December 1999 ECN-C--99-095

POTENTIAL AND COST OF CLEAN DEVELOPMENT MECHANISM OPTIONS IN THE ENERGY SECTOR

Inventory of options in non-Annex I
Countries to reduce GHG emissions

On behalf of the Netherlands Development Cooperation (DGIS)

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Abstract

This report presents an assessment of the potential and cost of the Clean Development Mechanism as an instrument to partially meet the Greenhouse Gases emission limitation commitments of the Netherlands for the first budget period, 2008-2012. Information about the cost and emission reduction potential in the energy sector has been collected from national mitigation studies. In total, some 300 GHG emission reduction options in 24 non-Annex I countries have been collected Together, these countries account for two-thirds of current non-Annex I GHG emissions.

The mitigation potential in non-Annex I countries is significant when compared with Annex I reduction requirements. The inventory of mitigation options suggests that an annual mitigation potential in the first budget period at costs up to 1990 USD 10/ton CO_2 is approximately 1.7 Gt CO_2 equivalents. However, this estimate should be viewed with caution, as the mitigation studies on which this estimate is based have been carried out as capacity-building exercises and they should not be viewed as definitive, technically rigorous, exhaustive, analysis of national GHG mitigation potential.

Acknowledgement

This study has been carried out jointly by ECN Policy Studies, The Netherlands, Alternative Energy Development, Inc., USA, and Stockholm Environment Institute-Boston, USA, under a contract of the Directorate General of International Co-operation (DGIS) of the Ministry of Foreign Affairs. The project leader was Mr N.H. van der Linden (n.vanderlinden@ecn.nl). This report is registered at ECN under number 7.7201. The following persons have contributed to this report.

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SUMMARY

The present report assesses the potential of the Clean Development Mechanism (CDM) as an instrument to partially meet the Greenhouse Gas (GHG) emission limitation commitments of the Netherlands for the first 'budget period', 2008-2012. The Dutch government made the aforementioned commitments by signing the Kyoto Protocol, drafted at the Third Conference of the Parties in 1997, and the subsequent EU burden sharing agreement. The GHG assignment to which the Netherlands is committed for the first budget period, amounts to 94% of the 1990/95 benchmark emission level of 219 million tonnes of CO_2 equivalents per annum. Compared to a credible baseline scenario, this will require a reduction in middle budget year 2010 of at least 50 million tonnes of CO_2 equivalents.

The signing of the Kyoto Protocol initiated the debate on the design of the three flexible mechanisms. The CDM has received the most attention because it will be the first of the flexible instruments to become operational once the Kyoto Protocol is ratified. The debate on the CDM is centred around a number of complex and contentious issues such as the design of the baseline, the concept of additionality, distribution of credits between host country and investor, and the problem of gaming and leakage. These issues need to be resolved if the CDM is to become an effective means by which the emission reduction and sustainable development commitments of the Kyoto Protocol can be met. The focus of this study however is on the assessment of the potential and cost of GHG emission reduction options in the energy sector in the non-Annex I countries.

The CDM has the potential of an important mechanism to assist Annex I countries in fulfilling their targets and to allow developing countries to meet national development targets. This study, commissioned by the Netherlands Development Co-operation (DGIS), aims to assess the potential market of CDM, cost of generating Certified Emission Reductions (CERs) and identifying promising technologies. The study is based on a comprehensive compilation of abatement costing studies, projects carried out within the framework of Activities Implemented Jointly (AIJ) and projects under the Global Environment Facility (GEF).

Information about the cost and emission reduction potential has been collected for some 280 GHG options from GHG abatement costing studies in 24 non-Annex I countries. Together, these countries account for two-thirds of current non-Annex I GHG emissions. In addition, some 60 AIJ/GEF projects have been reviewed. This information has been entered into a database of CDM opportunities, aggregated for the 24 non-Annex I countries, and extended to the rest of the non-Annex I region, using a simple extrapolation method.

The resulting GHG abatement cost curve is depicted in the figure below, for those options with an incremental economic cost below 50 USD/ton CO_2 (all costs in 1990 USD unless otherwise specified). The projected total potential for the Non-Annex I countries at economic costs per tonne up to 50 USD amounts to 2.25 Gt of CO_2 equivalents. Most of this potential is projected to be achievable at quite low costs. Up to 1.6 Gt/yr appears feasible at economic costs of USD 6/ton CO_2 or lower.

Even this rough quantitative estimate should be viewed with caution, as the cost and magnitude of abatement options that might ultimately be realised through the CDM will likely differ significantly from this figure. There is reason to believe, for instance, that the above estimate understates the total magnitude of CDM potential available at a given economic cost: numerous abatement costing studies excluded significant abatement options for lack of data, resources, and/or necessity; furthermore, active CDM markets are likely to uncover additional options that could not be easily included in modelling studies. On the other hand, there are reasons to

believe that the above figure might considerably overestimate the CDM potential at actual investor costs: investor costs are likely to significantly exceed economic costs reported in the abatement costing studies.

Abatement costing studies may neglect transaction costs and barrier reduction costs for many options, some measures might not be exploitable under the modalities ultimately adopted for the CDM regime, and most importantly, the investor may not recoup many of the economic benefits that accrue to other stakeholders as the result of a CDM project (and are factored into the above calculations).

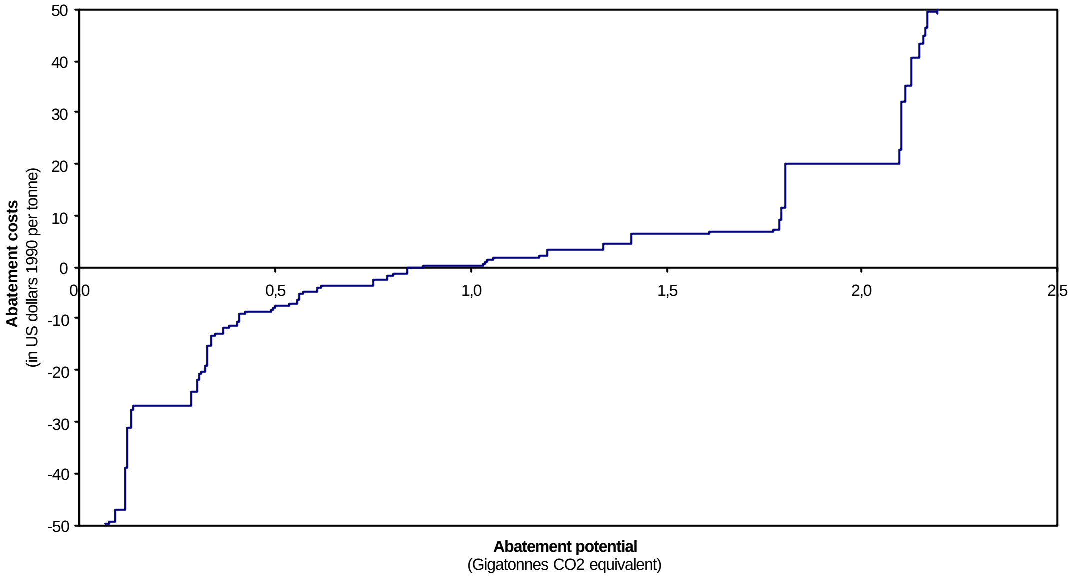

Figure S.1 *Extrapolated CO_2 abatement cost curve for all non-Annex I countries*

Only options in the energy sector have been considered. Other GHG abatement options might be pursued under the CDM, such as ‘sinks’ projects in the agriculture and forestry sectors, but these options have not been considered in the present study. GHG reduction options have been classified according to three main categories: non-power supply, power supply and demand side. Each category is further divided into three sub-categories: energy efficiency, renewable energy and fuel substitution. The figure below shows, for the non-Annex I countries for which detailed data was available, the distribution of total GHG abatement potential over the technologies DS-EE (Demand Side Energy Efficiency), DS-FS (Demand Side Fuel Switch), NPS (Non Power Supply), PS-FS (Power Supply Fuel Switch), PS-RE (Power Supply Renewable Energy) and PS-EE (Power Supply Energy Efficiency).

Two types of activities are indicated to encompass most abatement potential, i.e. energy efficiency measures in the power sector and demand side energy efficiency measures (together 66%). The role of renewable energy is limited to 14% of identified abatement measures and the role of fuel switch (from oil or coal to natural gas) is 17%.

The costs of reduction options do not necessarily correspond to the price that will be charged to potential 'buyers' of a particular option. The price is a function of both the supply of, and the demand for, CDM-based emission reduction in the Annex I countries, and as noted above, the supply curve of reduction options may not accurately represent the costs borne by CDM investors.

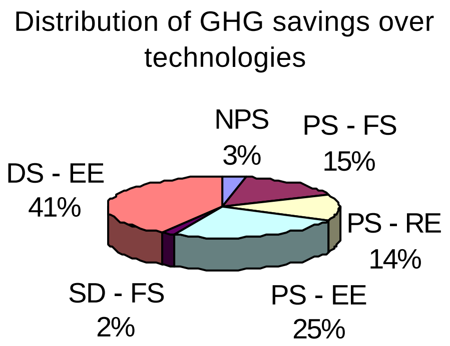

Figure S.2 *Distribution of abatement potential over technologies*

Using the available data, however, an attempt has been made to obtain rough indications of the market clearing price per tonne of GHG abatement through CDM by combining the non-Annex I marginal cost curve (suppliers of CDM options) established in the present study with the Annex I marginal cost curve (buyers of CDM options) developed in earlier studies (Harmelen et al, 1997). The main purpose of doing so is to gain useful insights into the potential of CDM and the price CDM buyers may have to pay for obtaining 'Certified Emission Reduction units' (CERs) from CDM projects. Price projections, derived this way, should be seen as a preliminary indication since there is much uncertainty in the modalities of the CDM and JI regimes and the response of the Parties to their Kyoto targets. Furthermore, no account was made of the possibility of credits banking. The demand for credits are for the period of 2008 to 2012 while the supply of credits can, in principle, take place from 2000 to 2012. The result of this preliminary analysis suggests that the presence of CDM could decrease the global CER trading price from USD18-29/tonne of CO_2 equivalents down to a level of USD 4-15/tonne during the first budget period, assuming that options will be available at roughly the scale and economic costs indicated in the literature reviewed.

1. INTRODUCTION

1.1 Background

During the third session of the Conference of the Parties to the United Nations Convention of Climate Change (UNFCCC), held in December 1997 in Kyoto, Japan, reduction targets for GHG emissions for the period 2008-2012 (compared to the reference year) were agreed for the US (7%), the EU (8%) and Japan (6%). Subsequently, during the meeting of the European Council in June 1998, an agreement was negotiated to divide the EU reduction target between the various EU member states. The Netherlands agreed on a reduction target of 6%, which corresponds to 50 million ton CO_2 equivalents per year below the expected baseline scenario.

The Dutch government is currently in the process of formulating policies to achieve the agreed reduction target. In addition to reduction options in the Netherlands, the Kyoto Protocol offers the possibility of meeting national commitments by reducing GHG emissions abroad. Three flexible instruments - Clean Development Mechanism (CDM) for non-Annex I countries, Joint Implementation (JI) for Annex I countries and emission trading between Annex I countries - have been adopted in the Kyoto Protocol although the specific conditions under which the CDM can become operational still have to be defined.

Several studies have already been conducted to identify the potential and cost of GHG reduction options in the Netherlands (Beeldman et al, 1998) and in Eastern Europe (Harmelen et al, 1997). However, to enable a proper evaluation of options taken domestically and options taken abroad, it is essential to also have better insight into the potential and cost for GHG reduction options in the non-Annex I countries. This is particularly true because, from 1 January 2000 onwards, the credits produced by projects in non-Annex I countries can be banked to be used by the Annex I recipient country during the commitment period 2008-2012[1] to meet national commitments. In comparison with JI and emission trading and with reduction options in the Netherlands, the CDM provides an initial eight years to help meet national commitments. This is an important incentive to initiate emission reduction projects under the CDM.

The CDM can be considered as an important option for achieving (a part of) the national reduction target. The merits and problems of the CDM compared to the other reduction options should be thoroughly analysed and evaluated. To this end, the Ministry of Foreign Affairs, Netherlands Development Co-operation (DGIS), commissioned the Netherlands Energy Research Foundation (ECN) to conduct this study with the objective to identify GHG emission reduction options in non-Annex I countries and to assess the associated costs.

The study has been conducted during the period January - April, 1999. The study team consisted of the following institutes:

- Unit Policy Studies of the Netherlands Energy Research Foundation (ECN-BS), Petten, The Netherlands.
- Alternative Energy Development, Inc. (AED), Silver Spring, USA.
- Stockholm Environment Institute - Boston (SEI-B), Boston, USA.

[1] assuming international agreement is reached on the rules and administration of the CDM

1.2 Objectives

The objectives of this study are to:

- investigate the potential for GHG emission reduction in non-Annex I countries,
- consider which GHG reduction options would be amenable for the CDM,
- assess the likely cost and market for various CDM emission reduction projects in non-Annex I countries,
- design a GHG abatement costs curve for the non-Annex I countries.

1.3 Scope of the study and purpose of this report

The signing of the Kyoto Protocol initiated the debate on the design of the three flexible mechanisms. The CDM has received the most attention because it will be the first of the flexible instruments to become operational once the Kyoto Protocol is ratified. The debate on the CDM is centred around a number of complex and contentious issues such as the design of the baseline, the concept of additionality, distribution of credits between the host country and the investor and the problem of gaming and leakage. These issues need to be resolved if the CDM is to become an effective means by which the commitments of the Kyoto Protocol can be met.

The focus of this study however is on the assessment of the potential and cost of GHG emission reduction options in the energy sector in the non-Annex I countries. Obviously, the issues mentioned above will affect the potential as well as the cost of these options. But rather than wait till the debate has reached a consensus among all parties involved, a first order estimate of potential and cost can be approximated by means of a compilation and review of existing country GHG abatement costing studies and implemented projects.

This study is particularly important because Annex I countries like the Netherlands are faced with the question of the extent to which CDM can assist them in fulfilling the agreed reduction obligation. To incorporate this information into the decision-making process requires sufficient insight into the potential and associated cost of CDM options. This study is based on a comprehensive compilation of abatement costing studies and projects carried out in the framework of the Activities Implemented Jointly (AIJ) Program and the Global Environment Facility (GEF). Potential and cost information on some 280 GHG reduction options in the non-Annex I countries and some 60 AIJ/GEF projects has been collected and systematically entered into a CDM data base which was specifically designed for this study.

Although this wealth of information provides a firm basis for detailed analysis on the total potential and cost of the CDM, the results should nevertheless be interpreted with caution. It was not within the scope of this study to verify, supplement, or correct the underlying data, even when evident shortcomings were suspected. However, where possible, minor adjustments have been made in order to establish a common and consistent database across all countries.

The aggregated abatement costs curve derived from technology based bottom-up analysis enables the identification of attractive CDM technology options and is an appropriate approach for providing projections of the incremental costs of GHG emission reduction at the sectoral level. In addition to bottom-up models, macro-economic top-down models can provide insight into the indirect and secondary effects and into the interactions between the sectors and, at a global scale, between the various parties. For example, macro-economic models can be applied to analyse the potential gains from emission trading for the various parties and to illustrate the effect of constraints on the selling or buying of CERs (for example, Ellerman et al, 1998a and 1998b).

1.4 Organisation of the report

This report is laid out as follows. Chapter 2 contains a general description of the approach used to achieve the objectives and addresses a number of relevant analytical issues. Chapter 3 presents the results by means of an aggregate abatement costs curve for the non-Annex I countries and an abatement costs curve based on project information. Finally, Chapter 4 contains the conclusions.

2. APPROACH

2.1 General overview of the approach to the study

The approach is based on a review, comparison, evaluation and integration of abatement costing studies and implemented projects in the non-Annex I countries. The approach consists of the following components:

- abatement costing studies,
- project information,
- comparison of information obtained from projects and abatement costing studies,
- demand - supply aspects.

The approach is depicted schematically in Figure 2.1 below.

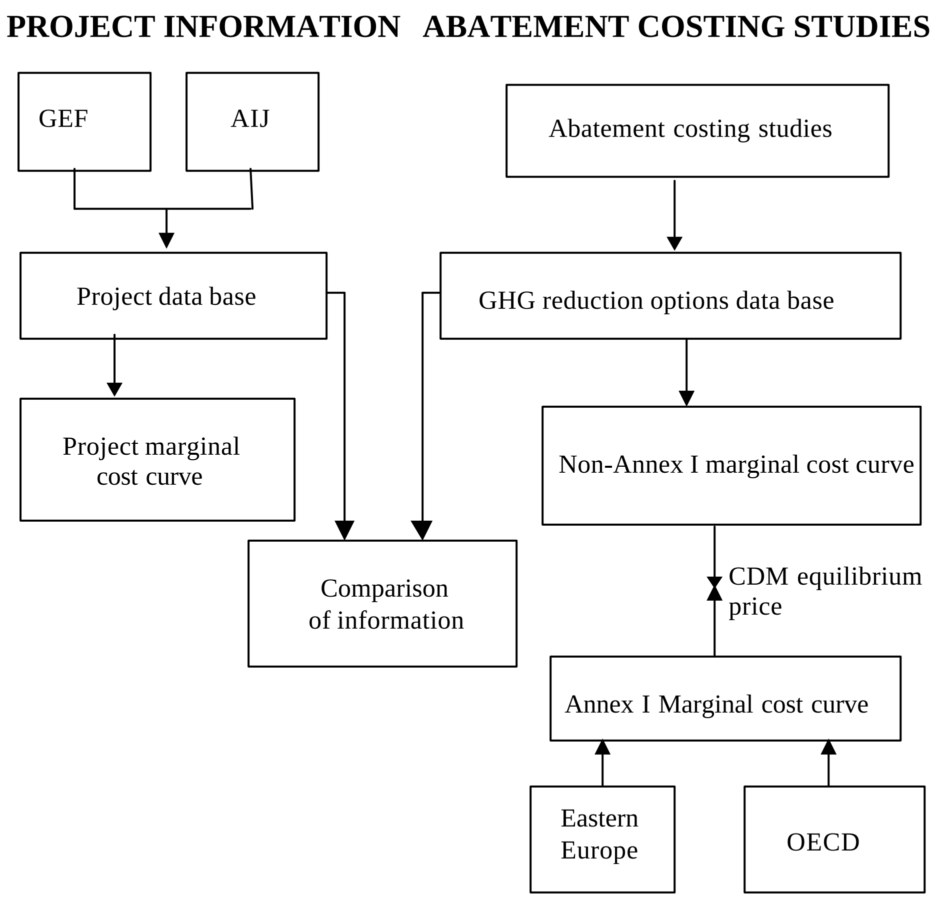

Figure 2.1 *Schematic illustration of the approach*

2.1.1 Inventory of options based on abatement costing studies

The aim of an abatement costing study is to identify a broad range of available options for a specific country to reduce the GHG emissions and to determine the reduction potential and associated cost for each option. Thus, a number of available abatement studies for non-Annex I countries were analysed and the results compiled in an inventory of the abatement options, their projected potential in the year 2010, and their associated project and GHG abatement costs.

Total global CO_2 emissions in 1995 are 21.8 Gt CO_2, of which roughly 36% stems from Non-Annex I countries. Appendix I shows that more than 90% of CO_2 emissions is concentrated in the 44 largest Non-Annex I countries.

The project team acquired GHG abatement costing studies for 24 non-Annex I countries. Of the countries covered, 13 are situated in Asia, 7 in Africa, and 4 in Latin America. The 24 non-Annex I countries for which abatement costing studies were available comprise a fairly extensive sample. These 24 non-Annex I countries currently account for no less than two thirds of total GHG emissions in non-Annex I countries (see Annex I for an overview of CO_2 emissions per country).

The principal national abatement costing studies have been obtained from the following sources:
- Asia Least-cost Greenhouse Abatement Strategy (ALGAS) project, sponsored by the UNDP/GEF and ADB in association with 11 Asian countries - Bangladesh, China, India, Indonesia, Mongolia, Myanmar, Pakistan, Philippines, Republic of Korea, Thailand, Vietnam.
- UNEP Greenhouse Gas Abatement Costing Studies - 9 countries - Argentina, Botswana, Egypt, Jordan, Senegal, Tanzania, Venezuela, Zambia, Zimbabwe.
- Country Studies Program with support from the United States - 3 countries-Kazakhstan, Mexico, Nigeria.
- The Netherlands Climate Change Assistance Programme - 1 country - Bolivia.

Each of the 24 studies used offers a set of GHG abatement options and their projected unit abatement cost and total abatement potential. These options only include CO_2 and CH_4 and not one of the other GHGs as determined in the Kyoto Protocol. Due to the nature of the exercise it was not possible to distinguish what amount was CO_2 related and what amount CH_4.

In principle, the unit abatement costs are on a net incremental basis relative to the costs in the baseline scenario. The abatement options were then categorised as 'eligible for CDM' or 'non-eligible'. Non-eligible options related to policy and institutional measures that are not likely to be amenable to funding by CDM project investors and the corresponding transfer of emission allowances. Sequestration options (afforestation, etc.) were also excluded, since this study is focusing on the energy sector. Eligible options were broken down into three categories: non-power supply, power supply and demand-side; each category was further divided into three subcategories: energy efficiency, renewable energy and others.

A simple extrapolation method has been employed to estimate the reduction potential for the missing non-Annex I countries (corresponding to the remaining one-third of non-Annex I emissions) based on the 24 non-Annex I countries for which abatements studies are available. Finally, a non-Annex I abatement costs curve has been derived which can be regarded as a first order estimate of the supply curve for CDM options from the non-Annex I countries.

2.1.2 Inventory of options based on AIJ/GEF projects

The abatement costing studies provide information at the macro level. Potential and costs of a particular option are not based on actual cases, but on model simulations and expert opinions of the total potential and the average costs. One would expect to get more accurate and detailed cost information from concrete projects, which have been implemented in the non-Annex I countries.

In the course of the present study, information on potential and costs were obtained for some 60 different projects under implementation. Although the total GHG reduction brought about by these projects is small in terms of total estimated reduction potential in the non-Annex I countries (some 3%) and the type of projects are heavily biased towards renewable energy projects, this information nevertheless offers the possibility to verify at least part of the cost information collected in the abatement costing studies and it also gives more insight into the institutional aspects which may hamper the implementation of projects and, consequently, affect the cost of the project. The project information has been obtained from the following sources:

- Activities Implemented Jointly Programmes
- Global Environment Facility.

A pilot phase for Activities Implemented Jointly was established during the first meeting of the Conference of Parties in Berlin in 1995. The emission reduction realised during this pilot phase cannot be added to the emission reduction target of investing countries. Furthermore, COP1 (Decision 5/COP.1) defined a number of criteria for AIJ projects. (UNFCCC, 1999).

A number of precautions should be borne in mind by translating AIJ projects into CDM projects. The absence of real crediting at AIJ projects makes it difficult to consider the AIJ projects as the beginning of the CDM market. Additionally, the absence of clear definitions for the 'additionality' and contribution to 'sustainable development' differentiate AIJ projects from CDM projects. Apart from that, project costs did not need to be reported under the AIJ framework, and are often confidential for protection of sensitive commercial information. Despite these limitations, projects implemented under the AIJ pilot phase provide a preliminary indicator of interest in different sectors and project categories selected for abatement of CO_2 in Non-Annex I countries.

By early 1999, approximately 123 AIJ projects were planned or under implementation (JIQ, 1999), of which 40 were in non-Annex I countries. Of these 40 projects, 28 involved energy related activities and 16 had project information that could be obtained through the UNFCCC (1998). In addition, information on three projects could be obtained from the Netherlands Development Co-operation, which were not included in the list of JIQ.

Table 2.1 *Overview of AIJ projects*

Type of project	Number
Total number of AIJ projects identified, of which:	126
in Non-Annex I Countries	43
energy involved	31
information retrieved and analysed	19

The Global Environment Facility has been set up as a mechanism to finance the agreed incremental costs of activities that benefit the global environment in four focal areas: climate change; biological diversity; international waters; and stratospheric ozone. Activities concerning land degradation, primarily desertification and deforestation, as they relate to the four focal areas, are also eligible for funding.

As the starting point for the selection of GEF projects, the 'Operational Report on GEF Programs', for September 1998 (GEF, 1998) was consulted. Excluding the global and regional projects and the projects implemented in Annex I countries, a total number of 59 projects was considered as the starting list. Correcting for the number of documents which we were unable to retrieve and adding 2 projects submitted for approval after September resulted in total of 41 projects from the GEF that were analysed (see Table 2.2).

Table 2.2 *Overview of GEF projects*

Type of project	Number
In Non-Annex I Countries	61
Included in analysis	41

Among the GEF projects analysed, not all projects may have been implemented due to various reasons, like the financial crisis in Asia, political reasons or project specific reasons. The few projects for which it was known that they were cancelled have still been included in the database, because they still provide valuable information on abatement projects.

2.1.3 Design of the GHG reduction options database

To facilitate the processing of country and project information two separate data bases have been developed which contains all the information extracted from the country reports and the project reports. The main purpose of these databases is to systematically store the large amount of information and to generate abatement costs curve based either on all options contained in the database or on a specific sub-set of options. This latter will facilitate the generation of cost curves for all options considered eligible for CDM, for all options with positive incremental cost (excluding the ‘no-regret’ options) or for all renewable options, for example. This flexibility allows an analysis of several scenarios reflecting different possible conditions/rules under which CDM could become operational.

2.1.4 Comparison of information

Initially, the intention was to combine the project-based cost information with the potential estimates from the abatement costing studies. Because project-based cost information is likely to be more accurate compared to the average cost estimates of reduction options, combining the two types of information could result in a more accurate non-Annex I abatement costs curve.

However, this appears not to be possible because the project-based information collected so far is too limited to establish a sound link with the about 290 reduction options obtained from the abatement costing studies. A comparison of cost information between project cost information and the abatement costing studies revealed only 6 corresponding technology-country combinations. In other words, only 6 cases could be identified, out of the 290 reduction options database and 60 AIJ/GEF projects database, whereby the technology and the country correspond in both databases. No meaningful conclusions can be drawn from this small sample.

2.1.5 Demand - Supply Aspects

The marginal cost curve for the non-Annex I countries shows how much it would cost to implement a particular reduction option, and what the estimated reduction potential is for that option. The costs however do not automatically correspond to the market clearing price that will be charged to potential ‘buyers’ of a particular option. The price is theoretically a function not only of supply of CDM options, but also of the demand of CDM options. The equilibrium price of GHG offsets will gravitate towards the point at which the marginal cost of reducing GHG emissions in the Annex I countries is equal to the marginal cost of producing GHG offsets in the non-Annex I countries (Hassing and Mendis, 1998).

It was beyond the scope of this study to examine the GHG offset market mechanism in detail, but an attempt has been made to paint the broader picture by combining the non-Annex I marginal cost curve (suppliers of CDM options) established in the present study with the Annex I marginal cost curve (buyers of CDM options) developed in earlier studies (Harmelen, 1997). The main purpose of this activity is to gain useful insights into the potential of CDM and the price CDM buyers may have to pay for obtaining 'Certified Emission Reduction' units (CERs) from CDM projects. This provides a unique attempt to quantitatively derive the market price of CERs. However, it should be seen as merely a preliminary estimate since there is so much uncertainty in the modalities of the CDM and JI regimes, the response of the Parties to their Kyoto targets, and the actual breadth and depth of abatement options that will ultimately emerge.

2.2 GHG reduction options considered

A reduction option may involve a switch in technology or fuel, a change in behaviour or a process of restructuring of energy sub-sectors. Only options in the energy sector have been considered. Other GHG abatement options might be pursued under the CDM, such as 'sinks' projects in the agriculture and forestry sectors, but these options have not been considered in the present study[2].

GHG reduction options have been classified according to three main categories: non-power supply, power supply and demand side. Each category is further divided into three sub-categories: energy efficiency, renewable energy and fuel substitution. The following table shows the allocation of reduction options and projects over the categories and sub-categories.

Table 2.3 *Allocation of reduction options over various categories*

Category	AIJ/GEF Projects	Abatement options
Non Power Supply	2	12
- Energy efficiency	2	5
- Renewables		4
- Fuel substitution		3
Power Supply	37	84
- Energy efficiency	2	29
- Renewables	34	39
- Fuel substitution	1	16
Demand Side	21	151
- Energy efficiency	21	132
- Renewables		5
- Fuel substitution		13
Not eligible		25
Not identified		6
TOTAL	60	278

Some 30 options have been screened out for which direct emission reductions would be difficult to certify (e.g. taxes or subsidies) or otherwise less amenable to CDM.

These GHG reduction options have been gathered from abatement costing studies carried out by in-country analysts. While this suggests that the measures are presumably consistent with local development priorities, this may or may not be true. Host countries might ultimately choose to put in place certain screens on CDM projects to ensure consistency with development priorities.

2 The reason why only energy sector projects are considered is that the projected GHG emissions from the energy sector will account for more than 70% of the total global GHG emissions. Furthermore, it is unlikely that most forestry and land-use related projects will meet the strict CDM criteria of contributing to sustainable development and having 'measurable long-term benefits' for the reduction of GHG emissions (see Hassing and Mendis, 1998).

2.3 Common analytical issues

Energy models
The energy models used in the abatement costing studies are bottom-up models such as MARKAL, EFOM and LEAP. Bottom-up models contain detailed information on specific technologies, but are less capable to describe the interactions between the energy sectors and the rest of the economy. Macro economic top-down models have been developed to analyse the impact of measures taken in the energy sector on the other economic sectors. However, these studies have not been reviewed.

With respect to aggregating results in bottom-up models, it is important to note that mitigation options are strongly interacting, i.e. the whole is clearly unequal to the sum of its parts. This is especially true for certain mutually exclusive options such as cogeneration with natural gas versus biomass, or possibly new vehicles versus vehicle fuel switching. For most abatement costing studies analysed, it was not possible to ascertain whether the studies accounted for these interactions.

Timeframe
The timeframe over which CERs from CDM projects are to be considered is clearly defined in the Kyoto Protocol to be that period from the year 2000 up to the end of the first commitment period which commences in 2008 and ends in 2012. This provides CDM projects an opportunity for banking of credits (i.e. utilising credits generated between 2000 and 2008 in the commitment period 2008-2012). This provides a significant advantage for CDM projects as compared to projects carried out under the Joint Implementation framework.

At the same time, it is important to recognise that only a maximum of 13 years of GHG reductions from a project would be eligible for consideration in the CDM (assuming the project is initiated in 2000). Many CDM projects may have an economic life in excess of 13 years and therefore will potentially provide credits for subsequent budget periods. However, the GHG offset value of the project would, by definition of the Kyoto Protocol, have to be recovered in a period of 13 or less years. This can have a significant impact on the average costs of the associated GHG emissions as the incremental or additional costs of the CDM project would have to be recovered by the sale of a smaller volume of emissions than would be available if the entire project life is taken into consideration.

The data utilised in this analysis does not necessarily recognise the timeframe restriction provided by the CDM. As a result, there is a strong possibility that the costs of CO_2 reductions, as represented in the database, underestimate the costs of emission reductions that would be represented by CDM projects.

Additionality and baselines
Each abatement option that is considered in an abatement costing study is presumed to be over and above any existing GHG-reducing behaviour, and to cause GHG emissions reductions that are *additional* to any that might be occurring anyway. The GHG benefit of a given abatement option is quantified by comparing to a credible *baseline* emissions path that can be justified on technical, policy, and economic grounds. The definition of the baselines (or reference scenarios), therefore, is a critical step in assessing the efficacy of GHG abatement activities.

The baseline should capture, to an adequate degree of accuracy and certainty, the greenhouse gas emissions that would result if the abatement option were not carried out. The projected baseline scenario therefore requires a fairly detailed understanding of the country’s sources of emissions and future trends. It must rely on projections regarding growth rates of the population and economy, structural changes in energy-using sectors, evolution of fuel supplies and prices, technological and infrastructural changes, etc. It should also reflect compliance with all applicable laws and agreements, including measures that would have to be adopted anyway to satisfy the Kyoto Protocol requirements.

Such projections, of course, are exceedingly difficult to foresee with confidence. As with any prognosis, there are great uncertainties, especially for developing countries, where the domestic economies are dramatically changing and connections to the global economy are rapidly evolving. Any projection regarding the future structure of a sector is somewhat speculative, which introduces considerable uncertainty into GHG abatement costing studies, as well as opportunities for gaming.

An illustrative example of the problems one might come across when designing a baseline scenario for a particular project is a GEF project on Solar Home Systems. In this particular project, Solar Home Systems will replace kerosene as energy source for light in rural households. According to GEF guidelines, one should compare the costs and benefits of the clean alternative for the same level of energy services as the baseline technology would provide. The question is what amount of kerosene to take as the baseline of the SHS:

1. The current consumption is 4 litres per month. Normally this amount would be the baseline fuel consumption, because this will be the actual CO_2 emissions reduced.
2. However, 4 litres of kerosene does no compare to the same level of energy services provided by a SHS. The SHS will increase the amount of lights in the house and the time they will be used. To compensate for the increase in lights, 15 litres of kerosene would be required as the baseline.
3. Also, the SHS provides a higher quality of light than kerosene would. If the amount of lumen would be taken as the reference point for the baseline, 60 litres of kerosene would be the appropriate baseline, making the SHS a negative cost option.

Discounting

In abatement costing studies reductions are not discounted for most of the GHG reduction projects considered in the database. However, monetary flows are discounted. Details on the exact rates of discount vary, as do the assumed rates for various projects. As the monetary discount rate is a function of local monetary conditions, it is difficult to generalise or adopt a uniform monetary discount rate for all projects. Thus, the actual costs of GHG reductions from a specific type of project may have a wide range of values depending on the assumed discount rate employed. Similarly, the costs of GHG reductions from a specific type of project will tend to vary from one country to another depending on the prevailing discount rate, all other factors remaining equal. This issue of the variance of the discount rate will lead to a variance in the estimated GHG reduction costs entered into the database.

In project analysis, ideally a uniform discounting methodology should be applied. As a standard for discounting it was chosen to discount the costs and not discount the GHG savings (i.e. following Sathaye and Meyers, 1995). Not all projects did provide explicit information on applied discounting methodology and discount rate. The general impression is, however, that in most of the projects the GHG savings were not discounted. For the single cases, which did explicitly discount GHG savings, the GHG abatement figure was corrected.

Discounting cost was most relevant for comparing incremental cost analysis. With regard to investment costs and AIJ cost it was assumed that total expenditures were committed at the start of the project and required thus no further discounting. It was found that for the incremental cost calculations very few projects provided explicit information on applied discounting methodology. In the interpretation of the results of the economic incremental costs, a certain caution should therefore be taken in the exact figure in the curve.

Cost definitions
Cost and benefits of distinct activities can be regarded from three major perspectives: the private perspective, the perspective of the national economy, and the perspective of society. Monetary costs and benefits accruing to individual persons or entities are called *financial costs and benefits*. Cost from the perspective of the national economy, including national external effects, are often referred to as *economic costs and benefits*. When assessing the value of the effects of distinct activities from the broadest societal perspective, including also transborder external effects impacting on other countries, costs and benefits are often referred to as *social costs and benefits*.

In the abatement costing studies, cost of reduction options are assessed from the perspective of the national economy and compared with the baseline scenario. The appropriate basis therefore is the net (costs minus benefits) economic costs compared to the baseline; this is referred to as the *net incremental costs.*

An explanation of how the net incremental costs of a project are determined is given in Table 2.4. The example concerns the Ilumex: High efficiency lighting AIJ/GEF project in Mexico. The objective of this project was to replace approximately 200,000 incandescent light bulbs with Compact Fluorescent Light bulbs (CFLs) in the Mexican cities Monterrey and Guadalajara. The AIJ component is USD 3 million from the Government of Norway and is complemented by USD 10 million from the GEF. Total project costs are USD 23 million (UNFCCC, 1998).

Table 2.4 *Incremental Costs of 'Ilumex: High efficiency lighting project in Mexico' (source: adapted from UNFCCC, 1998)*

Cost category	Costs in millions (1994 USD)
Incremental Costs for GEF/AIJ	
Project Costs	13
Incremental Costs for utility	
Project costs	10
Lost income of unsold electricity	28.5
Incremental costs for consumer	
Cost for consumers (buying CFLs)	12.9
TOTAL INCREMENTAL COSTS	64.4
Incremental Benefits for utility	
Revenues from avoided capacity expansion and electricity generation	98.4
Sales of CFLs	12.3
Incremental benefits for consumer	
Energy savings and avoided purchase of incandescent bulbs	29.7
TOTAL INCREMENTAL BENEFITS	140.4
NET INCREMENTAL COSTS (COSTS MINUS BENEFITS)	-76

The total estimated GHG savings are 727 kton. CO_2 equivalents, resulting in net incremental costs of -105 1994 USD per ton CO_2 equivalents. Total AIJ/GEF contribution amounts to 13 million USD, or 18 1994 USD CO_2 equivalents per ton.

In some cases (for example, in the above project) the net incremental costs are negative (benefits exceed costs). Implementation of these ‘no regrets’ cases can be justified on pure economic grounds. However, in cases of projected negative incremental costs one should consider carefully why the activities concerned have not already been implemented. In some cases, the estimate of negative incremental costs might neglect implementation barriers that can only be scaled at substantial additional costs (e.g. technology transfer, large awareness campaigns, the provision of extension services, use of foreign exchange to arrange loans from foreign financiers, etc.).

The Ilumex project provides a useful example of how financial and economic perspectives can differ. From an economic perspective, the project appears to yield emission reductions at -USD 105/ton, while at the financial perspective of GEF the project cost +USD18/ton. Even though the project is a so-called ‘no-regret’ project, it was unlikely to have happened in absence of GEF assistance. Therefore, such a programme, if initiated under CDM, would likely be considered additional and eligible for crediting, and the cost borne by GEF (+USD18/ton) might be a better indicator of investor costs under CDM than the overall economic cost (-105 USD/ton) of such a CFL programme. This interpretation suggests that the use of abatement costs curves based on economic costs may substantially understate the likely investor cost and price of CERs generated.

3. RESULTS

3.1 Analysis of CO_2 abatement costing studies

3.1.1 CO_2 Abatement costs curve for 24 non-Annex I countries

Figure 3.1 depicts the projected CO_2 abatement costs curve in year 2010 for the 24 non-Annex I study countries for options in the unit cost range of -50 to +50 USD/ton CO_2 equivalents. Out of the total of 247 eligible options included in the database, the unit costs of 22 options are below -50 1990 USD and for 15 options the unit costs exceed 50 1990 USD. Consequently, the abatement costs curve in Figure 3.1 includes 210 CO_2 reduction options.

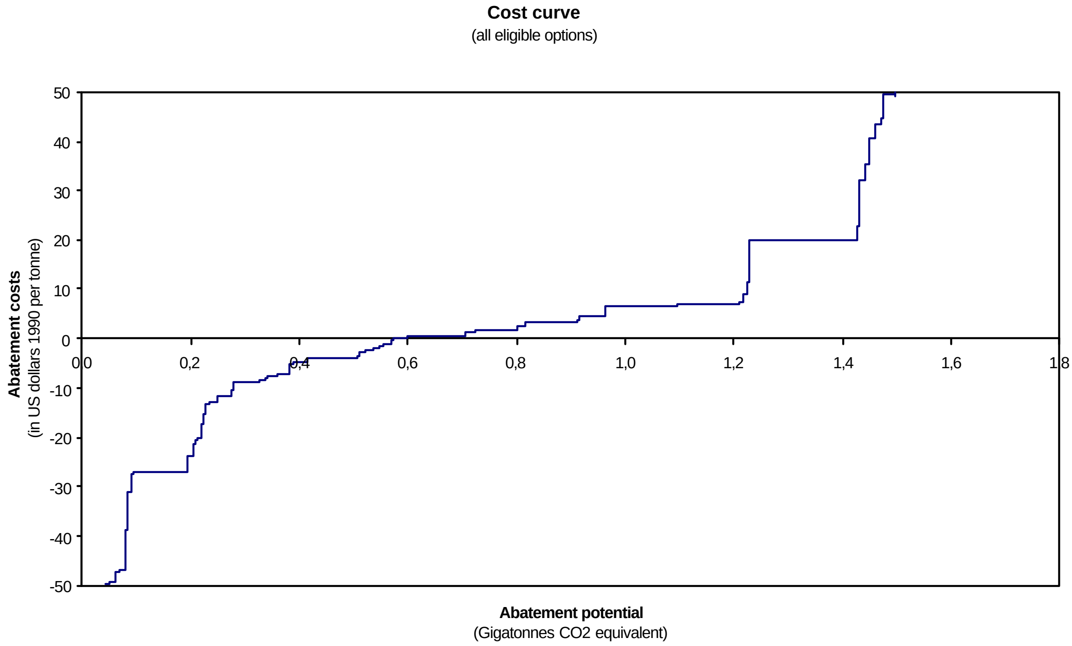

Figure 3.1 *The CO_2 abatement costs for 24 non-Annex I countries*

The total abatement potential in the 24 study countries in the year 2010 at a price of USD 50/ton CO_2 equivalents or lower is estimated at roughly 1.5 Gt CO_2 equivalents. Roughly 38% of this potential is projected to be achievable at negative or zero incremental costs.

Of the total abatement potential for the 24 countries studied, 80% arises from options in only four of the countries (see Table 3.1). Note that for some large non-Annex I countries (Brazil, South Africa) no information could be obtained. The distribution of percentage emissions abated in 2010 as shown Table 3.1 indicates a high variety in percentage of emissions reduced in 2010 (third column). This high variety does not necessarily imply a large in abatement potential between, let's say, China and Egypt. It could also be caused by different approaches of the country study teams or by other limitations in the analysis (see limitations in 3.1.3).

Table 3.1 *Overview of abatement potential in the larger non-Annex I countries*

Country	abatement potential [Mton CO_2]	2010 emissions [%]
China	644	13.3
India	410	26.4
Egypt	105	56.0
Mexico	68	17.0
Subtotal for 4 countries	*1227*	
Remaining 19 countries	300	
Total for 24 countries	*1527*	

The pie chart below shows the distribution of total identified abatement potential in the 24 non-Annex I countries analysed over the following categories:

- Non Power Supply (NPS). This category includes activities related to mining of coal, oil and gas; distribution of gas, but also the provision of biogas and landfill gas.
- Power Supply (PS) includes all renewable power generation options (also small-scale), cogeneration and energy efficiency improvements in existing power infrastructure.
- Demand Side (DS), including options such as energy efficiency measures in households, commercial buildings, industry and transport.
- Not Eligible for CDM (NE-CDM) - these are the type of options such as tax measures, legislation which are deemed not eligible for CDM.
- Not Identifiable (NI). This concerns India and Indonesia. The MARKAL model used in these studies provides only the range of technologies for a given emission reduction, but not the amount of emission reduction per individual option.

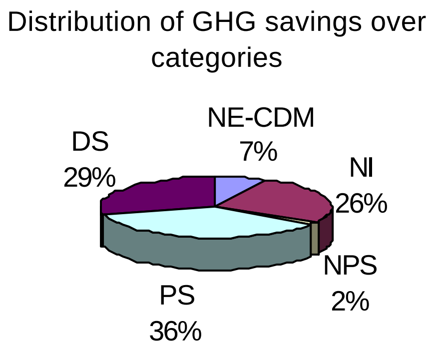

Figure 3.2 *Distribution of abatement potential over categories*

Only 7% of the total identified abatement potential is categorised as 'not eligible' for CDM. Furthermore, the 26% of the total potential that derives from the abatement costing studies for India and Indonesia could not be classified (NI). The abatement costing studies for these two countries are Markal-based integrated analyses, for which option-specific information is not presented. The remainder is distributed between power supply and demand side, with a trivial percentage being non-power supply.

The figure below shows the distribution of total CO_2 abatement potential over the technologies DS-EE (Demand Side Energy Efficiency), DS-FS (Demand Side Fuel Switch), NPS (Non Power Supply), PS-FS (Power Supply Fuel Switch), PS-RE (Power Supply Renewable Energy) and PS-EE (Power Supply Energy Efficiency).

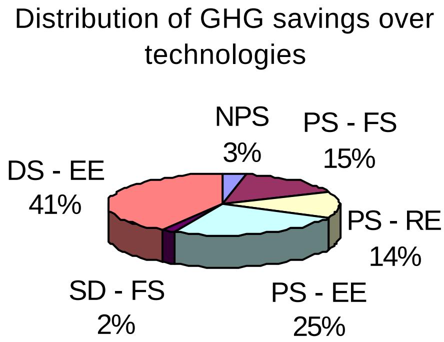

Figure 3.3 *Distribution of abatement potential over technologies*

Figure 3.3 clearly identifies two types of activities, which contain the most abatement potential. Energy efficiency measures in the power sector and demand side energy efficiency measures (together 66%). The role of renewable energy is limited to 14% of identified abatement measures and the role of fuel switch (oil and coal to natural gas) is 17%.

3.1.2 CO_2 Abatement costs curve for all non-Annex I countries

The next step is extending the projected CO_2 abatement unit cost curve of the 24 countries studied to the remaining non-Annex I countries. As no detailed information about abatement options for the other Non-Annex I countries is available, this extrapolation can only proceed in an admittedly rough manner. The following simple extrapolation method has been applied:

- The abatement costs curve for all of non-Annex I countries is derived from the curve for the 24 sample countries by looking at the proportion of CO_2 emissions in 1995 that are from the 24 countries against the emissions in 1995 of all non-Annex I countries. This extrapolation is based on the premise that the remaining non-Annex I countries have a abatement potential that is similar to the abatement potential of the 24 sample countries, as a fraction of total emissions. As mentioned already, the 24 countries considered cover two thirds of the current total CO_2 emissions in all non-Annex I countries, so extrapolating to all of non-Annex I corresponds to scaling up the abatement potential by a factor of approximately 1.5.

The abatement costs curve depicted in Figure 3.2 pertaining to all non-Annex I countries together has been derived from the abatement costs curve depicted in Figure 3.1, as explained above. The projected total potential for the Non-Annex I countries amounts to 2.25 Gt of CO_2 equivalents. This amount corresponds to approximately 17% of the IEA 'Business As Usual' scenario (IEA, 1998) in the year 2010.

The total annual abatement potential in the non-Annex I countries in the first budget period (2008-2012) at unit costs up to 50 USD/t CO_2 has been projected at approximately 2.25 Gt CO_2 equivalents[3]. Most of this potential is projected to be achievable at quite low costs. Up to 1.6 Gt/yr appears feasible at costs of USD 6/ton or lower. *Hence, the main conclusion of the present exercise is that an enormous abatement potential in non-Annex I countries can be potentially harnessed at very low incremental costs.*

[3] The possibility to bank credits produced by projects implemented in the period 2000 - 2008 has not been included in the analysis.

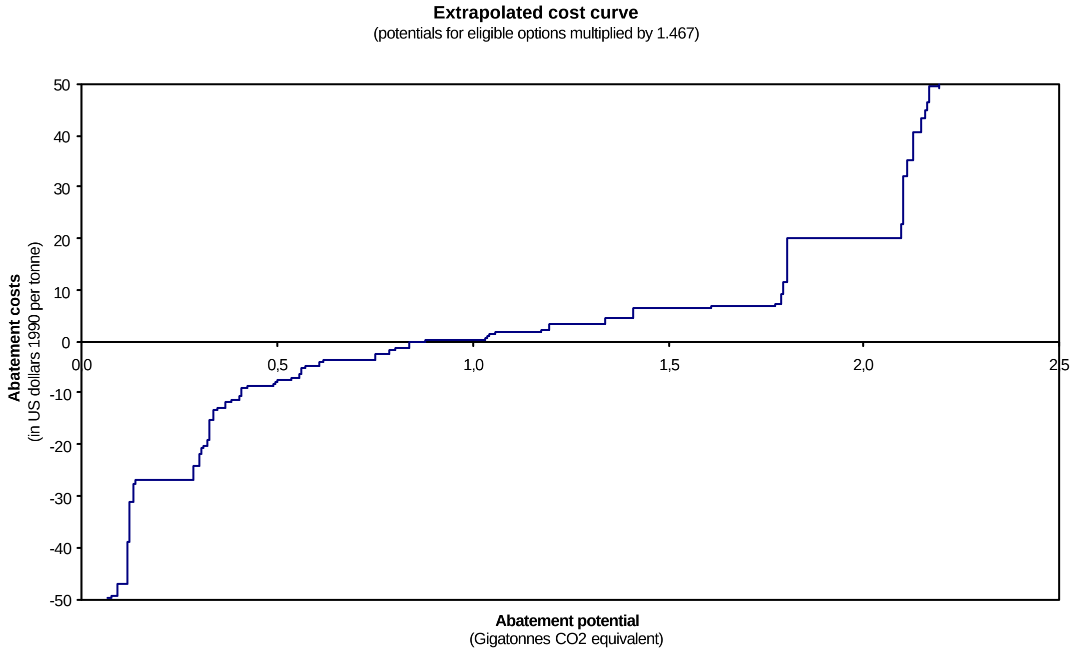

Figure 3.4 *The abatement costs curve for all non-Annex I countries*

3.1.3 Limitations to the analysis

It is important to note some limitations of this analysis and its conclusion. To a large extent, the abatement costing studies on which this analysis is based have been carried out as capacity-building exercises without peer review - they should not be viewed as definitive, technically rigorous, exhaustive, analyses of national GHG abatement potential. Therefore, the inventory of options and the cost curves derived here are subject to the same shortcomings, and should be interpreted cautiously.

Specifically, we would like to note the following limitations:

a. *The abatement costing studies are far from comprehensive.* Most of these studies were implemented as capacity building exercises, rather than attempting to obtain an exhaustive abatement potential of the country. The studies do not exhaustively consider all options, or even *most* options in the case of some countries. While some countries considered as many as 40 options, others considered only 5 or fewer. Some studies considered only one or two sectors, or highlighted a few examples within a sector without estimating total sector-wide potential. For example, Argentina did not consider any demand side options for residential or commercial buildings; Venezuela did not consider any electric supply options; Kazakhstan considered only options for the electric supply sector, Mexico considered cogeneration only, etc.

b. *Different assumptions and approaches across abatement costing studies make it difficult to reconcile and combine results.* In calculating GHG reduction potential and costs, studies make different assumptions about important parameters such as discount rates, fuel prices, global warming potentials, technology characteristics, etc. These assumptions strongly affect the calculated GHG savings potential and cost. The studies also vary considerably with respect to basic modelling approach - some are integrated/optimisation models while some are discrete/option-specific models, yielding results in very different formats. For example, the information available from LEAP-based studies might yield concrete information about specific options, but neglect the interactions between different options. On the other hand, the information available from MARKAL-based studies provide an integrated analysis, but often do not yield enough option-specific information such as emissions savings and cost.

c. *The studies do not reveal all information needed to construct cost curves from all available options*. Most notably, the integrated analyses for India and Indonesia did not reveal the abatement potential and costs for individual options, they only provided combined results for entire scenarios. Other specific problems arose in many studies. The final projection year sometimes differed from year 2010, (e.g. year 2020 or year 2030), necessitating to some extent arbitrary interpolation of projections to the year 2010.
d. *Estimates of abatement potential and incremental costs depend very sensitively on assumptions about the baseline scenarios.* Baseline scenarios are supposed to reflect what would have occurred if the CDM project hadn't been implemented, but no definitive methodology has been, nor can be, designed to unambiguously predict what would have happened. The selection of baseline scenarios in the abatement costing studies therefore depends on the subjective judgement of the analysts. This subjectivity influences many critical assumptions - growth rates of populations and economies, rates of autonomous efficiency improvement, presumed future fuel choices, infrastructural changes, etc.
e. *Definition of costs was not consistent across studies.* In general, the abatement costing studies attempted to calculate the incremental costs of abatement options. However, different definitions of what is incremental (for instance barrier removal) were used by different studies. Economic benefits were excluded in some instances and apparently double-counted in others. Several studies noted that the cost calculations were 'preliminary' and 'highly uncertain', 'merely qualitative'.
f. *CDM transaction costs were often excluded*. Estimates based on AIJ projects in Eastern Europe indicate that project development costs are around 12% and other transaction costs in the range of 1-8% (Harmelen et al, 1997).

3.2 Analysis of AIJ/GEF projects

3.2.1 Introduction

The purpose of collecting cost information and CO_2 savings at the project level is to validate the CO_2 abatement costs curve derived from the country abatement costing studies. As mentioned in section 2.3, three different costs figures where distinguished in the project analysis: The total project costs, the GEF/AIJ contribution and the net incremental costs. In this section, the focus is on the net project CO_2 abatement cost curve since this curve comprises the same cost information as the curves in section 3.1, and on the total GEF/AIJ contribution.

Since the information sources for the projects differ to a great extent in nature compared to the information sources for the country studies, a few critical points should be borne in mind for the interpretation of the results.

Project documents and briefs which were drafted in advance of the start of the project, served as the information source for this analysis. The information is therefore an ex ante projection of estimated CO_2 savings and incremental costs retrieved by feasibility studies. Another critical issue is that total carbon savings over the total project lifetime have been chosen instead of annual carbon savings[4]. This makes the CO_2 savings figures from the project analysis difficult to compare with the CO_2 savings from the country studies in paragraph 3.1. The CO_2 savings from this paragraph should be divided through the technology lifetime in order to be compared with the figures from paragraph 3.1, which means that the figures are on average at least an order of magnitude 10 to 15 too high. Furthermore, in case a range for costs or CO_2 savings was given, the average was taken in the database and costs have been expressed in 1990 US dollars. Finally, for GEF projects major benefits were expected in terms of long-term market transformation and thus large-scale CO_2 savings in the long run. In case a project made this explicit, only the amount of CO_2 emissions directly reduced by the project were used in the analysis.

[4] Note that in some cases, this includes reductions after the year 2010.

Project documentation was found for 79 projects. Out of the 79 project documents, 62 reported useful CO_2 savings in the documentation. Table 3.2 provides an overview for how many projects what costs where reported and what total CO_2 savings are per cost type.

Table 3.2 *Overview of AIJ/GEF projects*

	Projects	GHG Abatement (Gigatonnes CO_2 eq.)
Total projects analysed	79	
Total projects with abatement potential	62	0.635
Total projects with investment costs	60	0.631
Total projects with GEF/AIJ costs	50	0.611
Total projects with incremental costs	31	0.501

3.2.2 The project CO_2 abatement cost curve

The project CO_2 abatement cost curve shown in Figure 3.5 below is derived based on the same methodology as the cost curves derived from the abatement costing studies. However, it was generally difficult to extract reliable information from the project documents regarding incremental costs, so the resulting cost curve should be interpreted cautiously. For one, it should be noted that the fewer project points are included in this figure than in the incremental cost curve from section 3.1. This means that individual projects influence the outcome to a greater extent.

With regard to the interpretation of the results, no conclusions should be drawn from the abatement potential listed on the X-axis. As noted above, these represent total abated CO_2 potential per project and not annual as in Figures 3.1 and 3.4. However, this analysis is useful with regard to comparing the costs on project level with the costs from the abatement costs curve based on bottom up curves.

The project cost curve confirms the shape of the country abatement costs, but is more flat. That implies that the number of projects with high negative costs are less than in Figure 3.1, but on the other hand, the costs rise less fast at the end of the curve. According to this curve, 99% of the potential is below USD10. The share of negative options in the project curve in Figure 3.5 is approximately 60%, which is substantial higher than the 38% of the abatement costs curve shown in Figure 3.1.

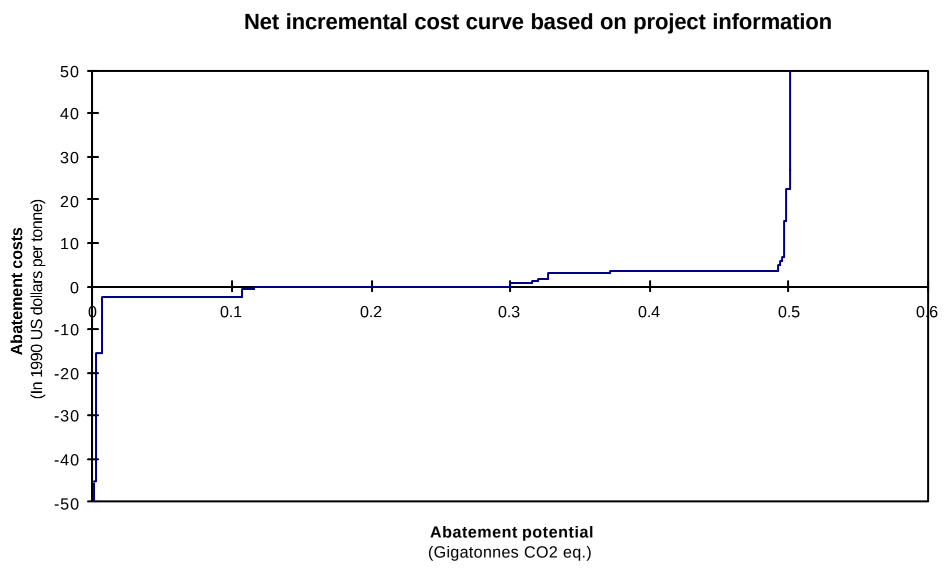

Figure 3.5 *Net incremental cost curve*

In order to be able to properly interpret the results shown above, the following notes are in order:

1. A number of projects did not include cost component of the baseline in their incremental cost analysis, although they reported incremental costs. These projects were all expelled from the list of incremental costs in the database as they did not follow the incremental cost definition as outlined in section 2.3.
2. The fact that a number of options were expelled from the incremental cost list, did not mean that the other projects which followed more or less the incremental cost methodology did not have any problems. As discussed above, incremental cost calculations are based on theorised counterfactual baselines, which leave a lot of scope for manipulation, and often display considerable bias in favour of the project. However, the study did not provide the time and resources to examine the cases in detail.

3.2.3 AIJ/GEF Contributions

In the previous section the net incremental cost curve based on project information was reported. In this section the AIJ/GEF contributions, which are an indication of the actual costs required to acquire credits from CDM projects, are presented.

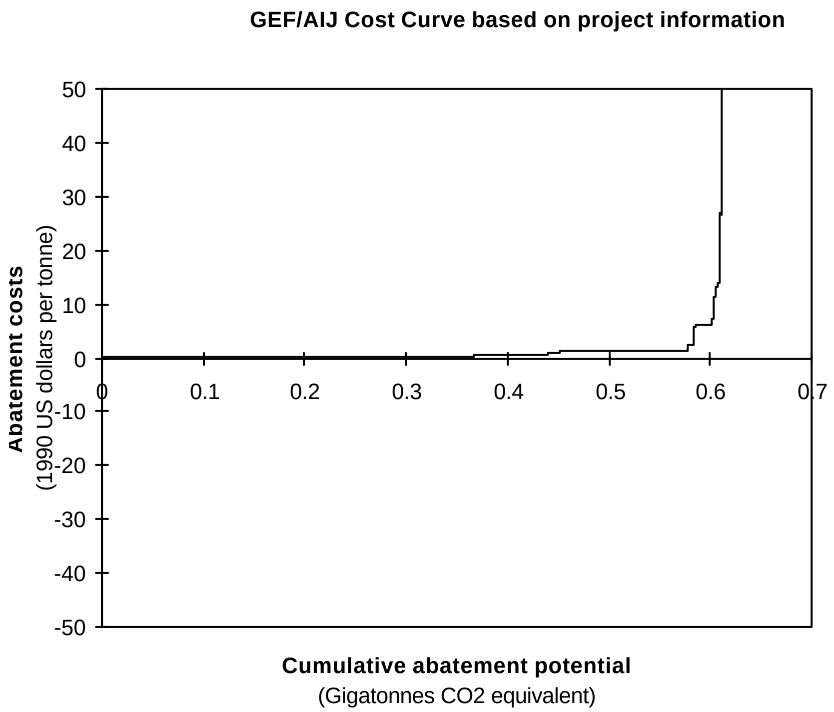

Figure 3.6 *Total AIJ/GEF Contribution*

Figure 3.6 shows the GEF/AIJ Cost Curve, which shows high resemblance with the shape of the incremental cost curve and indicates that when these costs are taken as reference the same conclusion holds.

The distribution of GHG savings over technologies is presented in Figure 3.7 below.

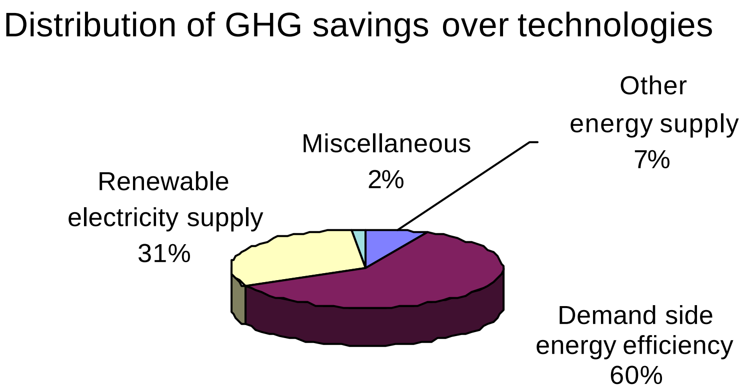

Figure 3.7 *Distribution of GHG Savings over technologies*

Figure 3.7 shows that demand side energy efficiency (60%) has received the most attention in the GEF/AIJ projects, followed by renewable energy (34%). Comparing Figure 3.7 with Figure 3.3 shows that especially the share of energy efficiency projects in the power sector (part of miscellaneous) is lower for projects implemented to date, and the share of renewable energy projects is much higher for the implemented projects. Also the share of projects involving a fuel switch (also part of miscellaneous) is smaller for implemented projects.

3.3 Demand - supply aspects

The abatement costs curve for the non-Annex I countries shows how much it would cost to implement abatement options on top of the baseline, and what the estimated potential is for abatement in this area at incremental cost below 50 USD/ton CO_2. In this sense, the abatement costs curve presented in section 3.1.2 could be regarded as a CDM supply curve. (i.e. while respecting the number of limiting assumptions that may have a large impact on the curves; see section 3.1.3).

In principle, the scope for trade in CDM-based CERs relates to the part reduction requirements of Annex I countries that can be realised at a lower associated incremental cost in Non-Annex I countries than in Annex I countries. It should be noted, however, that the costs of reduction options do not necessarily correspond to the price that will be charged to potential ‘buyers’ of a particular option. The price is a function of both the supply of, and the demand for, CDM-based emission reduction in the Annex I countries.

3.3.1 Main assumptions

It is beyond the scope of this study to examine this market mechanism in detail. Nonetheless, a preliminary attempt will be made in this section to paint a broader picture of the scope for an emerging market for CDM-based CERs. This is done by assessing the scope for trade CDM-based CERs through a comparison of:

- The incremental cost of CDM-eligible CO_2 abatement in non-Annex I countries (potential suppliers of CDM-based CERs) over the whole range up to <50 USD/t potential as established in the present study.
- The incremental cost of CO_2 reduction within Annex I countries (potential buyers of CDM-based CERs) as developed in earlier studies (Harmelen et al 1997) over the whole range of the baseline emissions in Annex I countries over and above the Kyoto commitments.

This exercise can gain useful insights into the potential of CDM for the Netherlands and the price Dutch CDM buyers may have to pay for obtaining CERs from CDM projects. It is however important to keep the following limitation in mind:

1. The possibility of banking CDM emission reduction credits from 2000 to 2008 is not incorporated in this analysis. The demand for credits covers the period of 2008 to 2012 while the supply of credits is to be created from 2000 to 2008. This temporal difference between supply and demand actions provides for the possibility that one can accumulate low-cost supply options over the CDM period and that the supply curve will look different from what is shown in this section.
2. The analysis mainly includes energy-related CO_2 emissions and does not cover the full basket of 6 global pollutants comprised by the Montreal Protocol. Also sinks have not been incorporated. Including all those gases would considerably expand the potential for CDM. At the same time, if the basket of gases and sinks would be included for the Annex I countries, the demand for CDM decreases. This is in particular relevant as many non-CO_2 reduction options are available at low costs (see for instance Beeldkamp et al, 1998).
   No specific criteria with regard the exclusion of certain projects were applied in this analysis. Such criteria (related to additionality and sustainable development (see Article 12 of the Kyoto Protocol (UNFCCC, 1999)) and other issues such as baseline definition (see section 2.3) are likely to limit the number of options eligible for CDM. The same would apply for the criteria regarding monitoring and verification.
3. It has been assumed that no other restrictions exist that would limit countries to realise their targets in the most cost-effective way. Examples of such restrictions could be credit sharing between the importing country and the country of origin of CDM projects, or the application of ceilings on the amount of credits to be obtained abroad (for a further analysis of the consequences of ceilings see Ybema et al, 1999).

3.3.2 CO_2 market simulation

The global trade in CERs has been simulated by means of a simple model which combines demand of GHG reduction with supply of GHG reduction potential for three regions: OECD, other Annex I and non-Annex I. The model assumes perfect competition. This assumption enables to determine the CDM equilibrium market price. In practise, strong buying and selling parties might exercise monopolistic (e.g. China) or monopsonistic (e.g. the USA) power that would result in less predictable market prices.

Table 3.4 shows actual and projected CO_2 emission levels in years 1990 and 2010, broken down by region. Without Climate Change policy interventions annual global CO_2 emissions are projected to increase form an estimated level of approximately 20 Gt in 1990 to nearly 29 Gt in 2010. The non-Annex I countries are expected to contribute the main share of the incremental global emissions, with their total emissions rising from some 6 Gt to nearly 13.4 Gt. Moreover, the OECD countries that account for the main share of historical emissions are also expected to increase their emission levels in the absence of Climate Change abatement policies. In contrast, broadly on account of dismal economic conditions during the 1990, the other Annex I countries are likely to achieve a reduction in annual emissions in year 2010 as compared to year 1990, even in the absence of dedicated Climate Change abatement policies.

Table 3.4 *Global CO_2 emission levels in 1990 (estimate) and 2010 (projected baseline) [Mton CO_2]*

	1990	2010
OECD	9,770	11,519
Other Annex I	4,234	3,962
Non Annex I	5,899	13,352
Total	19,903	28,833

Source: van Harmelen et al and this report (Non-Annex I)

Some main outcomes of the preliminary simulation of trade in CERs are shown in Table 3.5 below. Three scenarios have been examined:

1. Should trading of Emission Reduction Units be confined to the OECD countries, there would be limited emission trading. A relatively high CER equilibrium price of 57 USD/ton CO_2 would result.
2. If the negotiations on implementation of the Kyoto mechanisms were to result in an unconstrained application of emission trading and Joint Implementation, but not include CDM, the equilibrium price would range from 18 to 29 USD/ton CO_2. OECD countries could then acquire a total amount of CERs from non OECD or Central and Eastern European Countries or the Former Soviet Union on the order of Mton 673 - 1174. The 18 USD/ton CO_2 price and Mton 1174 refers to the eligibility of 'No Regrets' options, that would be economically feasible as such even without any climate change transfer, whereas the other bounds refer to a situation with exclusion of 'No Regrets'.
3. The third and most extended, genuinely global, trading system would include CDM. This extension (depending on the treatment of 'No Regrets') could decrease the global CER trading price from USD18-29/tonne of CO_2 equivalents down to a level of USD 4-15/tonne. Because of the sweeping nature of the assumptions underlying the aforementioned figures, these should be treated with commensurately due caution.

Table 3.5 *Results of simulation of trade in CO_2 Emission Reduction Units at three levels*

		Required reduction OECD [Mton CO_2]	Equilibrium price [USD/tonne] [a)]	Total amount of CERs acquired externally by OECD countries [Mton CO_2]
1	Intra-OECD trading system	2,427	57	-
2	Intra-Annex-I trading system	2,427	18 - 29	673 - 1,174
3	Global trading system	2,427	4 - 15	1,639 - 2,356

[a)] depending on whether or not including No-Regrets options.

4. CONCLUSIONS

In the framework of capacity building exercises for non-Annex I countries, a large number of national GHG abatement costing studies have been undertaken. In addition, several projects to reduce emissions have already been implemented under the aegis of GEF and AIJ. These sources can provide very useful insights into the extent to which reduction possibilities in non-Annex I countries can contribute to the national reduction target of the Netherlands. However, this information is not easily accessible because to date no systematic compilation and analysis of this information has been done.

The present study represents the first major attempt to compile this information and to draw from a synthesis of this information, observations that might inform strategies to achieve the national reduction target. The present study has assembled information on GHG abatement options from studies of 24 non-Annex I countries. Together, these 24 countries contribute about two thirds of total anthropogenic CO_2 emissions originating from all non-Annex I countries (based on the 1995 emissions). In addition, the costs and GHG savings of 60 GEF and AIJ projects in these and other non-Annex I countries were analysed and compiled.

Although, as noted in the preceding sections, several aspects of these studies and projects severely limit the extent to which they can be used to generate accurate estimates of the costs and magnitude of potential CDM activity, the following important observations emerged from this study:

1. The abatement potential in non-Annex I countries is significant when compared with Annex I reduction requirements, and a considerable fraction of this potential can be harnessed at low cost. Subject to the limitations explained in the previous sections, an annual abatement potential in the non-Annex I countries in the first budget period (2008-2012) at costs up to 50 1990 USD/ton CO_2 equivalents has been projected of approximately 2.3 Gt CO_2. The GHG abatement costing studies further suggest that approximately 1.7 Gt CO_2 equivalents per year would be available during the 2008-2012 budget period, at net incremental costs below 10 1990 USD/ton CO_2. If CERs are banked from projects implemented during the 2000-2008 period, the annual reduction potential increases substantially.
2. Even this rough quantitative estimate should be viewed with caution, as the cost and magnitude of abatement options that might ultimately be realised through the CDM will likely differ significantly from this figure. There is reason to believe, for instance, that the above estimate understates the total magnitude of CDM potential available at a given economic cost: numerous abatement costing studies excluded significant abatement options for lack of data, resources, and/or necessity; furthermore, active CDM markets are likely to uncover additional options that could not be easily included in modelling studies. On the other hand, there are reasons to believe that the above figure might considerably overestimate the CDM potential at actual investor costs: investor costs are likely to significantly exceed economic costs reported in the abatement costing studies. Abatement costing studies may neglect transaction costs and barrier reduction costs for many options, some measures might not be exploitable under the modalities ultimately adopted for the CDM regime, and most importantly, the investor may not recoup many of the economic benefits that accrue to other stakeholders as the result of a CDM project (and are factored into the above calculations).
3. The information collected from the abatement costing studies indicates that a large fraction of total identified abatement potential can be realised in a relatively small number of non-Annex I countries. The identified abatement potential for China and India already constitutes nearly 70% of the total identified potential.

4. The breakdown to technologies shows that most identified reduction potential (more than 65%) can be expected in power sector energy efficiency and demand-side efficiency measures.
5. The price CDM buyers may have to pay for obtaining 'Certified Emission Reduction' units (CERs) may differ from the costs to realise these units. The demand-supply analysis suggests that a full scale implementation of CDM will have a significant downward pressure on the clearing price level of CERs, to a level in the range of 4-15 USD/ton CO_2 equivalents.
6. The analysis performed on around 60 AIJ and GEF projects confirms the main conclusion mentioned above. The different nature of the analysed projects limits the extent to which they can be used to generate representative aggregate cost curves. Nevertheless, an analysis of the net incremental cost curve and the AIJ/GEF contribution cost curve results in the same conclusion that a large number of the projects (up to 99%) has a potential with abatement costs less than 10 USD/ton CO_2.

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ANNEX A GHG EMISSIONS OF NON-ANNEX I COUNTRIES IN 1996

Table A.1 *GHG emissions of non-Annex I countries in 1996*

Country	Total CO_2 million metric tons	Per capita metric tons
1. China	3364,0	2,8
2. India	997,4	1,1
3. Korea, Rep. (South)	408,1	9,0
4. Mexico	348,1	3,8
5. Brazil	273,4	1,7
6. Saudi Arabia	267,8	13,8
7. Iran	266,7	4,4
8. Korea, DPR (North)	254,3	11,3
9. Indonesia	245,1	1,2
10. Thailand	205,4	3,4
11. Kazakhstan, Rep.	173,8	10,9
12. Argentina	129,9	3,7
13. Malaysia	119,1	5,6
14. Uzbekistan	95,0	4,1
15. Algeria	94,3	3,3
16. Pakistan	94,3	0,8
17. Iraq	91,4	4,3
18. Nigeria	83,3	0,7
19. United Arab Emirates	81,8	33,3
20. Colombia	65,3	1,7
21. Philippines	63,2	0,8
22. Israel	52,3	9,2
23. Chile	48,8	3,4
24. Syrian Arab Rep.	44,3	3,1
25. Libya	40,6	8,0
26. Kuwait	38,7	24,4
27. Vietnam	37,6	0,5
28. Turkmenistan	34,2	7,4
29. Cuba	31,2	2,8
30. Azerbaijan	30,0	4,0
31. South Africa	29,7	7,3
32. Morocco	27,9	1,0
33. Peru	26,2	1,1
34. Ecuador	24,5	2,1
35. Bangladesh	23,0	0,2
36. Trinidad and Tobago	22,2	17,1
37. Tunisia	16,2	1,8
38. Oman	15,1	7,0
39. Lebanon	14,2	3,5
40. Côte d'Ivoire	13,1	0,9
41. Jordan	13,1	3,0
42. Dominican Republic	12,9	1,6
43. Bolivia	10,1	1,3
44. Mongolia	8,9	3,6
45. Yemen	8,3	0,5

Source: 1999 World Development Indicators, The World Bank