expected to change significantly from those evident today. The geographic distribution will depend upon the level of CDM activity in China.

5.2 Key Factors Affecting the Market for CERs

Four factors could have a significant impact on the market for CDM:

- Sales of surplus AAUs by Russia and the Ukraine;
- CDM activity in China;
- Market value of post-2012 reductions; and
- The lead time required to implement new projects.

These factors are discussed in turn.

5.2.1 Sales of Surplus AAUs by Russia and the Ukraine

Surplus AAUs held by Russia and the Ukraine are estimated to be sufficient to supply the total demand for Kyoto units. Since these AAUs have zero cost they could drive CERs and ERUs from the market. The existence of a market for the CDM, then, requires that sales of surplus AAUs by Russia and the Ukraine be restricted.

Some segments of the market for Kyoto units are being restricted to CERs and ERUs. This creates a market for the CDM and restricts sales of surplus AAUs. Those segments include initiatives by several Annex B governments to purchase CERs or ERUs and the proposal in the draft EU Linking Directive that would allow only CERs and ERUs to be exchanged for EU allowances for use in the EU emission allowance trading scheme.

In addition, model results suggest that Russia and the Ukraine have an economic incentive to limit sales of their Kyoto units. Thus, preferences by buyer governments and economic incentives for Russia and the Ukraine combine to ensure a market for CERs. These conditions must be sustained to maintain the market for the CDM.

5.2.2 CDM Activity in China

Most of the potential CDM supply, especially the low cost supply, is estimated to occur in Asia. Table 5 indicates that 60 to 80% of the global CDM potential in 2010 is estimated to be in Asia. That estimate is consistent with Asia's share of the projected 2010 emissions and of the 2000-2010 emissions growth in non-Annex B countries. Using 2010 emissions and 2000-2010 emissions growth as indicators of its CDM potential, China represents 35 to 45% of the total CDM potential in 2010.[126] This is comparable to the estimated potential of Latin America, Africa and the Middle East combined.

Some CDM projects are being developed in China; CERUPT selected one project and the PCF has two projects in China. However, the available data indicate that more projects accounting for a larger share of the estimated potential have been identified in India, Indonesia, Brazil and Mexico than in China.

The scale of CDM activity in China affects the total supply of CERs. If China implements projects on a scale consistent with 10 to 15%, rather than 35 to 45%, of the total CDM potential the total supply is reduced by 25 to 30%.[127] Higher implementation rates in other regions, such as Latin America, could offset some of the reduction. But the reduction could be equivalent to the total potential of Africa and the Middle East so lower activity in China could not be offset entirely by higher implementation rates in other regions.

The larger the demand for CERs, the more important it becomes that the CDM potential in all regions be fully developed. A demand for 250 $MtCO_2e$ of CERs requires emission reductions of 200 $MtCO_2e$ in 2010 from an estimated potential of 335 $MtCO_2e$. This demand could be met with a relatively low implementation rate in China combined with high implementation rates in all other regions. But the high estimate of the demand (500 $MtCO_2e$) requires emission reductions of 400 $MtCO_2e$ in 2010, which is all of the estimated potential. That would require full implementation of the CDM potential in all non-Annex B countries.

5.2.3 Market Value of Post-2012 Reductions

Emission reductions post-2012 have limited market value at the present time because commitments beyond 2012 have not yet been negotiated. CDM projects are eligible to earn CERs for 10 to 21 years, so most CDM projects expect to generate CERs for a number of years after 2012. Since reductions beyond 2012 have limited value, the project cost must be recovered from the emission reductions achieved prior to December 31, 2012.

Unless a project begins to achieve emission reductions in 2007 or earlier, it is unlikely to be able to recover its cost from the reductions achieved prior to December 31, 2012. Thus, unless a market value for post-2012 reductions is established soon, the flow of new projects is likely to stop by 2008.

The EU emission allowance trading scheme and draft Linking Directive create a market for post-2012 emission reductions. The market value of those reductions is positive but still very uncertain since allocations for the 2005-2007 and 2008-2012, let alone 2013-2017, have not yet been determined.

[126] Calculated from EIA (2003b) Table A10, p. 191.

[127] The scale of activity in China also affects the regional distribution of CDM activity.

Failure to ensure a market value for post-2012 emission reductions soon could have a major impact on the market potential for the CDM. The annual demand for CERs during 2008-2012 is estimated to be 250 $MtCO_2e$ (range 50 to 500 $MtCO_2e$). With no market value for post-2012 reductions, the CDM would be limited to existing project ideas, which would yield an annual supply of 50 to 90 $MtCO_2e$.

Ways of giving a market value to post-2012 reductions are discussed in section 5.3.

5.2.4 The Lead Time Required to Implement New Projects

The typical lead time required to implement a large CDM project is estimated at four to five years. This means that potential projects identified now will not yield emission reductions until 2008 or later. The virtual absence of a market value for emission reductions beyond 2012 may delay implementation further making fewer projects economically viable and reducing the scale of CDM activity.

The effect of the lead time and virtual absence of a market value for post 2012 reductions is that the CDM may be limited to currently identified projects. Table 8 above estimated the emission reductions likely to be achieved by currently identified projects. They would yield a supply of 50 to 90 $MtCO_2e$ per year during 2008-2012. This is less than the minimum demand of about 100 $MtCO_2e$ per year of CERs and ERUs by Annex B governments and participants in the EU emissions trading programs.

A continuous flow of new CDM projects is needed if the estimated demand for CERs is not to be constrained by a limited supply. A market potential of up to 150 $MtCO_2e$ in 2010 could be supplied by maintaining a steady flow of new projects. A larger market potential in 2010 would require more new projects. But due to the lead time, the flow of new projects is unlikely to increase before 2008. A significant acceleration in the flow of new projects in 2008 could strain the capacity of the designated operational entities and the Executive Board.

5.3 Policy Implications

This section addresses the policy implications raised by the issues discussed in the previous section.

Assuming entry into force of the Kyoto Protocol, the existence of a market for the CDM will depend on limiting some segments of the market for Kyoto units to CERs and/or ERUs.[128] Limiting a portion of government purchases to CERs and/or ERUs as is currently being done and restricting the exchange of EU allowances to CERs and ERUs as is proposed by the draft

[128] Of course, even in the event of non entry-into-force of the Kyoto Protocol, a market for the CDM (or CDM-like instrument) could still exist. Such a market would depend on the existence and stringency of domestic GHG commitments and the willingness of countries to accept CERs (or CER-like credits) for domestic compliance purposes.

Linking Directive should be sufficient to ensure the continued existence of a market for the CDM.

The host government must approve each CDM project, so each non-Annex B country controls the nature and extent of the CDM activity within its borders. A government may decide to limit the scale of CDM activity in the country for a variety of reasons. But the scale of CDM activity could be limited by lack of capacity, institutional limitations, or bureaucratic inefficiency. In such cases assistance from external sources can help reduce the barriers and increase the scale of CDM activity.

A number of international agencies and non-governmental organisations offer a variety of assistance in implementing the institutional structure for the CDM. Efficient deployment of that capacity suggests that the groups focus their services on countries and regions where CDM potential exists yet CDM activity appears to be proceeding slowly.

The ability to shorten project lead times appears to be very limited. Project developers have an economic incentive to get their project into operation as quickly as possible. But the project is subject to a variety of approval requirements established by the host government. Registration as a CDM project adds more requirements. There are specified time periods for several of the CDM requirements. Thus, there appears to be limited scope for reducing project lead times, but a more detailed examination of possible ways to reduce project lead times may be warranted.

To date the Executive Board has made decisions expeditiously, but the volume of CDM projects could become large enough to tax the capacity of the Executive Board to process the new projects, accredit the designated operational entities, and issue CERs for the emission reductions achieved. The Executive Board may need to alter its procedures if the workload begins to cause delays.

Emission reductions achieved by CDM projects after 2012 can be given a market value in any of several ways. The most obvious way is to negotiate national emission reduction commitments for some period after 2012 with the ability to use CERs for compliance. While negotiation of future commitments is scheduled to begin in 2005 if the Kyoto Protocol enters into force, the negotiations could take several years to complete. One way to indicate that post-2012 reductions will have a value is to agree that existing emission limitation commitments will remain in effect until new commitments are agreed.[129]

More immediate possibilities are:

- The inclusion of an option to purchase post 2012 CERs in the contracts currently being negotiated by governments in anticipation of future commitments.[130] Governments

[129] The assigned amount specified for each Annex B Party for 2008-2012 would apply for 2013-2017 (and 2018-2022, etc.) until revised by new, probably more stringent, commitments.

[130] Some Annex B governments already have their own longer term greenhouse gas emission targets.

currently buying CERs could add an option to buy the post-2012 CERs under specified terms. The terms of the option could vary to suit the buyer and seller, but government buyers could propose options that add little to the cost, such as an option to purchase a specified quantity at the prevailing market price in various years after 2012. Since the present value of CERs ten years in the future is low, an option to sell at the future market price might be more attractive to the seller than an immediate sale. And it would indicate to the seller that post-2012 reductions have a market value.

- Commitments by Annex B Parties to continue domestic greenhouse gas emission trading programs that allow industry participants to use CERs beyond 2012 regardless of future international agreements to limit greenhouse gases. The EU Emission Allowance Trading Directive establishes five-year phases continuously beyond 2012. If the provisions of the draft Linking Directive governing the exchange of CERs for EU allowances are adopted, it would allow continued use of CERs after 2012. That would create a private sector market for post-2012 CERs. Other Annex B countries implementing domestic emissions trading programs could incorporate similar provisions into their designs. The CDM governance structure would need to continue regardless of the outcome of negotiations on future commitments. Specifically, the Executive Board and Designated Operational Entities would have to continue to operate after 2012 regardless of future Kyoto negotiations to verify, certify, and issue CERs.

It is possible and highly desirable to use the above mechanisms to indicate that post-2012 CERs are likely to have a market value. To enable project developers to assess the economic viability of proposed projects, emission reductions at least ten years into the future need to have a market value.

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Appendix A

Tables

Table A-1

Assigned Amount, Emissions for Selected Years and Demand for and Supply of Kyoto Units by Annex B Country

(1 000 tCO_2 equivalent)

Country	Annual Assigned Amount	Emissions			Kyoto Units	
		Base Year	2000	2010	2010 Demand	2010 Supply
Australia	457 925	424 005	500 941	580 000	122 075	
Austria	67 328	77 388	79 754	86 060	18 732	
Belgium	132 034	142 739	152 357	165 300	33 266	
Bulgaria	144 523	157 090	77 697	133 694		10 829
Canada	570 751	607 182	726 249	770 000	199 249	
Croatia	30 348	31 945	22 259	24 500		5 848
Czech Republic	176 657	192 019	147 680	141 700		34 957
Denmark	54 794	69 360	68 505	80 100	25 306	
Estonia	40 014	43 494	19 746	11 660		28 354
Finland	77 093	77 093	73 959	89 900	12 807	
France	559 343	559 343	550 034	688 000	128 657	
Germany	965 984	1 222 765	991 422	979 403	13 419	
Greece	131 119	104 895	130 052	147 206	16 087	
Hungary	95 535	101 633	84 338	62 800		32 735
Iceland	3 078	2 798	2 989	3 494	416	
Ireland	60 679	53 698	66 997	84 656	23 977	
Italy	486 733	520 570	546 905	579 700	92 967	
Japan	1 171 922	1 246 725	1 386 307	1 317 000	145 079	
Latvia	28 570	31 054	11 164	13 000		15 570
Liechtenstein	201	218	218	218	17	
Lithuania	47 425	51 549	34 980	59 148	11 723	
Luxembourg	9 683	13 449	5 971	6 653		3 030
Monaco	93	101	133	127	34	
Netherlands	197 721	210 342	216 916	233 942	36 221	
New Zealand	73 162	73 162	76 955	84 044	10 882	
Norway	52 485	51 965	55 263	63 611	11 126	
Poland	530 554	564 419	386 187	496 836		33 718
Portugal	82 485	64 949	84 700	82 091		394
Romania	243 689	264 879	204 345	284 368	40 679	
Russia	3 040 332	3 040 332	2 281 100	2 911 800		128 532
Sensitivity				*1 876 690*		*1 163 642*
Slovakia	67 102	72 937	49 165	66 975		127
Slovenia	17 675	19 212	20 697	19 897	2 222	
Spain	329 392	286 428	385 988	343 196	13 804	
Sweden	73 389	70 566	69 357	70 877		2 512
Switzerland	48 975	53 234	52 743	48 190		785
Ukraine	919 220	919 220	454 934	527 314		391 906
United Kingdom	649 681	742 492	649 105	681 626	31 946	
United States	5 701 575	6 130 726	7 001 225	8 115 000	2 413 425	
Total	17 339 267	18 295 967	17 669 337	20 054 085	3 405 316	689 298
Ex USA, Aust.	11 161 767	11 741 236	10 167 171	11 359 085	868 616	689 298

Table A-2

IEA and EIA Emissions and EIA Demand for Kyoto Units by Annex B Country for 2010

Country/Region	**IEA Energy-Related CO_2 Emissions 2010** ($MtCO_2$)	**EIA Energy-Related CO_2 Emissions 2010** (MtC)		
		Reference Case	**Low Economic Growth Case**	**High Economic Growth Case**
Canada		186	170	202
France		108	102	115
Germany		232	222	238
Italy		129	580	136
Japan		334	310	361
Netherlands		71	64	65
Russia	1 829			
United Kingdom		163	154	164
United States		1 800	1 759	1 852
Australia/New Zealand		131	128	136
Former Soviet Union		825	789	973
Eastern Europe		213	199	253
Other Western Europe		280	260	332
United States and Canada	3 990			
European Union	3 422			
Other OECD Europe	827			
Transition Economies ex. Russia	3 041			
OECD Pacific	2 251			
Rest of Annex B	711			
Energy-Related CO_2 Emissions	16 070	4 472 (16 397)[c]	4 281 (15 697)[c]	4 829 (17 706)
Total GHG Emissions[d]	20 088[d]	20 496[d]	19 621[d]	22 133[d]
Assigned Amount (Table A-1)	17 339	17 339	17 339	17 339
Demand for CERs[e]	2 749[e]	3 157[e]	2 282[e]	4 794[e]
Demand for CERs excluding Australia and the United States	214[f]	622[f]	0[f]	2 259[f]

Notes: a Estimated by multiplying the figure for energy-related emissions by 3.6667 to convert to $MtCO_2$ and then applying the ratio of total GHG emissions to energy-related CO_2 emissions for the country/region in 2000 as calculated from national communications to the UN climate change secretariat.

b Calculated as the difference between the estimated GHG emissions and the annual assigned amount given in Table A-1.

c Energy-related CO_2 emissions expressed in $MtCO_2$; e.g., 4 472 * 3.66667 = 16 397.

d Estimated as energy-related CO_2 emissions multiplied by 1.25.

e Total greenhouse gas emissions by Annex B countries less the total assigned amount.

f Demand for CERs less the demands by the Australia (122 $MtCO_2e$) and the United States (2 413 $MtCO_2e$) as calculated in Table A-1.

Sources: IEA (2002) and EIA (2003b), Table A10, p. 191; Table B10, p. 209: and Table C10, p. 227.

Table A-3

Summary of Model Results for 2010

($MtCO_2$ equivalent)

Model or Study	**2010 Emissions All GHGs**	**Unrestricted Sales of Russian AAUs**				**Restricted Sales of Russian AAUs**				
		Annex B Demand ex US	**Annex B Supply ex Russia**	**Russia/ FSU**	**CDM**	**Annex B Demand ex US**	**Annex B Supply ex Russia**	**Surplus AAUs Sold**	**Russia/ FSU**	**CDM**
Blanchard, Criqui and Kitous	20 414[a]	862[a]	193[a]	1 429[a,b]	0	688[a]	73[a]	10%	443[a,b]	174[a]
Böhringer and Löschel	19 616[a]	1 298[a]	271[a]	1 027[a,b]	0[d]	830[a]	399[a]	31%	431[a,b]	0[d]
Eyckmans, et al.	21 101[a]	1 731[a]	0[e]	1 470[a,e]	261[a]	1 414[a]	0[e]	55-60%[f]	915[a,e]	499[a]
Grubb-Low surplus		807[a]	279[a]	844[a,c]	0			56%	473[a,c]	55[a]
Grubb-High surplus		195[a]	488[a]	1 395[a,c]	0			0%	0	184[a]
Grütter		1 100 to 1 500[a]	200 to 600[a]	500 to 900[a,b]	0 to 500[a]	1 000 to 1 200[a]		25%	250 to 300[a,b]	250 to 500[a]
Hagem and Holtsmark		900[g]	325[g]	500[g]	75[g]					
Holtsmark-Case 1[j]	19 974[a]	1 404[a,i]	230[a]	1 174[a,b]						
Holtsmark-Case 3[j]						1 246[a,i]	280[a]	48%	588[a,b]	379[a]
Holtsmark-Case 5[j]						1 298[a,i]	264[a]	64%	778[a,b]	256[a]
Jakeman, et al.	21 620	2 372		1 074[b]		935[a]	387[a]	45%	500[b]	<49[h]
Jotzo and Michaelowa		1 040[a]	75[a]	1 562[a,b]	0			32%	500[a,b]	465[a]
Jotzo and Tanujaya		1 375[a]	255[a]	1 200[a,b]	0			75%	1 100[a,b]	62[a]
Löschel and Zhang	19 610[a]	1 375[a]	255[a]	1 350[a,b]	0	865[a]	395[a,b]	34%	470[a,b]	0[d]
Average		**1 220**	**277**	**1 144**	**59**	1 047	**300**	**43%**	**539**	**250**
Range	19 610 to 21 620	807 to 2 372	75 to 600	500 to 1 562	0 to 500	688 to 1 298	73 to 399	10% to 75%	250 to 1 100	49 to 500

Notes: a: CO_2 values multiplied by 1.25 (assumes that energy-related CO_2 emissions are 80% of total GHG emissions. b: Includes Russia, Ukraine and other countries of the former Soviet Union. c: Includes Russia and the Ukraine. d: Model does not include developing countries. e: Russia includes all Annex B countries in central and eastern Europe. f: Includes 55% of hot air and 60% of JI potential. g: Scaled from a graph in the paper. h: CDM for 2015 is 48.6 $MtCO_2e$. i: Excludes Australia and the United States. j: Case 1 assumes unrestricted sales on Kyoto units but no CDM; Case 3 includes CDM and assumes the Former Soviet Union behaves strategically in the market for Kyoto units; Case 5 includes CDM and assumes the Former Soviet Union maximises the income from the sale gas and Kyoto units.
Sources: Blanchard, Criqui and Kitous (2002); Böhringer and Löschel (2001); Eyckmans, Van Regemorter and van Steenberghe (2001); Grubb (2003); Grütter (2001); Hagem and Holtsmark (2001); Holtsmark (2003); Jakeman, et al. (2001); Jotzo and Michaelowa, (2002); Jotzo and Tanujaya (2001); Löschel and Zhang (2002) and Springer (2003).

Table A-4

Estimates of the International Price of Kyoto Units in 2010:
The Effect of Withdrawal by the United States
$(2000US\$\ tCO_2e)$

Source	**With the US in the Protocol** ($\$/tCO_2$[a])	**After US Withdrawal from the Protocol**		
		Unrestricted Sales of Russian AAUs ($\$/tCO_2$[a])	**Restricted Sales of Russian/Ukrainian AAUs** ($\$/tCO_2$[a])	**Share of AAUs Sold**
Babiker, et al.	<$15.00	<$1.50	$7.50	50%
Blanchard, Criqui and Kitous	$8.50	$0	$5.00	10%
Böhringer[b]	$18.50	$0	$17.00	40%
Böhringer and Löschel[b]	$11.00	$0	$9.50	31%
Buchner, Carraro & Cersosimo	$8.00[c] $15.00[e]	$5.00[c] $13.50[d]		
Ciorba, Lanza and Pauli	$11.00[e]	$3.50[e]		
de Moor, et al.			$4.50 to $6.00[f]	
den Elzen and de Moor	$10.00	$3.00 $0 to $3.00[f]	$6.00[k] $5.00 to $7.00[f]	60%
Eyckmans, Van Regemorter and van Steenberghe	$24.00	$6.00 $1.00 to $13.00[f]	$16.00 $6.00 to $37.50[f]	55% AAUs 60% of JI
Gr✧tter[b]	$4.50 to $6.00[f]	$0 to $4.00[g]	$0 to $33.00[f]	25%
Hagem and Holtsmark[b]	$16.00	$5.50		
Holtsmark[n]		$0	$4.00[o] $2.70[o]	48% 64%
Jakeman, et al.			$12.50	45%
Jensen and Thelle	$10.50[e]			
Jotzo and Michaelowa (2001)	$1.50	$1.00 $0.50 to $1.50[f]	$1.00	32%
Jotzo and Tanujaya[b]		$0.50[g]	$11.50	75%
Löschel and Zhang[b]	$12.00	$0	$19.50[h] $13.50[h] $10.50[h]	36% 32% 34%
Manne and Richels[i]	$38.00	$1.00[j]	$33.00[k]	15%
Nordhaus[b]		$3.50[l]		
Sijm, et al.	$9.00			
WHETHER[m]		$2.00		
Average Range	**$13.50** $1.50 to $38.00	**$2.35** $0 to $13.50	**$11.40** $1.00 to $33.00	**41%** 10% to 75%

Notes:
a Where necessary, reported values are converted from tC to t/CO_2, converted to 1995US$ using the GDP implicit price index (1990 = 86.51, 1995 = 98.10, 1997 = 101.95 and 2000 = 107.04), and rounded to the nearest $0.50.
b Currency units not specified, assumed to be 1995US$.
c Including induced technological innovation and diffusion, but no spillover effects.
d Including induced technological innovation and diffusion with spillover effects.
e Annex B trading only.
f Price range for the sensitivity cases analysed.
g A minimum price of $1/tC is assumed.
h The estimates assume respectively (1) a cartel involving all countries with hot air that maximizes the revenue from the sale of permits, (2) countries with hot air maximizing their revenue from the sale of hot air subject to the behaviour of the other sellers (Nash equilibrium), and (3) Russia maximizing its revenue from the sale of permits with other sellers accepting the market price.
i Values are scaled from the graphs in the paper.
j Assumes banking is prohibited, so all hot air permits are sold during the first commitment period.
k Assumes anticipatory behaviour and banking.
l Nordhaus calculates the shadow price of carbon as $9.68/tC in 2005 and $13.99/tC in 2015, averaging these values yields $11.84/tC or $3.22/t$CO_2$ for 2010.
m Personal communication, Peter Wooders, Environmental Resources Management, November 2001, 2000$/t$CO_2$.
n Currency specified as euro with an exchange rate of €1 = US$1.17, but the year for the euro is not specified.
o The estimates assume respectively that (1) the former Soviet Union acts strategically in the international market for Kyoto units and (2) the former Soviet Union acts to maximise its income from exports of gas and Kyoto units.

Table A-5
Estimates of CDM Potential by Project Type in 2010

CDM Project Type[a]	Additionality 5[a], \$0 (MtCO2e)	Additionality 5[a], \$0 (%)	Additionality 3[a], \$20 (MtCO2e)	Additionality 3[a], \$20 (%)
Building & Appliance Energy Efficiency	26.3	31.9	211.4	20.0
Material Efficiency Improvements			21.4	2.0
Industry Process Controls & Energy Mgmt.			50.8	4.8
Industry Cogeneration			20.2	1.9
Industry Efficiency Measures	20.0	24.2	101.8	9.6
Nuclear Displacement of Fossil Fuel				
Gas Displacement of Coal	0.1	0.1	48.6	4.6
CO_2 Capture				
Clean Coal Displacement of Standard Coal			1.6	0.2
Forest Sequestration			117.2[b]	11.1
Soil Carbon Sequestration			8.6[c]	
PFC Reductions by the Aluminum Industry			4.4	0.4
HFC-23 Reductions by Chemical Industry			11.5	1.1
Landfill Methane Capture/Utilization			99.8	9.5
Enteric Methane Reduction	5.5	6.6	30.2	2.9
Methane - Oil & Gas	21.8	26.4	98.3	9.3
Methane Reductions From Coal Mining	2.5	3.0	84.3	8.0
Methane Reductions From Sewage			27.3	2.6
Methane Reduction from Rice Paddy Irrigation & Fertilizers			81.7	7.8
N_2O Reductions from Chemical Industry				
CO_2 Removal from Fertilizer/Refineries			0.1	
Cement Process Conversion			2.0	0.2
Biomass Displacement of Fossil Fuel	0.3	0.4	3.7	0.4
Renewables Displacement of Fossil Fuel	5.5	6.7	30.3	2.9
Hydro Displacement of Fossil Fuel	0.6	0.7	5.2	0.5
Transportation - Improved Auto Efficiency			2.9	0.3
Total	**82.5**	**100.0**	**1 054.5**	**100.0**

Notes: a Consolidated from the 61 project types used by Trexler and Associates in their GHG Supply Tool©. See the note to Table A-7 for a description of the GHG Supply Tool© and the uncertainties inherent in the estimates.

b Trexler and Associates estimate a potential of 236.8 $MtCO_2e$, but the limit on afforestation and reforestation under the CDM is 1% of the base year emissions which is estimated at 117.2 $MtCO_2e$ for Annex B Parties excluding the United States and Australia.

c Excluded from the total since soil sequestration measures will not be eligible under the CDM for 2008-2012.

Source: Trexler and Associates, personal communication, 2003

Table A-6
Transaction Costs for CDM Projects

Transaction Cost Components	**Relation to Project Size**	**Estimate (000 €)**	
Search costs	Fixed	15	
Negotiation costs	Degressive	25-400	
Baseline determination costs	Fixed	35	
Approval costs	Fixed	40[a]	
Validation costs	Fixed	15-30	
Registration costs	Fixed	10	
Monitoring costs	Fixed	10	
Verification costs	Degressive	8 per turn	
Certification costs	Degressive	NA	
Enforcement costs	Proportional		
Transfer costs	Proportional	1%	
Registry costs	Proportional	0.03%	
Minimum fixed cost		150	

Project types	**Typical Reduction ($t\ CO_2e$/year)**	**Transaction Costs (€/$t\ CO_2e$)**	**Size Category**
Large hydro, gas power plants, large CHP, landfill methane capture, pipeline methane capture,cement plant efficiency, large-scale afforestation, geothermal[b]	>200 000	0.1	Very large[c]
Wind power, energy efficiency in large industry, solar thermal[b]	20 000 to 200 000	0.3 to 1	Large
Boiler conversion, DSM, small hydro	2 000 to 20 000	10	Small
Energy efficiency in housing and SME[b], mini hydro[b]	200 to 2 000	100	Mini
Photovoltaic[b]	<200	1 000	Micro

Notes: a Can be much higher if CDM bodies do not do capacity building, especially in earlier stages
b These projects have relatively high marginal abatement costs
c There is no experience with very large projects yet

Source: Michaelowa, et al. (2003), Tables 11 and 12

Table A-7
Estimates of Regional Distribution of CDM Potential in 2010

	Jakeman, et al.	Trexler[a], Additionality 5			Jotzo and Michaelowa	Trexler[a], Additionality 3			Sijm, et al.	
	$12.50/t$CO_2$	**$0/t$CO_2$**	**$10/t$CO_2$**	**$20/t$CO_2$**	**$3/t$CO_2$**	**$0/t$CO_2$**	**$10/t$CO_2$**	**$20/t$CO_2$**	**Case A**	**Case B**
	($MtCO_2e$)	($MtCO_2e$)	($MtCO_2e$)	($MtCO_2e$)	($MtCO_2e$)	($MtCO_2e$)	($MtCO_2e$)	($MtCO_2e$)	($MtCO_2e$)	($MtCO_2e$)
Asia	30.0	62.1	220.1	282.2	147.8	184.4	580.6	699.3	1 117	1 001
Latin America	6.0	5.8	39.1	66.3	12.7	19.4	107.9	136.5	151	177
Africa	1.7	4.4	36.8	60.9	22.7	15.1	94.6	111.3	113	68
Middle East	4.3	10.3	27.0	38.6	22.7	34.9	81.8	107.4	57	159
Other	6.5									
Total	**48.6**	**82.5**	**323.0**	**448.0**	**205.9**	**253.7**	**864.9**	**1 054.5**	**1 438**	**1 405**
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Asia	61.7	75.2	68.2	63.0	71.8	72.7	67.1	66.3	77.7	71.2
Latin America	12.3	7.0	12.1	14.8	6.2	7.6	12.5	13.0	10.5	12.6
Africa	3.5	5.3	11.4	13.6	11.0	5.9	10.9	10.6	7.9	4.8
Middle East	8.8	12.5	8.4	8.6	11.0	13.7	9.5	10.2	4.0	11.3
Other	13.4									

Note: a These cost estimates were developed using a proprietary GHG Supply Tool© developed by Trexler and Associates, Inc. (TAA). The GHG Supply Tool© is based on publicly available data from a wide variety of bottom-up studies of the global "technical potential" for emissions reductions, combined with TAA's independent analysis of typical projects costs and cost ranges, as well as additionality assessments at the sector level. The Supply Tool© includes data on global potential emission reductions for 61 separate technologies and generates regional and global supply curves for project-based reductions.

A key feature of the GHG Supply Tool© is its assessment of the extent to which potential emissions reductions will be creditable under different standards of "additionality," i.e., the extent to which the reductions result from activities beyond "business as usual." The assessments do not correspond to specific baseline policies or additionality criteria, but rather are qualitative assessments about the degree to which the emissions reductions are likely to be judged to arise from activities that go beyond "business as usual." A rank of 1 implies "poor" additionality, meaning that the reduction in question probably would have happened anyway. A rank of 5 implies "unquestioned" additionality, meaning that the reduction would likely receive credit under almost any screening standard. Thus, the Supply Tool© offers estimates of the cost and availability of GHG credits under different policy scenarios involving the strictness of Clean Development Mechanism crediting criteria.

The GHG Supply Tool© is focused exclusively on project-based reductions. There may be a very large global potential for emissions reductions that could be achieved through a variety of government policies and measures. Those reductions are not included in the estimates. The potential emission reductions in the transportation sector, for example, reflect the difficulty involved in achieving such reductions through project-based activities.

The costs in the Supply Tool© are intended to reflect private investment costs, not overall societal costs. Many measures that reduce GHG emissions may produce positive externalities or savings that accrue to society at large. These benefits are not reflected in the cost estimates. Similarly, some measures may appear "cheaper" if one uses a societal discount rate rather than a private discount rate. In most cases, the costs are derived using TAA's own analysis of the private investment costs under varying assumptions (e.g., plausible "typical" values for discount rates, fuel costs, construction costs, electricity prices, or other relevant variables). For some options, TAA consulted IPCC cost range estimates or cost estimates from other relevant literature as long as these estimates reflected a private cost perspective. The costs include transaction costs ranging from a few cents to several dollars per ton of CO_2 reduced, generally depending on the magnitude of the reductions from a typical project for the technology.

Costs for individual technology options are entered as a range. Then a cost distribution indicates whether costs will tend to fall towards the low or high end of the range (or be evenly distributed across the range). The Supply Tool© uses a simple exponential function, ranging from very low to very high, to distribute costs over the practically achievable potential.

Most publicly available studies of mitigation potential estimate the potential as the "technical potential" level. In reality, the entire technical potential for a given technology is unlikely to be achieved. TAA has estimated the "practically achievable potential" for each technology in the Supply Tool©. Although the estimate varies from technology to technology, it averages 50% of the estimated technical potential. The practical potentials have been adjusted for possible "overlap" of technical potentials. For example, each of several renewable energy technologies could independently displace fossil fuel use in power plants. But in total, they can't displace more than the total fossil fuel use.

Consistent regional estimates of technical or practical potential are non-existent, or limited in scope, or would take a lot of work to develop. The regional estimates of potential in the Supply Tool© Tool are derived from the global estimate in a couple of ways. For energy-based and F-gas reduction potentials, installed generating capacity was used as a proxy for the distribution of emission reduction potential. It is unclear how big an error use of this proxy introduces, but no better dataset or proxy was available. For methane potentials, studies that estimated regional reduction potentials were used.

The estimates do not reflect optimization modeling or feedbacks among different technologies. Many emission reduction measures have interactive effects. The cost and magnitude of reductions achievable through end-use energy efficiency, for example, will depend heavily on the mix of energy supply technologies. TAA has attempted to account for these possible interactions, but it is not possible to truly reflect feedback effects or to develop an "optimized" supply curve. Thus, the Supply Tool© provides a static view of global and regional mitigation potential.

Several caveats should be noted in interpreting these estimates. First, a considerable degree of uncertainty is inherent in the data underlying the cost curves. Even the best studies of technical potential are subject to large error bars, especially on a global level. Likewise, costs depend on a large number of underlying assumptions and uncertainties. Nevertheless, TAA has sought to make the data as consistent and accurate as possible for use in the GHG Supply Tool©.

Sources: Jakeman, et al. (2001), Jotzo and Michaelowa (2002), Sijm, et al. (2000) and Trexler and Associates, personal communication (2003).

Table A-8
Foreign Direct Investment and Official Development Assistance
(billion US dollars)

	1997	1998	1999	2000	2001	2002
	Foreign Direct Investment					
East Asia, South Asia and Pacific	$67.1	$61.1	$52.0	$47.1	$53.0	$62.0
Latin America and Caribbean	$66.1	$73.4	$87.8	$75.8	$69.3	$42.0
Middle East and Africa	$14.3	$14.0	$11.3	$8.5	$19.3	$10.0
Europe and Central Asia	$21.8	$26.0	$28.3	$29.2	$30.1	$29.0
Total	**$169.3**	**$174.5**	**$179.4**	**$160.6**	**$171.7**	**$143.0**
	Official Development Assistance					
East Asia, South Asia and Pacific	$10.9	$12.9	$13.7	$12.2	$12.7	
Latin America and Caribbean	$4.5	$4.5	$4.7	$3.8	$5.2	
Middle East and Africa	$18.1	$18.0	$16.5	$15.9	$16.6	
Europe and Central Asia	$5.6	$7.0	$9.6	$9.6	$9.1	
Unspecified	$7.6	$7.9	$7.9	$9.0	$8.5	
Total	**$46.7**	**$50.3**	**$52.4**	**$50.5**	**$52.1**	
Source World Bank (2003), Tables A.21 through A.28, pp. 200 - 207.						

Table A-9

Natsource Estimates of Government Demand for Kyoto Units in 2010

	Minimum $MtCO_2e$	Maximum $MtCO_2e$	**Basis for the estimate**
CANADA			
Planned purchases	12	12	Climate Change Plan for Canada
Estimated shortfall of 50 Mt from targeted measures and 60 Mt of undefined additional measures in Climate Plan	0	22	Assume 20% of estimated shortfall and undefined additional reductions
Additional government purchases associated with underestimated growth of trading sectors	0	13.6	Assume 20% of trading sector emissions increase from 1997-2010 and estimated exceedance of target due to faster growth by covered sectors
Additional government purchases associated with overestimated reductions from non-trading sectors	0	34.2	Assume 20% of estimated reductions not associated with planned government purchases or trading sectors
Total for Canada	12	81.8	
JAPAN			
Japan's projected 2010 shortfall from Kyoto target after additional measures are implemented	17.7		Japan's emissions with additional measures = 1 173.0; Kyoto target = 1 155.3 Mt.
Emissions 20% higher than projected, industry purchases shortfall from 1990 – 7% target and government purchases the balance		217.6	Total shortfall = 252.3 (total emissions + 20% less Kyoto target) – 34.8 (industry purchases) = 217.6 Other scenarios have lower government purchases
Total for Japan	17.7	217.6	
EUROPEAN UNION			
Requirements after reductions from additional policies and measures and purchases by EU trading sector	53.9		Shortfall after additional policies and measures = 98.9 less trading sector purchases of 45 = 53.9
Requirements with high government share of shortfall with higher emissions and less effective policies		462.8	Total emissions 20% higher than forecast and policies 20% less effective than planned yields shortfall of 694.2 of which government purchases 67%
Total for European Union	53.9	462.8	
Total Government Purchases	**83.6**	**762.2**	
Source: Natsource (2003), Appendix A, pp. 64-69			

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