CLIMATE CHANGE

Scientific Assessment and Policy Analysis

WAB 500102 030

Balancing the carbon market

Carbon market impacts of developing country emission reduction targets

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Report

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Wetenschappelijke Assessment en Beleidsanalyse (WAB) Klimaatverandering

Het programma Wetenschappelijke Assessment en Beleidsanalyse Klimaatverandering in opdracht van het ministerie van VROM heeft tot doel:

- Het bijeenbrengen en evalueren van relevante wetenschappelijke informatie ten behoeve van beleidsontwikkeling en besluitvorming op het terrein van klimaatverandering;
- Het analyseren van voornemens en besluiten in het kader van de internationale klimaatonderhandelingen op hun consequenties.

De analyses en assessments beogen een gebalanceerde beoordeling te geven van de stand van de kennis ten behoeve van de onderbouwing van beleidsmatige keuzes. De activiteiten hebben een looptijd van enkele maanden tot maximaal ca. een jaar, afhankelijk van de complexiteit en de urgentie van de beleidsvraag. Per onderwerp wordt een assessment team samengesteld bestaande uit de beste Nederlandse en zonodig buitenlandse experts. Het gaat om incidenteel en additioneel gefinancierde werkzaamheden, te onderscheiden van de reguliere, structureel gefinancierde activiteiten van de deelnemers van het consortium op het gebied van klimaatonderzoek. Er dient steeds te worden uitgegaan van de actuele stand der wetenschap. Doelgroepen zijn de NMP-departementen, met VROM in een coördinerende rol, maar tevens maatschappelijke groeperingen die een belangrijke rol spelen bij de besluitvorming over en uitvoering van het klimaatbeleid. De verantwoordelijkheid voor de uitvoering berust bij een consortium bestaande uit PBL, KNMI, CCB Wageningen-UR, ECN, Vrije Universiteit/CCVUA, UM/ICIS en UU/Copernicus Instituut. Het PBL is hoofdaannemer en fungeert als voorzitter van de Stuurgroep.

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The main commissioning bodies are the National Environmental Policy Plan departments, with the Ministry of Housing, Spatial Planning and the Environment assuming a coordinating role. Work is also commissioned by organisations in society playing an important role in the decision-making process concerned with and the implementation of the climate policy. A consortium consisting of the Netherlands Environmental Assessment Agency (PBL), the Royal Dutch Meteorological Institute, the Climate Change and Biosphere Research Centre (CCB) of Wageningen University and Research Centre (WUR), the Energy research Centre of the Netherlands (ECN), the Netherlands Research Programme on Climate Change Centre at the VU University of Amsterdam (CCVUA), the International Centre for Integrative Studies of the University of Maastricht (UM/ICIS) and the Copernicus Institute at Utrecht University (UU) is responsible for the implementation. The Netherlands Environmental Assessment Agency (PBL), as the main contracting body, is chairing the Steering Committee.

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Preface

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Executive Summary

Context and scope
In the period leading up to Copenhagen, when a new climate deal needs to be finalized, scientific evidence is mounting that deep reductions in GHG emissions, in Annex I countries as well as in non-Annex I countries, are needed. To bring global GHG emissions on a path to a low stabilization level which increases the chances that global mean temperature rise will be limited to 2ºC, Annex I countries would have to reduce their emissions by 25-40% by the year 2020, while non-Annex I countries need to substantially deviate from their emission baselines. These 'substantial deviations from the baseline' of non-Annex I countries have been quantified in a recent paper to be in the order of 15-30% below their 2020 baseline emission levels.

In the current study, we explore the implications of achieving the lower end of the emission reductions necessary to stabilize atmospheric GHG concentration at 450 ppm CO_2-eq. For Annex-I countries, an overall 30% emission reduction below 1990 levels is assumed for 2020. For the non-Annex I region in its entirety, we assume emission reductions of about 15% below business-as-usual in the same timeframe, to be achieved by domestic mitigation efforts of the so-called 'emerging economies[1]'.

Domestic emission reductions in emerging economies imply both a cost for the countries themselves and a reduction of mitigation potential available to the carbon market. The main aim of this report is to quantify these two highly relevant aspects of any future climate agreement involving domestic emission reduction efforts in emerging economies by answering the following questions:
a) What would be the cost of domestic mitigation action for emerging economies?
b) What would be the impact of such actions on the carbon market?

The carbon market impacts evaluated are the cost of remaining mitigation options, the change in sectoral contribution to the overall mitigation potential and the role of different groups of countries as potential suppliers of carbon credits. A reduction in this potential would also have cost implications for those Annex I countries that achieve part of their emissions by purchasing carbon credits from non-Annex I countries, but this is not within the scope of this report.

Method
The main tool used in this study is an aggregated marginal abatement cost curve of bottom-up, detailed mitigation options in the whole non-Annex I region developed at ECN. The ECN MAC provides insight in the technical mitigation potential and in the marginal abatement costs for a given level of emission reductions. For this study, it has been calibrated to the emission baselines in the IMAGE/TIMER model, which were used as representations of future GHG emissions in emerging economies. By assuming that emerging economies would use their lowest-cost options, we first explore at what cost they could achieve domestic emission reductions and in which sectors could those emission cuts be realized.

Next, we investigate how much and what types of technical and economic mitigation potential would remain available to the carbon market, after much of the low-cost potential from emerging economies is used to achieve their own emission reduction 'targets'. As avoided deforestation is an important factor in this, we examine the remaining carbon market impacts with and without avoided deforestation as an option that can generate carbon credits.

Costs of emerging economy reductions
The results of the analysis with the ECN MAC curve suggest that sufficient mitigation potential in emerging economies exists to achieve half of the required emission reductions at negative or no cost. The remainder of the reductions can be attained at a cost up to around 30 $/t$CO_2$-eq.

1 In this study: Argentina, Brazil, China, India, Indonesia, Mexico, South Africa, South Korea.

This result is not significantly affected by the availability of avoided deforestation, since it is only a significant mitigation option for Brazil and Indonesia[2].

Remaining carbon market potential
The emission reductions realised domestically by emerging economies greatly reduce the potential from developing countries available to the carbon market (See figure ES.1). As most of the cheapest mitigation options are used by emerging economies for their domestic emission reductions, they are not available anymore to the carbon market. Avoided deforestation has a considerable effect on the remaining potential, by increasing supply of potential at relatively low cost. The changes in the remaining mitigation potential in the non-Annex I region available to the carbon market are presented in Figure ES.1.

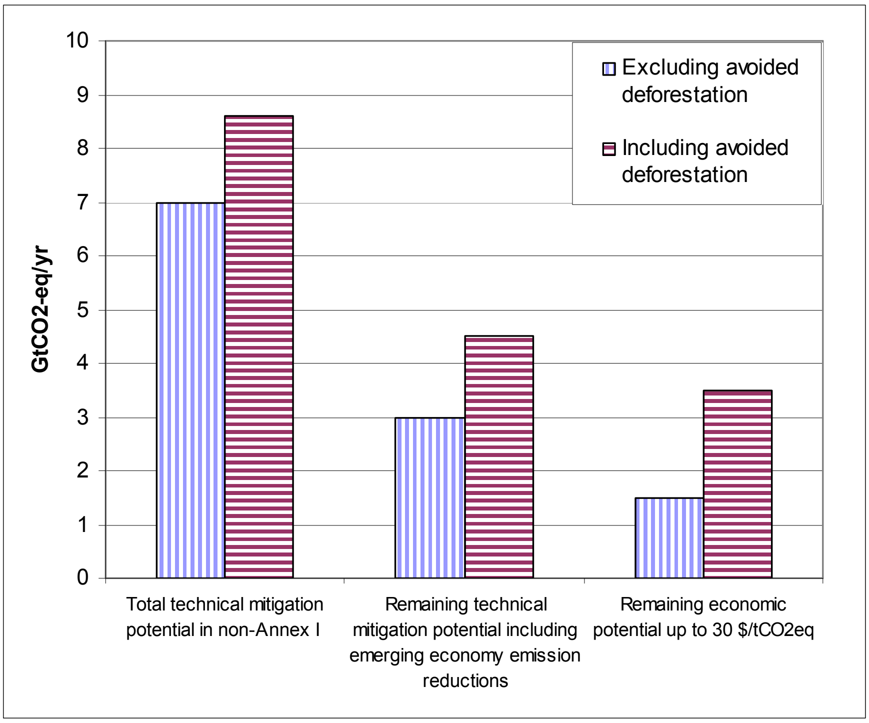

Figure ES.1 Mitigation potential in non-Annex I before and after emerging economies domestic emission reductions.

The left two bars indicate the total potential of mitigation options in the ECN MAC, the middle bars what remains after emerging economies achieve their emission reductions compared to the baseline in 2020, and the right bars the remaining potential up to a carbon price of 30 US$/t$CO_2$-eq.
A sectoral analysis reveals that most of the technical mitigation potential that remains available to the carbon market is in the power, industry and waste sectors. Domestic emission reduction in emerging economies would increase the share of least developed countries as potential suppliers to the carbon market from some 10% to 20%.

Theoretically maximum emerging economy emission reductions
Although the coverage of mitigation options in the ECN MAC curve is not uniform across all countries, based on the potentials included, we assess what are the maximum possible reductions that are technically feasible for emerging economies. They vary significantly across countries, and combined exceed 6.5 G tCO_2-eq, although this figure must be interpreted with care due to the significant uncertainties underlying the level of mitigation potential in individual countries. Achieving such reductions by emerging economies domestically, would leave roughly

[2] However, avoided deforestation would also be an important option for a number of other developing countries that have not been included in this analysis for lack of data.

2 $GtCO_2$-eq of mitigation potential to the CDM (including avoided deforestation), half of which in the LDCs.

Sensitivity of results to non-economic factors
The results from the ECN MAC are estimates of overall technical potential or the economic potential up to a certain cost level, and do not take into account a variety of market failures and non-economic barriers. In reality, because of these market failures and non-economic barriers, only part of the technical potential is actually developed on the carbon market. To provide some insight into a more realistic market potential we develop two scenarios of possible developments on the CDM market (an optimistic and a pessimistic one) by using two sets of correction factors on: 1) the eligibility of technologies (avoided deforestation, CCS) under the CDM; 2) the future application of the additionality criterion; 3) the existence of non-financial barriers related to the uptake of technology and 4) the success of Programmatic CDM.

In the optimistic scenario, where we assume high eligibility, projects easily passing the additionality test, few barriers for energy efficiency and successful Programmatic CDM. The resulting market potential amounts to 1.7 $GtCO_2$-eq up to a cost of 25 US$/t CO_2-eq, including some 200 $MtCO_2$-eq from avoided deforestation. In the pessimistic scenario, there is only 1 $GtCO_2$-eq of potential remaining below 25 US$/t CO_2-eq, and no avoided deforestation.

Samenvatting

Inleiding
In de aanloop naar Kopenhagen, waar een nieuwe klimaatovereenkomst zal worden opgesteld, stapelt het wetenschappelijke bewijs zich op dat substantiële reducties in broeikasgasemissies, in zowel Annex I als niet-Annex I landen, noodzakelijk zijn. Om wereldwijde broeikasgas-emissies op een laag stabilisatieniveau te brengen, hetgeen de kansen vergroot om de gemiddelde temperatuurtoename wereldwijd te beperken tot 2ºC, zouden Annex I-landen hun emissies moeten reduceren met 25-40% rond het jaar 2020, terwijl niet-Annex I landen substantieel moeten afwijken van hun referentie-emissies. Deze 'substantiële afwijkingen van de referentie' van niet-Annex I landen worden in een recent paper gekwantificeerd in de orde van15-30% onder de referentie-emissies van 2020.

In deze studie onderzoeken we de implicaties van het behalen van de minimale emissiereducties die nodig zijn om de concentratie broeikasgassen in de atmosfeer te stabiliseren naar 450 ppm CO_2-eq. Voor Annex I-landen is een algehele emissiereductie aangenomen voor 2020 van 30% onder 1990-waarden. Voor de niet-Annex I regio als geheel nemen we emissiereducties aan van rond de 15% onder business-as-usual binnen dezelfde tijdspanne, wat behaald kan worden door nationale mitigatie-inspanningen van de zogenoemde 'opkomende economieën[3]'.

Nationale emissiereducties in opkomende economieën impliceren zowel kosten voor de landen zelf als een reductie van beschikbaar mitigatiepotentieel voor de koolstofmarkt. Het belangrijkste doel van dit rapport is om deze twee uiterst relevante aspecten van een toekomstige klimaatovereenkomst, welke mogelijk gepaard gaat met nationale emissiereductie-inspanningen in opkomende economieën, te kwantificeren door de volgende vragen te beantwoorden:
a) Wat zouden de kosten zijn van nationale mitigatie-acties voor opkomende economieën?
b) Welke invloed hebben dergelijke maatregelen op de koolstofmarkt?

We evalueren de invloed van nationale inspanningen op de koolstofmarkt in de vorm van de kosten van resterende mitigatie-opties, de verandering in de sectorale bijdrage aan het algehele mitigatiepotentieel en de rol van verschillende groepen landen als potentiële leveranciers van koolstofkredieten. Een afname in dit potentieel zou ook kostenimplicaties hebben voor de Annex I-landen die een deel van hun emissies verkrijgen door koolstofkredieten af te nemen van non-Annex I landen, maar dit ligt niet binnen het bereik van dit rapport.

Methode
Voor deze studie gebruiken we een samengevoegde marginale broeikasgasreductie-kostencurve (MAC) van gedetaileerde bottom-up mitigatiestudies in de hele niet-Annex I regio, ontwikkeld door ECN. De ECN MAC biedt inzicht in het technische mitigatiepotentieel en in de marginale reductiekosten voor een gegeven hoeveelheid emissiereducties. Voor deze studie is het model gekalibreerd naar de business-as-usual-emissies in het IMAGE/TIMER model, welke gebruikt zijn als representatie van toekomstige broeikasgasemissies in opkomende economieën. Door aan te nemen dat opkomende economieën hun laagste-kostenopties gebruiken, onderzoeken we eerst tegen welke kosten zij nationale emissiereducties kunnen behalen en in welke sectoren deze emissiereducties het beste kunnen worden gerealiseerd.

Vervolgens onderzoeken we hoeveel en welk type technisch en economisch mitigatiepotentieel beschikbaar blijft voor de koolstofmarkt, nadat een groot deel van het lage-kosten potentieel van opkomende economieën gebruikt is om hun eigen emissiereductiedoelen te behalen. Aangezien voorkomen van ontbossing een belangrijke factor is hierin, onderzoeken we de invloed op de koolstofmarkt met en zonder vermeden ontbossing als een mogelijkheid om carbon credits te genereren.

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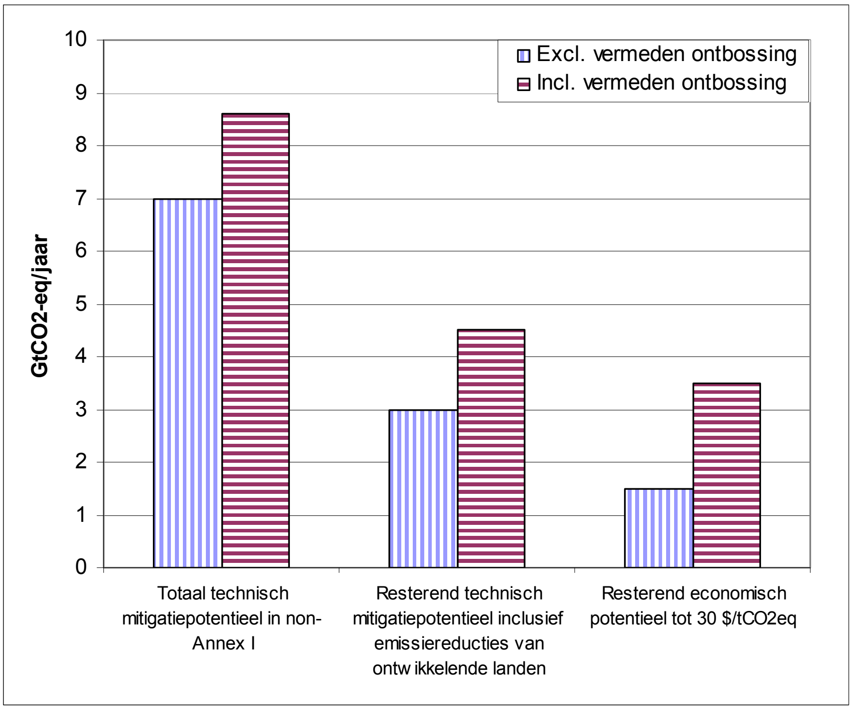
3 In deze studie Argentinië, Brazilie, China, India, Indonesie, Mexico, Zuid Afrika, Zuid Korea.

Kosten van reducties in opkomende economieën

De resultaten van de analyse volgens de ECN MAC curve geven aan dat er voldoende mitigatiepotentieel bestaat in opkomende economieën om de helft van de vereiste emissiereducties te behalen tegen negatieve of geen kosten. Het restant van de reducties kan gerealiseerd worden tegen een prijs van circa 30 $/t$CO_2$-eq. Dit resultaat wordt nauwelijks beïnvloed door de beschikbaarheid van vermeden ontbossing, omdat het slechts voor Brazilië en Indonesië[4] een significante mitigatieoptie is.

Resterend potentieel voor de koolstofmarkt

De nationaal behaalde emissiereducties van opkomende economieën impliceren een substantiële reductie van het beschikbare potentieel van ontwikkelingslanden voor de koolstofmarkt (zie Figuur ES.1). Gezien het feit dat het grootste aandeel van de goedkoopste mitigatieopties gebruikt worden door opkomende economieën voor de nationale emissiereducties, zijn ze niet meer beschikbaar voor de koolstofmarkt. Vermeden ontbossing heeft een aanzienlijk effect op het resterende potentieel, wegens een toename in het beschikbare potentieel tegen relatief lage kosten. De veranderingen in het resterende mitigatiepotentieel in de niet-Annex I regio dat beschikbaar is voor de koolstofmarkt worden weergegeven in Figuur ES.1.



Figuur ES.1 Mitigatiepotentieel in niet-Annex I landen voor en na nationale emissiereducties in opkomende economieën

De twee linkerkolommen geven het totale potentieel aan mitigatieopties in de ECN MAC aan, de middelste kolommen het restant nadat opkomende economieën hun emissiereducties hebben behaald volgens de baseline in 2020, en de rechterkolommen het resterende potentieel bij een koolstofprijs van 30 US$/t$CO_2$-eq.

Het grootste aandeel van het technische mitigatiepotentieel dat beschikbaar blijft voor de koolstofmarkt ligt binnen de elektriciteits-, industrie- en afvalsectoren. Nationale emissiereductie in opkomende economieën zou het aandeel van minder ontwikkelde landen als potentiële leveranciers in de koolstofmarkt verhogen van circa 10% zonder opkomende-economiedoelen naar 20%.

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[4] Echter, vermeden ontbossing zou ook een belangrijke optie zijn voor een aantal ontwikkelingslanden die niet opgenomen zijn in deze analyse wegens gebrek aan beschikbare gegevens.

Theoretisch maximale emissiereducties opkomende economieën
Hoewel de dekking van mitigatieopties in de ECN MAC curve niet uniform is binnen de verschillende landen, bepalen we de maximaal mogelijke reducties die technisch haalbaar zijn voor opkomende economieën aan de hand van het opgenomen potentieel. Dit varieert aanzienlijk binnen de verschillende landen, en gecombineerd meer dan 6,5 G tCO_2-eq per jaar in 2020, hoewel deze waarde met terughoudendheid geïnterpreteerd dient te worden in verband met de substantiële onzekerheden in en verschillen tussen de studies die ten gronde liggen aan het mitigatiepotentieelniveau in individuele landen. Dit hypothetische scenario, waarin het potentieel van opkomende economieën niet meer beschikbaar is voor het CDM, laat ruwweg 2 GtCO_2-eq aan potentieel over voor het CDM (inclusief vermeden ontbossing), waarvan de helft in de minst-ontwikkelde landen.

Gevoeligheid van resultaten ten opzichte van niet-economische factoren
De resultaten verkregen via de ECN MAC zijn schattingen van technisch potentieel bij een bepaald kostenniveau, en houden geen rekening met een verscheidenheid aan marktmissers en niet-economische belemmeringen. In werkelijkheid, door deze marktmissers en niet-economische belemmeringen, wordt slechts een deel van het technische potentieel ontwikkeld op de koolstofmarkt. Om enig inzicht te verkrijgen in een meer realistisch marktpotentieel voeren we een gevoeligheidsanalyse uit aan de hand van een aantal correctiefactoren: 1) de beschikbaarheid van technologieën (vermeden ontbossing, CCS) binnen het CDM; 2) de toekomstige toepassing van het additionaliteitscriterium; 3) het optreden van niet-financiële belemmeringen voor de implementatie van technologieën en 4) het succes van Programmatic CDM.

Het optimistische scenario, waarbij we uitgaan van toepasbaarheid van CDM op veel projecttypen, minder strikte toepassing van het additionaliteitscriterium, minder belemmeringen op het gebied van energie-efficiëntie en succesvolle programmatic CDM, omvat een resulterend marktpotentieel van 1,7 GtCO_2-eq tegen kosten tot ca. 25 US$/t CO_2-eq, inclusief ca. 200 MtCO_2-eq van vermeden ontbossing. In het pessimistische scenario blijft 1 GtCO_2-eq van het potentieel onder de 25 US$/t CO_2-eq, zonder vermeden ontbossing.

List of acronyms

CCS	CO_2 Capture and Storage
CDM	Clean Development Mechanism
CO_2	Carbon Dioxide
CER	Certified Emission Reduction
ECN MAC	Energy Research Centre of the Netherlanlds' Marginal Abatement Cost (curve)
EU ETS	EU Emissions Trading Scheme
GDP	Gross Domestic Product
GHG	Greenhouse gas
$GtCO_2$-eq	Giga tons of Carbon Dioxide Equivalent
IPCC	Intergovernmental Panel on Climate Change
IMAGE	Integrated Model to Assess the Global Environment
LDC	Least Developed Country
LULUCF	Land-Use, Land-Use Change and Forestry
$MtCO_2$-eq	Mega tons of Carbon Dioxide Equivalent
OECD	Organisation for Economic Cooperation and Development
TIMER	Targets Image Energy Regional model
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

In order to keep global mean temperature rise below 2ºC, long-term atmospheric concentration of GHGs needs to stabilise around 450 ppm of CO_2-eq, which would require global emissions of CO_2 to peak before 2015 and decrease by 50 to 85% by 2050 compared to 2000 levels (IPCC, 2007). Such deep emission reduction requirements raise questions around the path towards a 2050 target and the distribution of the efforts between the developed (Annex I) and developing (non-Annex I) regions of the world. Although there is broad consensus that the lead in emission reductions needs to be taken by Annex I countries because of their historical responsibilities and their better technological, human and economic endowments to address the problem, even if developed countries were to reduce their emissions to zero, global involvement would still be necessary to achieve long-term low stabilization levels. Developing country emissions, particularly those in fast-growing emerging economies, are expected to overtake developed countries' GHG emissions in the 2020 to 2030 timeframe (Medvedev et al., 2008). Some studies expect this to happen as soon as 2010 (Russ et al., 2009), which points to the need for developing-country participation in any new agreement to reduce emissions.

Setting to the path to low stabilization level requires emission reductions in Annex I countries of 25-40% below their 1990 emission levels by 2020 and that several non-Annex I regions deviate substantially from their baseline emission projections (IPCC, 2007). Den Elzen and Höhne (2008) quantified these 'substantial deviations from the baseline' in the order of 15-30% below the 2020 baseline emission levels. These reductions would have to be achieved domestically in their entirety and should be fully additional to the reductions achieved by Annex-I countries in order to keep the 450 ppm CO_2-eq stabilisation level within reach. However, Annex I countries should play a role in facilitating part of the emission reductions in non-Annex I countries by following the Bali Action Plan's call for financial, technological and capacity-building support for 'nationally appropriate mitigation action' in developing countries.

Negotiations on a post-2012 climate agreement succeeding the Kyoto Protocol are expected to reach a conclusion in December 2009. The EU has set a unilateral target of reducing its GHG emissions by 20% by the year 2020 compared to 1990 levels and committed to increase its reductions to 30% in the same timeframe, if a comprehensive international agreement that broadens global participation is reached and if other developed countries commit themselves to comparable emission reductions.

Although the voluntary participation in the carbon market through the CDM is seen as an important incentive for developing country mitigation action, the mitigation projects currently developed under the CDM are actually offsets for emissions reductions not achieved in Annex I countries, which do not contribute to, and may even discourage, 'own emission reductions' in non-Annex I countries. The ongoing discussion between Annex I and non-Annex I countries on responsibilities to reduce GHG emissions, together with the economic consequences of domestic emission reductions, make non-Annex I countries hesitant to taking on any binding commitments. In addition, those non-Annex I countries whose fast economic growth defines them as emerging economies, are the biggest beneficiaries of the Kyoto carbon market and these benefits could be reduced if they accepted a domestic mitigation target. At the same time, emission reduction targets in those countries would have an impact on the mitigation potential available for the carbon market. Making participation in the carbon market attractive thus requires a proper balance between the targets of industrialised countries and their resulting demand for emission credits, and emerging economies' own mitigation action and credit supply to the carbon market.

The aim of this report is to quantify these two highly relevant aspects of any future climate agreement involving own mitigation action of emerging economies by answering the following two questions:

a) What would be the cost of domestic mitigation action for emerging economies?
b) What would be the impact of such actions on the carbon market?

The carbon market impacts evaluated are the cost of the remaining mitigation options, the change in sectoral contribution to the overall mitigation potential and the role of different groups of developing countries as potential suppliers of carbon credits.

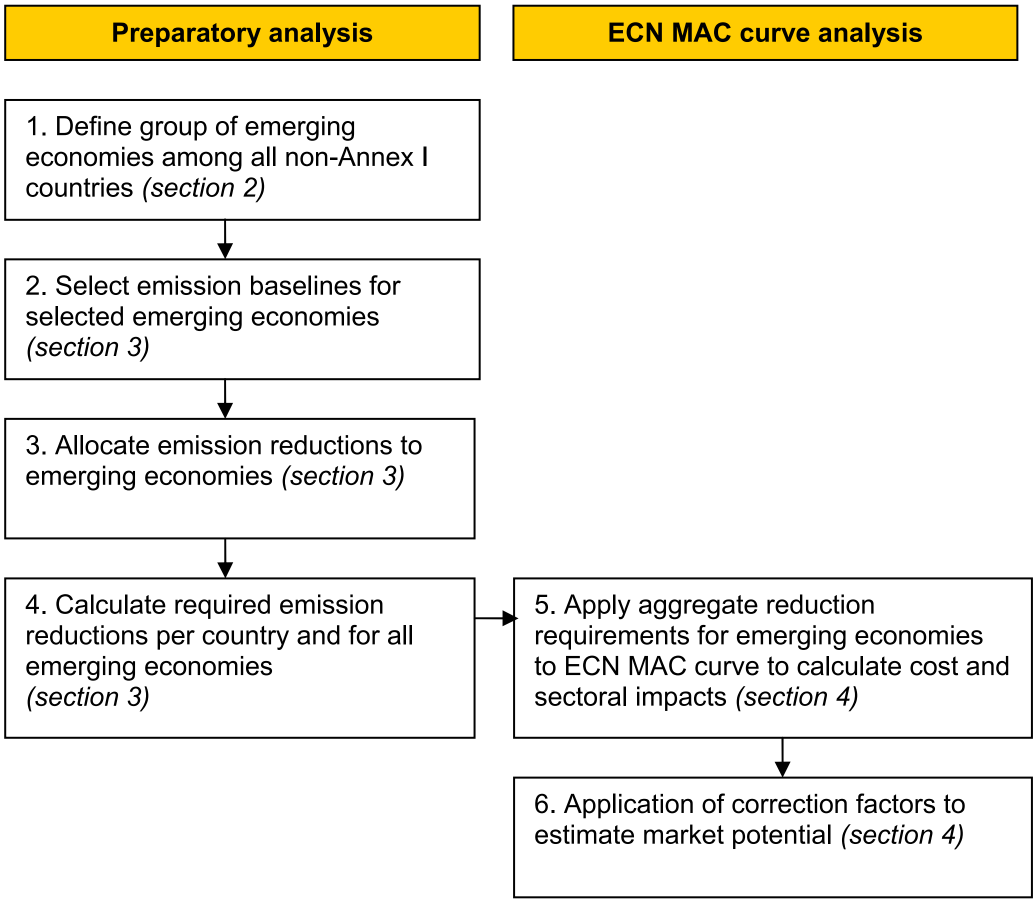
This study reports on the use of an aggregated marginal abatement cost (MAC) curve of mitigation options in the non-Annex I region (Bakker et al., 2007). The ECN MAC curve is able, first, to explore at what cost the emerging economies could reach emission reductions required to stay in line with the 450 ppm CO_2-eq scenario (possibly partly supported by Annex I) and, second, how much mitigation potential from the non-Annex I region would still remain available to the carbon market after we deduct from it what would be used by emerging economies to achieve their own emission reductions.

The structure of this report is as follows: Chapter 2 explains the methodology and the main tools used for the analysis, while Chapter 3 presents the results for the technical potential in the MAC curve, and Chapter 4 presents an analysis based on assumptions on carbon market dynamics that provide an approximation of the market potential. Chapter 5 provides a discussion of the results. The conclusions and recommendations are presented in Chapter 6.

2 Methodology

2.1 Subsequent steps in the analysis

To assess the costs of domestic mitigation action in emerging economies and the related reduction in the non-Annex I carbon market potential, we need to calculate the required emission reductions in absolute terms, which we apply to the ECN MAC curve. The below diagram explains the subsequent steps of the analysis to arrive at such a figure.



First, the group of emerging economies is defined based on their perceived relevance in the global economy and their overall contribution to global GHG emissions (see next section). Second, an emission baseline for each emerging economy needs to be selected. Because the baselines underlying the ECN MAC curve are incomplete or outdated, the latest IMAGE/TIMER baselines were used as a representation of emerging economies future GHG emission.

Next, an emission reduction target in 2020 is suggested for each country that is consistent with the 15-30% diversion from the baseline suggested in den Elzen and Höhne (2008). By subtracting the emission reduction target in 2020 from the 2020 projected baseline emissions, the absolute emerging economy emission reductions are calculated. Then the required emission reductions for emerging economies are subtracted from the overall non-Annex I mitigation potential in the ECN MAC curve to arrive at the remaining mitigation potential in the carbon market. A cost classes analysis (the analysis of the mitigation potential up to a certain level of mitigation cost) allows us to estimate the marginal cost of own mitigation action in emerging economies. Most of the cheapest emission reduction options are not available for the CDM market anymore as they are used by emerging economies to reach their own targets.

The final step in the analysis answers the research questions. By assuming that the selected emerging economies reach their emission reduction targets through the cheapest mix of abatement options, starting with options with negative costs, followed by those with low positive costs up to the level required, we arrive at a mix of mitigation options implemented by the selected emerging economies, as well as the costs of domestic mitigation. By studying the remainder of the mitigation potential in the ECN MAC curve, the role of different sectors and countries as providers of potential to the carbon market, can be derived.

Because the ECN MAC curve estimates the *technical* mitigation potential that remains available to the CDM, we need to downsize this to a more realistic *market* potential. To achieve this we follow a methodology explained in Bakker et al. (2007). The method identifies a number of factors that determine to what extent this potential can be realised by the CDM. These are:
1) Eligibility of technologies (avoided deforestation, CCS) under the CDM;
2) Future application of the additionality criterion;
3) Existence of non-financial barriers related to the uptake of technology;
4) Success of Programmatic CDM.

Following the approach developed by Bakker et al (2007), we construct two scenarios by applying correction factors that mimic possible developments on the carbon market to the remaining mitigation potential. Two sets of correction factors represent an optimistic and a pessimistic scenario. In the optimistic scenario, we assume high eligibility, projects easily passing the additionality test, fewer barriers for energy efficiency and successful Programmatic CDM. In the pessimistic scenario, we assume low eligibility, strict additionality, large barriers for energy efficiency projects and unsuccessful Programmatic CDM. Avoided deforestation is fully included as a mitigation option in the optimistic scenario and not at all in the pessimistic one. In this way we explore these factors' impact on the possible market developments and down size the amount of carbon credits that could be available on the carbon market given market and practical constraints. The explanation and values for of the correction factors is given in Appendix D.

2.2 The ECN MAC curve

The ECN MAC curve is the main tool used in this study to evaluate the cost of emerging economies domestic mitigation action and the related changes in the carbon market potential. It is a bottom-up representation of the potential for greenhouse gas reduction in non-Annex I countries that has much detail but is not exhaustive.

2.2.1 Description of the ECN MAC curve

The MACs for CO_2 are based on national abatement cost studies in over 30 countries and include a large set of options in all sectors. The curves were aggregated in order to estimate the technical and economic potential for GHG reduction in 2010, which was subsequently extrapolated to 2020. It also includes bottom-up estimates for CO_2 capture and storage in power and industry (except natural gas processing) and LULUCF (afforestation, reforestation and avoided deforestation) (Bakker et al, 2007). Inclusion of non-CO_2 options in the MACs has mostly been performed by using data from an extensive study carried out by the US Environmental Protection Agency (USEPA, 2006).

All abatement cost figures were expressed in US$ and 2006 price levels. Transaction cost related to the project cycle of CDM projects were added according to different technology groups, between 0.2 and 0.7 US$/tCO2-eq. Other (non-economic) barriers were not taken into account (Wetzelaer et al, 2007). However, overall data availability has turned out to be a limiting factor. For example, no data on the biomass potential and abatement cost for India have been found. For a detailed methodology description see Appendix A to this report.

2.2.2 Strengths and shortcomings of the MAC curve

The advantages of the approach used to develop the ECN MAC curve are that it takes into consideration the national cirumstances of individual countries, is based on a detailed techno-economic assessment of options and does not ignore or automatically implement the no-regret potential that is realistically there – because top-down models tend to optimise for costs, they by definition (and wrongly) assume that options with negative costs are readily implemented.

However, there are also important limitations:
1. *The abatement costing studies are not always comprehensive.* The studies do not always exhaustively consider all options and even though the database underlying the MAC curves has been updated on several occasions, it cannot be considered as an exhaustive overview of mitigation options. This is especially true for renewable energy potentials. This strongly affects the total identified reduction potential. For example for China the identified potential is 1.8 $GtCO_2$-eq/yr (based on CCAP/Tsinghua, 2006), which is significantly lower than some other recent studies (e.g Höhne et al, 2008b).
2. *Uncertainties regarding the mitigation potential of CCS and particularly avoided deforestation are large.*
3. *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.
4. *The 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, uncertain or qualitative.

2.2.3 MAC update for this project

Because many of the country studies underlying the mitigation potential in the ECN MAC curve incorporate outdated or rather low emission baselines compared to the IMAGE/TIMER baselines we used to calculate the necessary emission reductions, there was a clear discrepancy between reduction targets for the emerging economies and their available mitigation potential. Lower baselines leading to lower abatement potential also imply that the potential presented by our MAC curves was very likely to be an underestimation of the actual abatement potential.

This shortcoming was most pronounced for the case of China, where the high baseline in IMAGE/TIMER requires emission reductions that exceeded the *total* abatement potential available in our database, which is based on the conservative emission baselines estimated by CCAP/Tsinghua (2006)[5].

To correct for these differences and achieve compatibility of the IMAGE/TIMER baselines and the ECN MAC curve mitigation potential, we needed to adapt the latter to the more up-to-date

[5] For example, the CCAP/Tsinghua (2006) study which provides most of the mitigation options for China that are included in the ECN Mac curve, projects emission for the Chinese power sector in 2020 to be 3.0 $GtCO_2$. The IMAGE/TIMER baseline based on the ADAM scenario on the other hand predicts those emissions to be in the order of 5.8 $GtCO_2$, an almost factor 2 difference.

emission baselines in IMAGE/TIMER. This was done by scaling the mitigation potential by the difference factor of the two baselines.

First of all, we re-grouped all the mitigation options in the database underlying the MAC curve to match the sectoral delineation used in IMAGE/TIMER. After that we retrieved the original baselines underlying the mitigation potential for each sector in each emerging economy for which we had data on mitigation options. By dividing IMAGE/TIMER baseline for any individual sector with the baselines underlying the mitigation options for the same sector in our database, we derived the scaling factors on a country-sector level[6], which were then applied to all the mitigation options in each individual sector in each of the emerging economies we include in our analysis.

2.2.4 Comparison with other MAC curves

Many other MAC curves for non-Annex I countries exist. Without going into detailed analysis of methodological differences, a comparison with other curves provides insight in the relative conservativeness of the ECN MAC curve estimates. The RITE curve estimates the abatement potential in non-Annex I countries at 15 Gt CO_2/y in 2020 (excluding CCS) but based on 'frozen technology' (CO_2 per unit GDP fixed at 2005 levels) and excluding avoided deforestation (Akimoto, 2008). McKinsey (Enkvist et al., 2007) estimates a potential of 13 GtCO_2-eq/yr in 2020 for non-Annex I countries including LULUCF (using higher baseline emissions than we have done in this study).

In comparison with other estimates of non-Annex I abatement potential the ECN MAC curve number of approximately 7 GtCO_2-eq of technical abatement potential is small. The above estimates do not include avoided deforestation. Relative to other studies, therefore, the ECN MAC curve is a conservative estimate.

2.3 Methodological concerns

There are several limitations to the methodology of this study. First, the adjustments made to the mitigation potential are done for some countries but not for all. This may lead to discrepancies and an internally not fully consistent picture.

Another issue related to the use of different baselines which remains unsolved even after the scaling exercise is that of technological development. Because we do not have full insight into all the assumptions used to develop baselines in the studies underlying the ECN MAC curve and in IMAGE/TIMER, we run the risk of double counting some or at least part of some abatement options that the IMAGE/TIMER model might have included as endogenous technological development in the emitting sectors and should thus not be counted also as still available mitigation options. This means the actual abatement potential could be smaller than estimated here. On the other hand, there might be technology options included in the baselines of the national studies not considered in the IMAGE/TIMER model's baselines which would have the opposite effect. The net effect of the different baseline assumptions is very difficult to quantify. What's important to note is that most country studies have made some assumptions on future technological developments meaning we do not have a 'frozen technology' situation.

Second, the assumption on emerging economies achieving the required level of emission reductions with the least-cost mitigation mix is not a very realistic assumption considering the significant non-economic barriers that have prevented no-regret options being exploited so far (even in Annex I countries).

[6] Except for the case of Mexico and South Korea, where the scaling could be done on a country-level only due to lack of data on sectoral emission baselines underlying the mitigation potential in the ECN MAC curve.

For data limitation reasons we do not include all emerging economies in our analysis (see next section), hence the overall reduction requirement for emerging economies is somewhat underestimated while the remaining mitigation potential is overestimated. However, those not included in the analysis are smaller countries with relatively low absolute GHG emissions. The emerging economies that we do include account for the majority of non-Annex I GHG emissions in 2020 as well as the biggest mitigation potentials. It is therefore expected that the exclusion of the smaller emerging economies will not significantly influence the outcome of the analysis.

The already mentioned shortcomings of the ECN MAC curve (not covering all abatement options in all countries) leads to an underestimation of the total mitigation potential in the non-Annex I region. The results presented here should therefore be considered as conservative.

And finally, the assumptions on correction factors used to arrive to a more realistic market potential for the CDM are to some extent (inherently) subjective (Bakker et al., 2007).

2.4 Definitions and countries

This report consistently uses a number of terms whose meaning needs to be clearly outlined. This section explains what is meant by 'emerging economies' and by 'own mitigation action' for non-Annex I countries.

The term '*emerging economies*' in the context of this report refers to non-Annex I countries, which based on data from WRI (2009)[7] are the largest non-Annex I emitters of GHGs: China, India, Brazil, Mexico, Indonesia, Iran, South Korea, South Africa, Thailand and Argentina. Because of data limitations however, we could not include all of those in our analysis. To include a country into the analysis, we needed information on both its baseline emissions in 2020 and on its mitigation potential. The emission baselines found in literature mostly refer to regions or bigger countries (den Elzen et al., 2007; Höhne et al., 2008). Due to unavailable individual baselines for 2020 for some countries and the insufficient information on mitigation potential in the ECN MAC curve for others, the analysis is limited to those emerging economies for which sufficient data on both was obtainable. The selected emerging economies are presented in Table 3.1 together with their level of emissions and economic activity:

Table 2.1 Selected emerging economies with basic indicators on emissions and economic activity

Country	Total GHG emissions in 2005 (excl LULUCF) In Mt CO_2	% of World total	tCO_2/p.c	GDP/p.c. (2005)$
China	7,219.2	19.12%	5.5	4,088
India	1,852.9	4.91%	1.7	2,230
Brazil	1,014.1	2.69%	5.4	8,474
Mexico	629.9	1.67%	6.1	11,387
Indonesia	594.4	1.57%	2.7	3,209
Korea (South)	548.7	1.45%	11.4	21,273
South Africa	422.8	1.12%	9.0	8,478
Argentina	318.3	0.84%	8.2	10,815

Source: World Resources Institute, 2009

Together, they account for almost 70% of all non-Annex I GHG emissions (WRI, 2009). In this report, we assume that only the above emerging economies would agree to a systematic deviation from their emission baselines. Not all of these economies can be considered as 'advanced' in terms of level of development (e.g. income, human development index) and there are significant differences within this group, which is clearly mirrored by the different levels of income and emissions per capita.

7 http://cait.wri.org/cait.php?page=yearly&mode=view&sort=val-desc&pHints=shut&url=form&year=2005&sector=natl&co2=1&ch4=1&n2o=1&pfc=1&hfc=1&sf6=1&update=Update

Own mitigation action are emission reductions below the country baseline incurred by emerging economies that are selected as candidates for domestic emission reductions. They are achieved by employing domestic mitigation options and cannot be traded on the carbon market as offsets (although other kinds of support may be appropriate). Furthermore, we assume that all own mitigation action takes place within the group of emerging economies and does not contribute to the demand for CDM credits.

3 Establishing domestic emission reductions in emerging economies

This study uses baseline emission projections calculated with the integrated climate assessment model IMAGE 2.3 (Bouwman et al., 2006)[8], including the energy model TIMER 2.0 (Van Vuuren et al., 2006) [9] and based on socio-economic and energy sector projections of the reference scenario developed for the ADAM project (van Vuuren et al., 2009, in preparation). The individual emission baselines for countries for which individual data was available are presented in table 3.1.

The scenario underlying the baselines used for the analysis presented in this report is a high economic growth scenario and includes optimistic growth assumptions in China and India. Outside these regions, growth assumptions are comparable to other medium economic growth projections (Den Elzen et al, 2008). Although the baselines for China and India are relatively high, Sheehan (2008) reports even higher baselines.

For the assessment of carbon market effects of including avoided deforestation as a mitigation option, we needed to include a deforestation baseline. We chose the one developed in Bakker et al (2007), which corresponds to the mitigation potential for avoided deforestation included in the ECN MAC curve based on current deforestation rates (see Appendix A).
In line with the 2°C threshold of a global mean temperature rise and a stabilization target of GHG concentration, we assume a 2020 Annex I emission target of approximately 30% below their 1990 levels. Such a reduction in Annex I countries would need to be matched by an at least 15% reduction below business as usual in non-Annex I countries, to keep in line with the 450 ppmv stabilization target (Den Elzen et al., 2008).

In order to achieve about 15% emission declines by all non-Annex I countries only through emerging economy action, reductions for the selected emerging economies as a group need to be higher than 15% while at the same time reflecting the different stages of development of the individual countries within the group of emerging economies. To reflect those differences, we assume that the more advanced ones (which are the majority in our group, with higher per capita income and emission levels) reduce their emissions by 20% below the baseline by 2020, while for those with lower income and lower emission rates this figure is 10%. LDC or other developing countries are not expected to engage in any own mitigation action. Such a distribution of mitigation efforts would result in slightly higher emission reductions than 15% below baseline for non-Annex I as a whole, that is 16% below baseline in 2020.

The absolute emission reductions for the selected countries are given in Table 4.1. For Brazil and Indonesia, emissions from deforestation are included in the baseline (the figures are shown in brackets), as these two countries have a high mitigation potential from avoided deforestation. If emissions from deforestation are added to the emission baseline of a country, its reduction target is increased proportionally, ensuring the consistency of the reduction target.

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8 The IMAGE 2.3 integrated assessment model consists of a set of linked models that together describe the long-term dynamics of global environmental change, such as agriculture and energy use, atmospheric emissions of GHGs and air pollutants, climate change, land-use change (including the impacts of bio-energy and carbon plantations) and environmental impacts (Bouwman et al., 2006).

9 The global energy model TIMER, as part of IMAGE, describes the primary and secondary demand and production of energy, and the related emissions of GHGs, on a regional scale (26 world regions) (Van Vuuren et al., 2006). The model describes the investments in, and the use of, different types of energy options influenced by technology development (learning-by-doing) and resource depletion. It calculates regional energy consumption, energy-efficiency improvements, fuel substitution and the supply and trade of fossil fuels and the application of renewable energy technologies as well as of carbon capture and storage.

Table 3.1 Absolute emission requirements in 2020 for selected non-Annex I countries. Where emissions from deforestation are included, the figures are in brackets

Country	Emission baselines in 2020 [in $GtCO_2eq$]	Reduction target (below baseline) [%]	Absolute emission reduction requirement [in GtCO2eq]
Argentina	0.39	20%	0.078
Brazil	1.32 (2.14)	20%	0.264 (0.427)
Mexico	0.76	20%	0.152
Korea region	0.89	20%	0.178
China region*	13.15	20%	2.63
South Africa	0.63	20%	0.126
India	3.95	10%	0.395
Indonesia region**	0.97 (1.25)	10%	0.097 (0.125)
Total reduction			3.92 (4.11)

* Includes Mongolia & Taiwan
** Includes Papua New Guinea, Timor

The combined emission reduction requirements by emerging economies included in our analysis would be around 3.9 $GtCO_2$-eq in 2020 for the case where deforestation emissions are not accounted for and 4.1 $GtCO_2$-eq for the case where they are.

These countries' reduction requirements equal the amount of their mitigation potential that would be engaged to meet these targets and thus become unavailable to the carbon market. We assess the impact of such development (for both cases, excluding and including avoided deforestation) with the help of the ECN MAC curve.

4 Cost of emerging economies domestic emission reductions and its impact on the carbon market

We apply the reduction requirements for the selected emerging economies established in section 3 to the ECN MAC curve by assuming that emerging economies start their domestic mitigation efforts by implementing the cheapest options first and continue along the cost curve until they have achieved the required level of abatement. The detail in the ECN MAC allows for the identification of sectors in which the own mitigation efforts of emerging economies would most likely take place. The analysis is concluded with a discussion of the sectoral and regional distribution of the remaining CDM potential.

4.1 Total abatement potential

The total technical potential of greenhouse gas reduction options in non-Annex I countries captured in the ECN MAC curve is roughly 7 GtCO_2-eq/yr in 2020, of which almost 5 GtCO_2-eq are available at a cost of up to 20 \$/tCO_2-eq abated. If avoided deforestation is included in this potential, the overall figure rises to 8.6 GtCO_2-eq/yr, including an economic potential of almost 6.5 GtCO_2-eq at a cost up to 20 \$/tCO_2-eq.

4.2 Mitigation potential given emerging economies domestic emission reduction

The effect of the emerging economy emission reduction targets on the non-Annex I marginal abatement cost curves, excluding and including the option of avoided deforestation are shown in figures 4.2 and 4.3, respectively. In the figures, the difference between the solid and the dashed curve is the amount of domestic emission reductions employed by the emerging economies, which is the 3.9 or 4.1 GtCO_2-eq, excluding or including emissions from deforestation, respectively.

4.2.1 Analysis excluding avoided deforestation

Given the uncertainties around the mitigation potential of avoided deforestation, we first present results without this option in the mix. According to an analysis of the mitigation potential up to a certain level of mitigation cost, the selected emerging economies would be able to meet approximately 2 GtCO_2-eq of their mitigation commitment of 3.9 GtCO_2-eq at a cost up to 0 US\$/tCO_2-eq. The other half could be achieved at a cost of around 30 \$/tCO_2-eq.

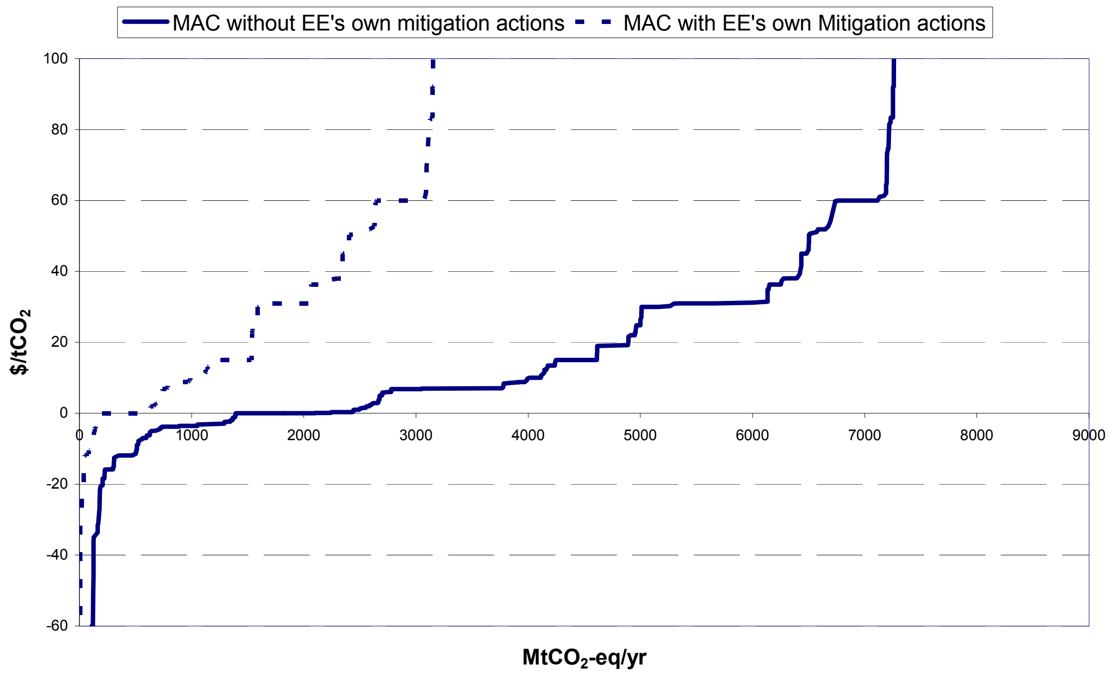

Figure 4.1 Marginal abatement cost curve (excluding avoided deforestation) of mitigation potential in non-Annex I countries before (continuous line) and after (dotted line) emerging economies domestic mitigation action

The total technical mitigation potential remaining available to the carbon market after the selected emerging economies carry out their own mitigation actions (as described in section 3) is reduced from a total of over 7 Gt CO_2-eq per year to approximately 3 Gt CO_2-eq per year, of which only 0.6 Gt CO_2-eq is available at a cost of up to 0$/t CO_2-eq. The reduction of the mitigation potential available to the CDM is significant, although a substantial part of it remains. At abatement costs below 40 $/t CO_2-eq, it remains sufficient to cover the projected demand for carbon credits in 2020 of between 0.5-1.7 GtCO_2-eq (UNFCCC, 2008). The wide range of demand projections reflects the difference between various published demand scenarios. If demand exceeds the high end of this range, costlier mitigation options such as capturing fugitive CH_4 gas from fossil fuel production, CCS in new power plants and more expensive renewable energy options would have to be employed leading to an increase in carbon credit prices.

4.2.2 Analysis including avoided deforestation

If avoided deforestation is allowed as a mitigation option, the overall cost of abatement for the emerging economies does not change dramatically compared to the case excluding avoided deforestation. The emerging economies would still use some 2 GtCO_2-eq of technical potential available up to a cost of 0 $/t$CO_2$-eq and the rest up to some 30 $/t$CO_2$-eq. Hence, the consequence of allowing avoided deforestation as a mitigation option are not very pronounced for the emerging economies meeting their reduction requirements as a group (while it is of course, an important mitigation option for some individual countries). For the remaining carbon market, however, the inclusion of avoided deforestation provides significantly more potential. At 20 US$/t$CO_2$-eq a potential of around 2.8 GtCO_2-eq/yr remains, as opposed to the 1.5 GtCO_2-eq/yr for the case without avoided deforestation.

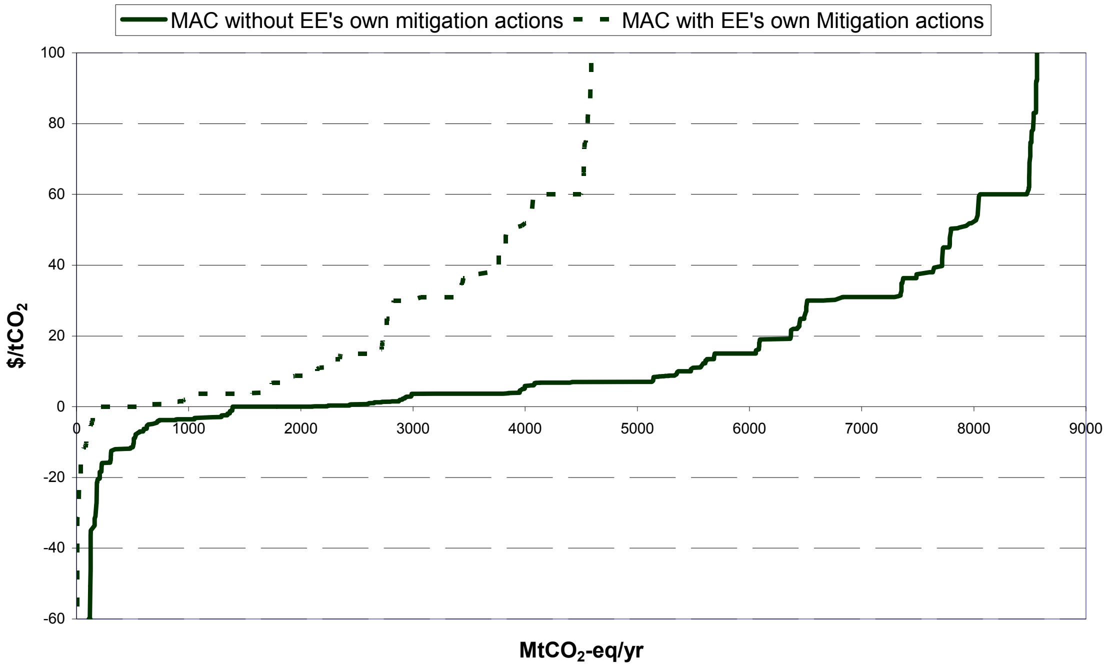

Figure 4.2 Marginal abatement cost curve (including avoided deforestation) of mitigation potential in non-Annex I countries before (continuous line) and after (dotted line) emerging economies domestic mitigation action

4.2.3 The role of avoided deforestation

When including avoided deforestation, Brazil becomes a major contributor to credit supply, alone offering a total of 815 $MtCO_2$-eq in 2020. Since this mitigation option has a relatively low abatement cost, it would likely be chosen by Brazil to reach its domestic reduction target, allowing other technological options to remain in the CDM market.

Although there are no avoided deforestation options at negative costs, there is significant potential at low positive cost (approximately 1.3 $GtCO_2$-eq at a cost below 10 \$/tCO_2-eq), which means that other mitigation options with higher abatement costs than avoided deforestation would only be developed if they offered substantial co-benefits and those co-benefits would be recognised and incorporated in the investment decision. By allowing avoided deforestation as a mitigation option (both for emerging economies to reach their targets as well as for CDM), the total technical mitigation potential would suffice to meet the high end of the 1.7 $GtCO_2$-eq demand projections for carbon credits from UNFCCC (2008) at relatively low cost of around 10 \$/tCO_2-eq.

4.3 Sectoral and regional distribution of mitigation potential

Figure 4.3 represents the sectoral break-down of the mitigation potential for three groups of non-Annex I countries, the Least developed Countries (LDCs), the Emerging Economies with targets (EE) and Other Developing countries (Other DCs), before and after (bars marked with a '*') emerging economies reduce their emissions to the level required. Because LDCs and Other DCs do not have a specific target yet, their potential remains unchanged.

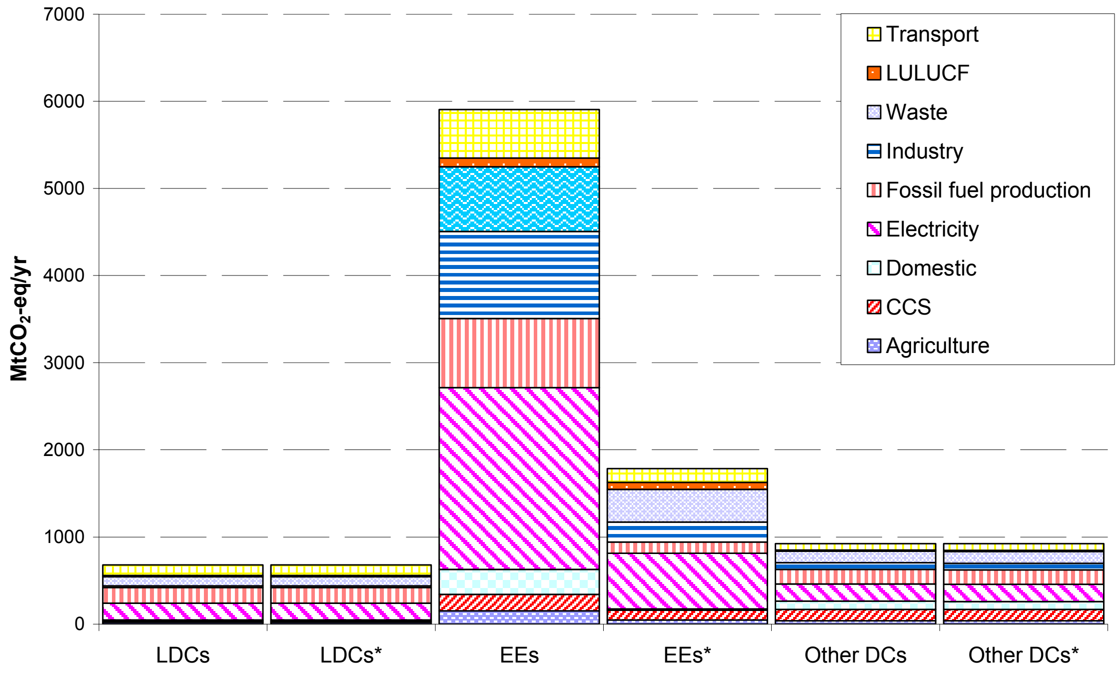

Figure 4.3 Mitigation potential for different groups on non-Annex I countries before and after (*) EE domestic emission reductions for the case excluding avoided deforestation

As can be seen from figure 4.3, the emerging economies could employ options across almost all sectors to reach their targets. The domestic sector covers a large number of low-cost demand side-management options[10], which are almost fully exploited. The power sector[11] offers the largest potential in absolute terms, followed by fossil fuel production[12] and industry[13]. A very large part of the mitigation options in the transport sector[14] are also mobilized. The change in the technical potential of these sectors is represented by the change in the size of their section on the bars representing the potential of EE before and after (*) they achieve their reduction targets.

This analysis suggests that a national program of demand-side management together with sectoral agreements on mitigation actions in the power, industry and fossil fuels producing sectors could deliver the largest and most cost-effective emission reductions for the selected emerging economies. Our findings are in line with the European Commission's Joint Research Centre's recent study which also identifies the largest GHG mitigation potential in developing countries being in the power sector, in industry and in reduction from other conversion (Russ et al., 2009).

The relative importance of the three groups of countries (there are no other developing countries outside these groups) as suppliers of potential to the carbon market now changes. Although the emerging economies continue to represent half of the remaining mitigation potential even after achieving their emission reduction targets (found mostly in the electricity

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[10] DSM appliances, lighting and other, domestic CHP

[11] The technological options in the power sector include several renewable power generation options (biomass heat & power, geothermal, hydro, photovoltaics, small hydro, concentrated solar power, wind), clean coal technology, energy efficiency improvements and CHP.

[12] Mitigation options focus on: coal mine methane, fugitive methane from oil flaring & natural gas production.

[13] Including: boiler & efficiency improvements, fuel switch, waste heat recovery, EE in cement, steel, pulp and paper, HFC avoidance & destruction, N_2O destruction, PFC destruction, SF_6 in industry and power network .

[14] Options include Bus rapid transit systems, efficiency, biofuels and otherfuel switch (gas, hydrogen) and modal shift.

and industry sectors and in waste management options[15]), the role of LDCs as suppliers of overall mitigation potential increases from some 10% to roughly 20%. Their potential of 0.7 $GtCO_2$-eq/yr, comes mostly from renewables (mainly biomass) and methane abatement options in fossil fuel production. Of the overall remaining mitigation potential of 0.6 Gt CO_2-eq per year at negative or zero cost, 0.2 Gt CO_2-eq or one third of it, is found in LDCs.

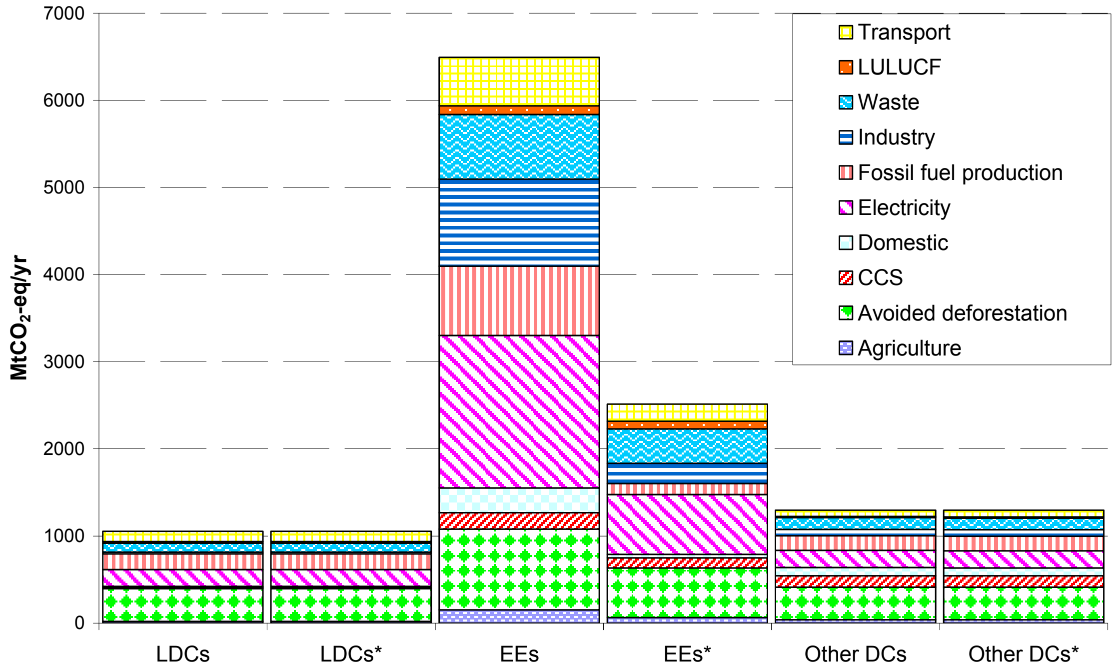

Figure 4.4 Mitigation potential for different groups of non-Annex I countries before and after (*) EE domestic emission reductions for the case including avoided deforestation

Figure 4.4 presents the sectoral distribution of mitigation potential if avoided deforestation is allowed as a mitigation option. Only part of the potential from avoided deforestation is employed by the emerging economies themselves to reach their emission reduction targets (most notably by Brazil), while the majority of the potential would remain available to the carbon market. This is mainly due to the fact that Brazil only uses a small amount (roughly 12%) of its avoided deforestation potential to meet its mitigation target in this model. Indonesia also uses merely 14% of its avoided deforestation potential, but it should be noted that Indonesia's total potential herein represents less than 10% compared to that of Brazil. Changes in other sectors are almost the same as before.

While avoided deforestation does not play a major role for emerging economies to reach their targets, it does represent almost a third of the remaining mitigation potential available to the CDM.

[15] There is also considerable mitigation potential in the waste sector, where landfill gas capture and flaring represents some 90% of mitigation potential. However, we must note here that the scaling of the ECN MAC mitigation potential with the IMAGE/TIMER baselines, resulted in a disproportionately high scaling factor for the waste sector compared to all others, and increased the overall potential by almost three times (6 times for China and even 12 times for India). The results for this sector must thus be interpreted with care.

4.4 Differentiating own contributions within emerging economies

There are significant differences among emerging economies in terms of mitigation potential, especially when avoided deforestation is included as a mitigation option (a detailed list of mitigation options per country is provided in Appendix C to this report).

Without attempting to add to the discourse on burden sharing and differentiation within non-Annex I countries in terms of reduction requirements, we provide an indication on how much emission reductions could *technically* be feasible in the major non-Annex I countries based only on their respective mitigation potentials, as described in the ECN MAC.

Before presenting the figures, an important methodological consideration must be raised again at this point: Because the coverage of mitigation options is not uniform across all countries, some of them might exhibit higher mitigation potentials than others, just based on data availability and not the actual mitigation potential. In other words, the evidence on mitigation potentials is better for some countries than for others, which skews the outcome to show higher emission reduction possibilities for countries for which more information on their mitigation potential exists[16].

Based on the potentials included in the database underlying the ECN MAC curve, the only country that could take on an emission reduction significantly higher than 20% below baseline, is Brazil, if avoided deforestation is included. The mitigation potentials included in the ECN MAC add up to the following maximum possible emission reductions compared to BAU emissions in 2020:

Table 4.1 Maximum emission reduction achievable based on technical mitigation potentials in the ECN MAC[17]

Country	Maximum emission reduction (in % below 2020 baseline)
Brazil	60%
Mexico	30%
China	27%
South Africa	35%
India	22%

These figures compares to a recent study by Ecofys, which for its ambitious scenario (including all abatement options up to 100 $/tCO2eq) identified the following possible reductions below baseline by 2020: 14% for Brazil (figure excluding avoided deforestation), 32% for China, 38% India, 39% for Mexico, 35% for South Africa and 42% for South Korea[18] (Höhne, 2008b).

In absolute terms, the maximum technically feasible targets as shown in table 4.1, translate to combined emission reductions exceeding 6.5 $GtCO_2$-eq. Achieving such reductions by emerging economies domestically, would leave roughly 2 $GtCO_2$-eq of potential to the CDM (including avoided deforestation), half of which in the LDCs.

The data limitations of the ECN MAC curve become more pronounced when we try to analyse mitigation potentials on a country-level so the different maximum technically feasible reduction targets must thus be interpreted with care.

16 The limited coverage of Argentina and South Korea for example does not allow for any higher reductions.

17 For each emerging economy, all its mitigation options together with their respective potentials as they appear in the ECN MAC are represented in Appendix C.

18 The biggest difference in the potential reductions between this study and the Ecofy's study is for the case of South Korea – which in not sufficiently covered in the ECN MAC thus not allowing for any increase in reduction targets.

4.5 Arriving at a CDM market potential

The final step of our analysis is to estimate how much of the remaining mitigation potential can realistically be expected to be developed under the CDM. The MAC curve potential after domestic mitigation action of emerging economies as shown in Figures 4.2 and 4.3 can be regarded as the technical potential with the associated monetary cost for mitigation options. In order to establish a more realistic market potential, we develop two scenarios (an optimistic and a pessimistic one) by applying to the ECN MAC curve a series of correction factors which reflect possible developments for the most important non-economic barriers facing some of the mitigation options available. The correction factors applied are explained in detail in Appendix D.

It is worth mentioning here, that the correction factors only apply to the *remaining* potential and *not the overall* potential. Factors such as eligibility of technologies, additionality and the success of programmatic CDM will not be issues for emerging economies reaching their reduction requirements; they apply only to the international carbon market. Some of the other factors, such as the economic attractiveness of developing a technology and the existence of non-financial barriers related to its uptake will be an issue in domestic mitigation as well. However, its effect on emerging economies reaching their emission reduction targets is beyond the scope of this study and their role in domestic mitigation action would be considerably less than in the international carbon market.

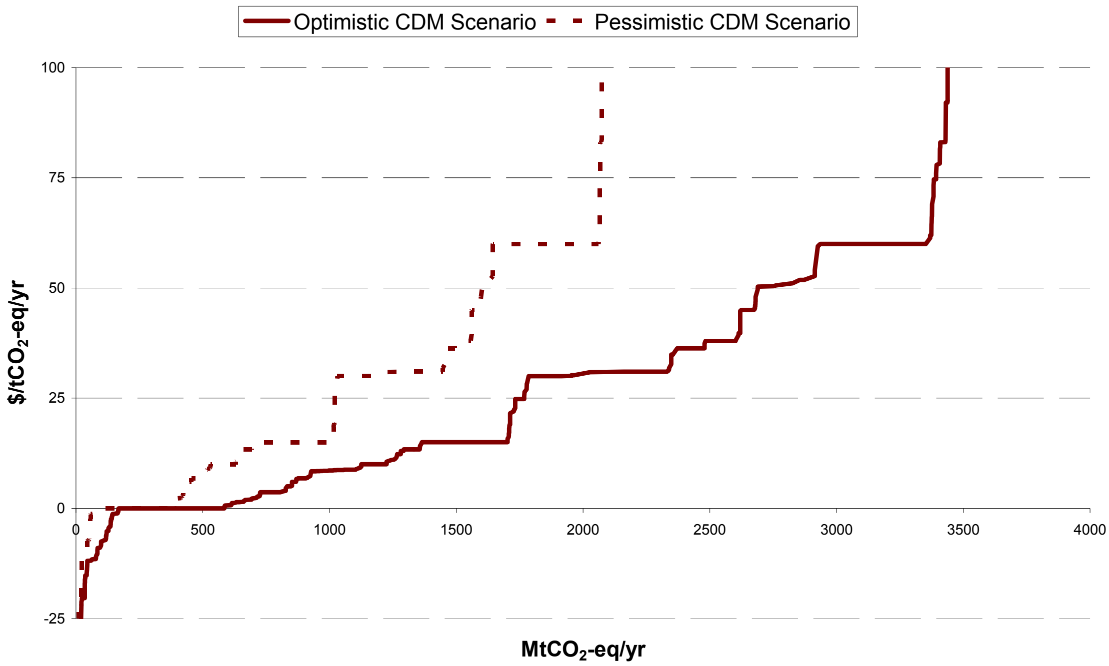

Figure 4.5 Remaining potential under two scenarios of CDM market developments: the continuous line represents the potential in the optimistic scenario and the dotted line in the pessimistic one

In the optimistic scenario, where we assumed high eligibility, projects easily passing the additionality test, successful Programmatic CDM and fewer barriers for energy efficiency the resulting market potential amounts to 1.7 GtCO$_2$-eq up to a cost of 25 \$/t CO$_2$, including some 200 MtCO$_2$-eq from avoided deforestation. In the pessimistic scenario, there is only 1 GtCO$_2$-eq of potential remaining in the same cost class and no avoided deforestation. This compares to the technical potential of 2.8 and 1.5 GtCO$_2$eq up to 20\$/tCO$_2$-eq for the case fully including and excluding avoided deforestation, respectively. Near-term market developments thus clearly play a very important role in determining the size of the potential supply of CDM credits. Should they turn out restrictive while the demand for credits reaches the upper bound of predictions in UNFCCC (2008), the market could become tight.

5 Discussion

This study has calculated costs and estimated the impacts on the carbon market in the case that a number of selected emerging economies would undertake significant domestic mitigation action by 2020. As the approach taken in the study includes implementing the lowest-abatement cost mitigation options first, and energy efficiency in industry and power often represent low-cost options, much of the potential in these sectors is used to achieve the emission reduction requirements for emerging economies, and is not available for the carbon market anymore.

In addition to the industry and power sectors, the remaining technical potential available to the carbon market in the transport sector is low. This reflects the fact that efficiency and fuel switch in the transport sector represent a substantial abatement potential at an abatement cost lower than 0 $/CO_2$-eq mostly in emerging economies and less so in other developing countries.

The assumption that emerging economy domestic emission reductions are implemented on a lowest-cost basis implies that the abatement cost will be the main factor considered in employing a mitigation option. In practice, other considerations play a role, such as co-benefits associated with the option, non-financial barriers or political considerations. For example, a hydro power station may be preferred over energy efficiency in industries due to the increasing electricity demand in a region, even if it is a more costly option. In the technical potential analysis, the method does not take into account any other barriers or opportunity costs. In reality, low abatement costs may require a vast initial investment or represent a larger opportunity cost, which would make investments unattractive in practice.

There are also important data limitations that need to be considered. Lack of comprehensive coverage of all mitigation options in all non-Annex I countries did not allow inclusion of all emerging economies into the analysis. This means that both the mitigation potential before and after emerging economies domestic emission reductions is underestimated. The same problem causes the targets for some of the emerging economies (Argentina and South Korea) to exceed their respective total mitigation potentials. Although part of the missing mitigation potential would have to be employed by the countries themselves to reach the target, the resulting remaining CDM potential should be viewed as a conservative estimate.

The remaining mitigation potential is a technical potential, subject to several non-monetary barriers before it can be developed on the CDM market. To arrive to a more realistic market potential we employed a number of correction factors, which reflect the up-to-date knowledge on the market so far but are inherently subject to uncertainties about future developments. The actual outcome can be anything in between, which given future demand projections (UNFCCC, 2008) can lead to the CDM market turn from a buyer's to a seller's market.

Despite all the limitations, the overall results presented in this study seem to be in line with similar recent studies. In their 2008 study on proposals for contributions of emerging economies to the climate regime under the UNFCCC post 2012, Höhne et al. (2008b) find that the emerging economies of China, Brazil, India, Mexico, South Africa and South Korea could reduce their emissions by around 9% compared to business as usual at negative costs in 2020. This is in agreement with our finding that half of the reductions required in emerging economies (20% below baseline) are available at a cots of up to 0 US$/$CO_2$-eq/yr. Our analysis adds to this a more detailed insight into sectors and technologies offering mitigation potential.

6 Conclusions

In this study we address the cost and carbon market impacts of involving emerging economies into own mitigation action that leads to considerable deviation from their projected future emissions. The reductions necessary to set global emissions on a path towards low GHG stabilisation levels (450 ppm CO_2eq) would require a considerable effort on the part of any country that has significant GHG emissions. In emerging economies, emission reductions of some 10 to 20% below business as usual in 2020 would lead to costs, although half of their reductions can come from no-regret options. For the remaining carbon market, the reduction of the potential in emerging economies would reduce the overall mitigation potential realisable in the CDM and roughly double the importance of least-developed countries as potential suppliers of CERs.

More specifically, over half of the necessary reductions in emerging economies could be achieved at negative or zero cost. The rest would be available at a cost of up to around 30 US$/t$CO_2$-eq, which is at the lower end of carbon price projections for the same stabilization level by other models[19]. The costs of achieving significant reductions stays roughly the same for emerging economies as a group when avoided deforestation is allowed as a mitigation option, since only Brazil and Indonesia have a significant forest cover. Those two countries would be able to reach their entire 10 to 20% emission reduction through avoided deforestation.

The emission reductions realised domestically by emerging economies greatly reduce the remaining potential available to the CDM. With much of the least-cost options from emerging economies depleted, the mitigation potential at negative or zero costs in the remaining carbon market is significantly reduced: from around 2.5 to 0.6 GtCO_2-eq. As there are no avoided deforestation options at negative costs, this figure is the same regardless of whether avoided deforestation is included as a mitigation option or not.

Avoided deforestation does however have a significant impact on the remaining potential above the cost of 0 US$/t$CO_2$-eq. In the case where avoided deforestation *is not* allowed as a mitigation option, the cumulative potential remaining to the carbon market is 3 Gt CO_2-eq/yr in total, of which about 0.6 GtCO_2-eq at negative or zero costs and a further 0.9 GtCO_2-eq at a cost of up 20 US$/t$CO_2$-eq. Summed up, at a cost up to 20 US$/t$CO_2$-eq, there is a potential of 1.5 GtCO_2-eq, which is below the upper bound of published estimates on future demand for carbon credits (0.5-1.7 GtCO_2-eq) (UNFCCC, 2008). If avoided deforestation *is* allowed as a mitigation option, it increases the remaining potential up to a cost of 20 US$/t$CO_2$-eq to 2.7 Gt$CO_2$-eq, although it would at the same time reduce the attractiveness of many other 'more expensive' technological options, such as renewables but also CCS. Without avoided deforestation, the carbon market is tighter and carbon prices could rise. Overall, most remaining low-cost potential lies in the power and industry sectors.

Having emerging economies pursue own mitigation action changes in the share of least developed countries in the remaining carbon market potential. Although emerging economies would continue to dominate the CDM, the relative importance of LDCs' potential would be increased from around 10 to approximately 20% of the remaining mitigation potential. Although this looks promising for the role of poor countries in the CDM, the non-economic and market barriers in these countries could still represent a significant problem for implementation and could effectively reduce the market potential and drive up prices.

Mitigation potentials between emerging economies may vary, especially if avoided deforestation is included. We explored what maximum emission reductions would be technically feasible in each of the countries included in the analysis. Assessing potentials on an individual country level exposes the limited coverage of mitigation options in some countries in the ECN MAC, which is based on country-specific bottom up studies. It appears that only Brazil has enough

[19] For an extensive discussion on carbon price projections see Bole, 2009 (forthcoming).

mitigation potential (including avoided deforestation) to achieve significantly deeper emission reductions, while for most other countries the technical mitigation potential is limited to around 30% or less. These results should be carefully interpreted due to data limitations.

Even after emerging economies undertake significant domestic mitigation efforts, they still have significant abatement potential remaining to be developed. Bakker et al (2007) shows that the extent to which this potential can be harnessed by the CDM strongly depends on future eligibility decisions, notably for avoided deforestation, the application of the additionality criterion, and to a lesser extent the adoption rate of technologies and the success of programmatic CDM. Under unfavourable institutional and technological circumstances, the potential that could be realistically developed would be as little as 1 $GtCO_2eq$ up to a cost of 25 US$/t CO_2. This would have significant implications for the CDM market, raising prices of CDM credits as more expensive options would have to be employed to meet the demand.

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Appendix A ECN-MAC updates

This annex gives a detailed overview of the changes in the ECN MAC for non-Annex I countries since November 2007, when Bakker et al (2007) was published.

1) Additional options
The most significant change is related to sub-Saharan African countries, for which the coverage of options was relatively weak until 2007. We updated the database by including the following options for sub-Saharan countries, based on a detailed bottom up assessment of cost and potential of climate mitigation options for 29 countries (Gouvello et al, 2008):

- Biomass for power generation
- Hydro power
- Fossil fuel switch in power production
- Energy efficiency in industry (steam optimisation)
- Biofuel based on Jatropha
- Bus rapid transit systems (BRT)
- Efficient lighting systems
- Gas flaring

Gouvello et al (2008) give for each option a detailed assessment of investment and operating cost, baseline emission factors and in some cases benefits of the options, i.e. no abatement in \$/tCO_2-eq are given. We had to calculate these ourselves, based on a 10% discount rate, 21 years economic lifetime. For the baseline power price we assumed a flat rate of \$30/MWh. The abatement cost is then based on the difference between the cost of the abatement option and the reference option, divided by the difference in CO_2 emission factor. The abatement cost for fossil fuel switch in the power sector is assumed to be similar to figure found for Europe: \$30/tCO_2-eq (Bakker et al, 2009). For BRT projects the cost was assumed to be similar to these found for BRT in China (\$2.7/tCO_2).

Energy for nuclear facilities was added, based on the National Strategy Studies for CDM implementation for South Africa (World Bank, 2002) and Argentina (World Bank, 1999), and for India and China based on CCAP/TERI (2006) and CCAP/Tsinghua (2006) respectively. In the curves published in this report the nuclear options is allowed as a mitigation option for emerging economies to reach their reduction targets but is not included in the mitigation potential for the carbon market.

For the mitigation potential in the buildings sector in China we used Li (2008), which report a figure of 201 MtCO_2/yr (11% reduction compared to the baseline emissions) in 2020 based on the medium energy efficiency scenario from the National Development and Reform Commission. The abatement cost is based on Ürge-Vorsatz and Nikova (2008) who analyse abatement cost curves for the buildings sector for 10 countries in different world regions (not including China), and we conservatively assumed the abatement cost for China to be equal to the most expensive of these (-3 \$/tCO_2)

CO_2 capture and storage in the natural gas processing sector may be an important 'early opportunity' for CCS as CO_2 is already captured in the baseline scenario. Until recently, data on this were hard to get by and estimates were based on top-down assumptions. We present here also a bottom-up analysis based on a database that was kindly made available by IHS, an oil and gas consultancy which owns a database of gas fields around the world, and their CO_2 contents. With the help of this database, we analyse the potential for GHG mitigation by CCS in the natural gas processing in more than 49 non-Annex I countries. The technical potential is estimated to be 146 – 222 MtCO_2 per year in 2020. Figure F.1 shows the break-down by country for the central estimate of 174 MtCO_2-eq/yr.

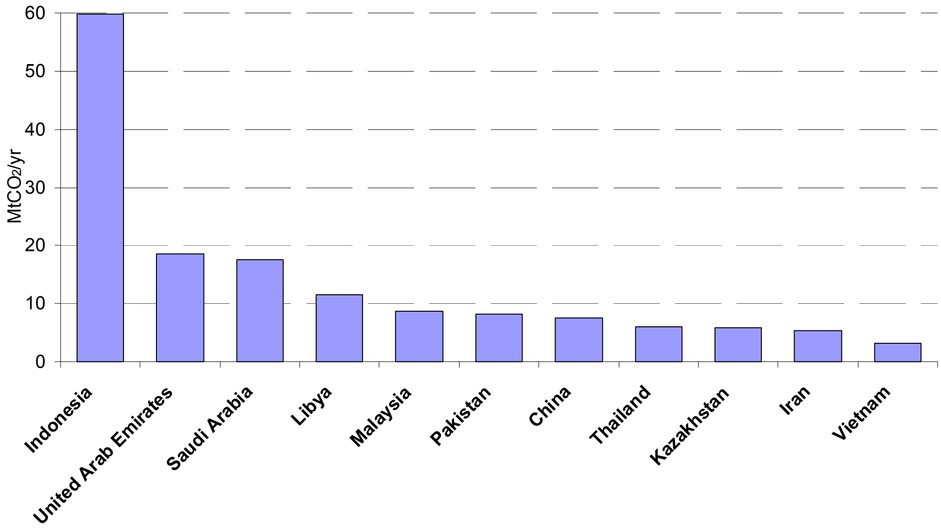

Figure A.1 Potential for CCS in the natural gas processing sector in 2020. Source: De Coninck et al, 2009.

The abatement cost of these options (8-30 $/tCO_2$) is based on Zakkour et al (2008), who use a detailed bottom up methodology based on whether the CO_2 capture and storage takes place on or offshore and whether the processing installation is new-build or retrofit.

2) New cost calculation for avoided deforestation

The potential for avoided deforestation has remained equal to that reported in Bakker et al (2007)[20]. The methodology to estimate the cost of REDD has changed and is based on a study by IPAM (Environmental Research Institute of Amazonia, Nepstad et al, 2008) on Amazon forest, in Brazil. This REDD program estimates the cost to eliminate the deforestation in Brazil within ten years. They consider the total cost of avoiding deforestation as a combination of three intermediate costs: (1) a compensation for living in forest, in order to them to protect the nature; (2) a compensation for private forest property, as a payment for owner to discourage making profits by land use, as agriculture and pastures; and (3) funds for governments for them to monitoring the forest.

To compensate people living in forest IPAM's study proposes to pay half an official minimal wages for approximately 150 thousands households. For the land owners, an opportunity cost based on the profitability of soil production, pasture and sustainable wood production was estimated. For forest monitoring, the additional cost for government to protect and manage the public forest was estimated. There were no data available to reproduce IPAM's methodology. However, for each intermediate cost, it is possible to have good proxies. In the case of compensation for people living in forest, instead of using minimum wages for each household, the GDP per capita could be used. We assume that an average household has four persons. As cost of opportunity, value of wood and non-wood forest products removals informed by FAO in its database could be used. A proxy for the cost of monitoring forest is harder to obtain, however it could be the cost per hectare estimated for Brazil in IPAM's study, which is 1.45 US$/ha. It is, in fact, an additional cost of monitoring. Table F.1 shows the updated cost (and potentials earlier reported) for the most important countries.

[20] Which was based on an extrapolation of current deforestation rates reported by Forest Resource Assessment. It is projected that 81 million hectares of land will be deforested between 2012 and 2020, or 12 Mha per year, resulting in baseline emissions of 2.3 $GtCO_2$/yr in 2020.

Table A.1 Potential and cost of avoided deforestation in ECN MAC

	Technical Potential ($MtCO_2$/yr)	Abatement cost (US$/$tCO_2$)
Democratic Republic of the Congo	158	0.7
Zambia	60	1.2
Bolivia	72	1.4
Lao People's Democratic Republic	33	1.5
Brazil	815	3.7
Cameroon	38	3.7
Venezuela (Bolivarian Republic of)	101	4.0
Central African Republic	4	4.6
Madagascar	17	5.0
Congo	8	6.3
Papua New Guinea	13	6.7
United Republic of Tanzania	31	6.7
Paraguay	14	6.9
Nigeria	65	11.1
Ethiopia	15	12.2
Peru	27	16.2
Mozambique	5	18.4
Gabon	1	22.2
Angola	10	22.4
Sudan	10	26.3
Malaysia	33	31.2
Colombia	19	31.4
Indonesia	72	39.8
Argentina	14	54.1
Kazakhstan	4	81.5
Nepal	1	139.0
Myanmar	9	152.2
Mexico	25	163.2
Afghanistan	1	244.0

3) Adjustment factors for the mitigation potentials

In Wetzelaer et al (2007) the potentials for each CO_2 reduction option were multiplied by 1.25, which aimed to extrapolate the findings of the approximately 20 country abatement studies to the rest of the non-Annex I region that was not covered. This resulted in an overall cost curve for the entire region. However for the current study we needed more detail on the regional or country level, and this factor was not deemed appropriate anymore and therefore deleted. This means that for a range of CO_2 reduction options the overall potential is likely to be underestimated, but not as much as a factor of 1.25, as for several countries (notably sub-Saharan Africa as mentioned before) new bottom up data was found.

Appendix B List of Least Developed Countries according to the UN[21]

1	Afghanistan	26	Madagascar
2	Angola	27	Malawi
3	Bangladesh	28	Maldives
4	Benin	29	Mali
5	Bhutan	30	Mauritania
6	Burkina Faso	31	Mozambique
7	Burundi	32	Myanmar
8	Cambodia	33	Nepal
9	Cape Verde	34	Niger
10	Central African Republic	35	Rwanda
11	Chad	36	Samoa
12	Comoros	37	São Tomé and Principe
13	Democratic Republic of the Congo	38	Senegal
14	Djibouti	39	Sierra Leone
15	Equatorial Guinea	40	Solomon Islands
16	Eritrea	41	Somalia
17	Ethiopia	42	Sudan
18	Gambia	43	Timor-Lesté
19	Guinea	44	Togo
20	Guinea-Bissau	45	Tuvalu
21	Haiti	46	Uganda
22	Kiribati	47	United Republic of Tanzania
23	Lao People’s Democratic Republic	48	Vanuatu
24	Lesotho	49	Yemen
25	Liberia	50	Zambia

[21] http://www.un.org/special-rep/ohrlls/ldc/list.htm

Appendix C List of mitigation options per country

Argentina

Sector	type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
CCS	CCS industry	Natural gas processing - existing fields	3.12
CCS	CCS industry	Natural gas processing - new fields	0.06
Domestic	Transport FS	Transport - fuel replacement Gasol. by CNG (taxis)	0.06
Domestic	Transport FS	Transport - fuel replacement Diesel Oil by CNG (buses)	1.07
Domestic	Transport FS	Transport - New autos New Taxis CNG	0.03
Domestic	Transport FS	Hydrogen in vehicles	0.57
Electricity	CHP industry	Cogeneration - natural gas Textiles	0.00
Electricity	CHP industry	Cogeneration - natural gas Dairy products	0.00
Electricity	CHP industry	Cogeneration - natural gas Cold-storage plants	0.00
Electricity	CHP	Cogeneration - natural gas Oil	0.03
Electricity	CHP	Cogeneration - biomass Oil	0.04
Electricity	CHP	Cogeneration - natural gas Paper	0.11
Electricity	CHP	Cogeneration - biomass Paper	0.10
Electricity	Hydro	Electric supply Corpus (hydro)	4.41
Electricity	Hydro	Electric supply Paraná Medio (hydro)	4.31
Electricity	Hydro	Electric supply Garabí (hydro)	0.77
Electricity	Hydro	Electric supply Arrazayal (hydro)	0.10
Electricity	Hydro	Electric supply Cambarí (hydro)	0.12
Electricity	Hydro	Electric supply Las Pavas (hydro)	0.09
Electricity	Wind	Electric supply Wind charger	0.04
Electricity	Hydro	Medium hydropower	0.31
Electricity	Wind	Wind	0.04
Electricity	nuclear	Nuclear power	0.98
Industry	EE industry	Industrial efficiency Textiles	0.64
Industry	Cement EE	Industrial efficiency Cement	1.22
Industry	EE industry	Industrial efficiency Oils	1.39
Industry	EE pulp & paper	Industrial efficiency Pulp and Paper	1.32
Industry	EE industry	Industrial efficiency Dairy products	0.37
Industry	EE industry	Industrial efficiency Cold-storage Plants	0.64
LULUCF	Afforestation/reforestation	Afforestation/reforestation	2.86
LULUCF	Avoided deforestation		14.00

Brazil

Sector	Type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	6.59
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	6.59
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	15.77
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	8.70
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	2.17
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	8.70
CCS	CCS industry	capture at ammonia plant	0.10
CCS	CCS industry	capture at ethanol plant	1.09
CCS	CCS power	combustion in new built coal plant	0.01
CCS	CCS power	combustion in new built gas plant	0.41
CCS	CCS industry	Natural gas processing - existing fields	0.00
CCS	CCS industry	Natural gas processing - new fields	1.50
Domestic	transport efficiency	Efficiency gains	10.35
Domestic	Biofuel	Flex fuel vehicles	35.40
Domestic	Biofuel	Biodiesel in HDV (use of 20% biodiesel blends (B20) in the place of diesel fuel)	16.70
Domestic	DSM appliances	Low-Medium	18.37
Domestic	DSM other	mitigation scenario (extensions of mitigation options included in recent policy)	5.01
Domestic	Biofuel	mitigation scenario (extensions of mitigation options included in recent policy)	0.00
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	2.30
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	3.02
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	0.37
Domestic	Biofuel	Flex fuel vehicles	3.01
Electricity	Small hydro	Small hydro	49.47
Electricity	Biomass power	Sugar cane bagasse	63.78
Electricity	Wind	Wind energy	64.44
Electricity	Biomass power	biomass (bagasse from additional ethanol exports)	4.85
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	2.90
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	1.54
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	2.00
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	1.16
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	2.49
Fossil fuel production	Fugitive CH4 oil flaring	crude oil production - flaring, direct use or reinjection	0.16
Industry	Cement EE	Reducing clinker- to cement ratio and increasing thermal eff.	5.90
Industry	EE pulp & paper	mitigation scenario (extensions of mitigation options included in recent policy)	3.37
Industry	EE steel	mitigation scenario (extensions of mitigation options included in recent policy) substitution of mineral coal coke by reforested charcoal)	11.79

Sector	Type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
Industry	N2O	nitric acid production - catalytic reduction	3.23
Industry	N2O	adipic acid production - thermal destruction	1.95
Industry	PFC	aluminum production - retrofitting production technology A	0.20
Industry	PFC	aluminum production - retrofitting production technology A	0.67
Industry	PFC	aluminum production - retrofitting production technology A	0.06
Industry	HFC destruction	HFCF-22 production - thermal oxidation	0.17
Industry	SF6 power network	electric power systems - SP6 recycling & leakage detection and repair	0.99
Industry	SF6 power network	electric power systems - SP6 recycling & leakage detection and repair	0.17
LULUCF	Afforestation/reforestation	Afforestation/reforestation	12.53
LULUCF	Avoided deforestation		203.75
LULUCF	Avoided deforestation		203.75
LULUCF	Avoided deforestation		203.75
LULUCF	Avoided deforestation		203.75
Waste	LFG	landfill - capture and flaring/use A	14.23
Waste	LFG	landfill - capture and flaring/use A	14.70
Waste	LFG	landfill - capture and flaring/use A	7.33
Waste	LFG	landfill - capture and flaring/use A	23.66

China

Sector	Type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	4.36
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	4.36
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	4.36
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	4.36
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	4.36
Agriculture	Agriculture CH4	rice cultivation - various technologies A	4.36
Agriculture	Agriculture CH4	rice cultivation - various technologies A	4.36
Agriculture	Agriculture CH4	rice cultivation - various technologies A	4.36
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	11.37
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	7.96
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	1.71
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	1.71
CCS	CCS industry	capture at ammonia plant	28.73
CCS	CCS power	combustion in new built coal plant	61.59
CCS	CCS power	combustion in new built gas plant	0.79
CCS	CCS industry	Natural gas processing - existing fields	3.26
CCS	CCS industry	Natural gas processing - new fields	4.23
Domestic	transport efficiency	Improvement of Transmission Technologies	15.45
Domestic	transport efficiency	Improvement of Vehicle Technologies	35.43
Domestic	transport efficiency	Fuel efficiency improvement (e.g. hybrid electric cars and direct injection gasoline/diesel)	110.00
Domestic	transport efficiency	Engine-Transmission-Vehicle Technologies	2.35
Domestic	Transport BRT	Buss Rapid Transit (BSR) system	2.26
Domestic	Transport FS	Fuel Switch in busses	8.33
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	9.97
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	1.68
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	4.85
Domestic	DSM other	Energy efficiency scenario B of NDRC	162.57
Electricity	Clean coal	CFBC (Circulating Fluidized bed combustion)	11.25
Electricity	EE Power	Demand-side management (technical measures to improve energy efficiency)	74.85
Electricity	Clean coal	(Ultra)-Supercritical coal	58.50
Electricity	FS power	Natural gas	8.27
Electricity	Wind	Wind Power	118.18
Electricity	Clean coal	IGCC and other advanced conventional thermal power technologies	27.77
Electricity	Solar thermal	Solar thermal	22.45
Electricity	Biomass power	biomass + waste	126.06
Electricity	hydro		337.22
Electricity	nuclear	Nuclear power	269.65
Fossil fuel production	Coal mine methane	coal mining - degasification, enhanced degasification, oxidation of ventilated air methane (VAM)	602.39
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	8.45
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	9.80

Sector	Type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	3.23
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	0.41
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	0.86
Fossil fuel production	Fugitive CH4 oil flaring	crude oil production - flaring, direct use or reinjection	9.39
Industry	Cement EE	Preventative Maintenance Cement	38.55
Industry	EE steel	Establish energy management center	5.91
Industry	Cement EE	Process management and Control Cement	31.99
Industry	Cement EE	Kiln Shell Heat Loss Reduction Cement	18.54
Industry	Cement EE	High-Efficiency Motors and Drives Cement	13.45
Industry	Cement blending	Active Additives Cement	8.59
Industry	Cement blending	Composite Cement Cement	23.46
Industry	EE steel	Advanced coke oven	14.93
Industry	Cement EE	Conversion to Multi-stage pre-heater kiln Cement	80.55
Industry	Cement EE	Combustion System Improvement Cement	57.09
Industry	EE steel	Advanced blast furnace technology	40.36
Industry	Boiler replacement	Reconstruction of conventional thermal power plant	41.18
Industry	Cement EE	High-efficiency roller mills Cement	46.92
Industry	EE steel	Adjust ratio of iron/steel	71.52
Industry	Cement EE	High-efficiency Powder Classifiers Cement	16.73
Industry	Cement EE	Efficient transport systems Cement	6.07
Industry	EE steel	Dry coke quenching	5.74
Industry	EE steel	Advanced sinter machine	17.22
Industry	EE steel	Advanced direct steel rolling machine	7.22
Industry	EE steel	Smelt reduction technology	42.00
Industry	EE steel	Advanced converter	12.47
Industry	N2O	nitric acid production - catalytic reduction	34.58
Industry	N2O	adipic acid production - thermal destruction	20.93
Industry	PFC	aluminum production - retrofitting production technology A	0.03
Industry	PFC	aluminum production - retrofitting production technology A	0.43
Industry	PFC	aluminum production - retrofitting production technology A	0.43
Industry	HFC destruction	HFCF-22 production - thermal oxidation	180.45
Industry	SF6 industry	semiconductor manufacturing - various technologies A	6.89
Industry	SF6 industry	semiconductor manufacturing - various technologies A	1.30
Industry	SF6 power network	electric power systems - SP6 recycling & leakage detection and repair	13.60
Industry	SF6 power network	electric power systems - SP6 recycling & leakage detection and repair	0.38
Industry	SF6 industry	magnesium production - replacement with alternative cover gases	6.14
LULUCF	Afforestation/refore-station	Afforestation/reforestation	66.38
Waste	Waste fuel utilisation	Use of Waste Derived Fuels Cement	148.22
Waste	LFG	landfill - capture and flaring/use A	34.26
Waste	LFG	landfill - capture and flaring/use A	110.31
Waste	LFG	landfill - capture and flaring/use A	36.75
Waste	LFG	landfill - capture and flaring/use A	118.16

India

Sector	Type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	7.92
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	7.92
Agriculture	Agriculture CH4	rice cultivation - various technologies A	7.92
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	7.55
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	8.18
CCS	CCS industry	capture at ammonia plant	1.13
CCS	CCS industry	capture at ethylene oxide plant	0.06
CCS	CCS industry	capture at hydrogen plant	0.07
CCS	CCS power	combustion in new built coal plant	16.81
CCS	CCS power	combustion in new built gas plant	0.55
CCS	CCS industry	Natural gas processing - existing fields	0.24
CCS	CCS industry	Natural gas processing - new fields	0.04
Domestic	Transport FS	Switch towards compressed natural gas (CNG) from conventional fuel based vehicles	30.89
Domestic	Transport Modal shift	Enhanced share of public-transport	30.06
Domestic	Transport Modal shift	Higher share of rail in freight movement + electrification	6.68
Domestic	Transport Modal shift	Higher share of rail in passenger movement	10.85
Domestic	transport efficiency	Efficiency improvements in fuel efficiency	99.36
Domestic	Biofuel	Replacing diesel by bio-diesel	90.17
Domestic	transport efficiency	Shift from 2-stroke motorcycle towards 4-stroke motorcycle	5.01
Domestic	transport efficiency	Shift from 2-stroke moped towards 4-stroke moped	2.50
Domestic	transport efficiency	Shift from 2-stroke scooter towards 4-stroke scooter	1.67
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	0.78
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	0.20
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	0.51
Electricity	EE Power new build	switch towards H -Frame Combined Cycle Gas Based Plant (60% Efficiency)	3.48
Electricity	Wind	Wind Power Plant Electricity	25.47
Electricity	Small hydro	Small Hydro Plant Electricity	31.67
Electricity	nuclear	Nuclear power	148.16
Fossil fuel production	Coal mine methane	coal mining - degasification, enhanced degasification, oxidation of ventilated air methane (VAM)	33.47
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	7.72
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	12.57
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	5.99
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	5.07
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	11.00
Fossil fuel production	Fugitive CH4 oil flaring	crude oil production - flaring, direct use or reinjection	0.08
Industry	EE pulp & paper	Wood based efficient -2 Pulp and Paper	0.82
Industry	EE pulp & paper	Retrofit- waste paper based Pulp and Paper	0.20

Sector	Type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
Industry	EE pulp & paper	Retrofit Agricultureo based Pulp and Paper	0.20
Industry	Cement EE	Advanced 6-Stage technology for producing (blended) Portland Pozzolana Cement (PPC)	6.96
Industry	Cement EE	Advanced 6-Stage technology for producing (blended) Portland Slag Cement (PSC)	3.89
Industry	EE pulp & paper	Waste paper based efficient Pulp and Paper	0.31
Industry	EE pulp & paper	Agricultureo based - efficient Pulp and Paper	0.31
Industry	EE steel	BF-BOF -Efficient Iron and Steel	19.87
Industry	N2O	nitric acid production - catalytic reduction	2.23
Industry	PFC	aluminum production - retrofitting production technology A	0.02
Industry	PFC	aluminum production - retrofitting production technology A	0.07
Industry	PFC	aluminum production - retrofitting production technology A	0.06
Industry	HFC destruction	HFCF-22 production - thermal oxidation	1.94
Industry	SF6 industry	semiconductor manufacturing - various technologies A	0.25
Industry	SF6 industry	semiconductor manufacturing - various technologies A	0.05
Industry	SF6 power network	electric power systems - SP6 recycling & leakage detection and repair	1.97
Industry	SF6 power network	electric power systems - SP6 recycling & leakage detection and repair	0.05
LULUCF	Afforestation/refore-station	Afforestation/reforestation	2.45
Waste	LFG	landfill - capture and flaring/use A	23.75
Waste	LFG	landfill - capture and flaring/use A	101.49
Waste	LFG	landfill - capture and flaring/use A	81.71

Indonesia

Sector	Type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
CCS	CCS industry	capture at ammonia plant	0.55
CCS	CCS industry	Natural gas processing - existing fields	7.78
CCS	CCS industry	Natural gas processing - new fields	52.00
Domestic	DSM-lighting	Energy efficient lighting systems	3.72
Domestic	DSM appliances	Refrigerators (Hitch, compact and compact panel)	0.14
Electricity	EE Power	Energy Conservation	0.00
Electricity	EE power	Utilisation of flared gas	4.88
Electricity	Hydro	Hydropower	0.58
Electricity	Small hydro	Mini Hydro	0.31
Electricity	CHP	Co-generation Low Temperature	0.77
Electricity	CHP industry	Co-generation & heating system reconstruction in textile industry	5.24
Electricity	FS power	Gas turbine (coal baseline	0.14
Electricity	Geothermal	Geo thermal PP	8.08
Electricity	CHP	Co-generation High temperature	0.52
Electricity	Biomass power	Biomass steam PP	1.30
Electricity	Solar central	Solar thermal	0.02
Electricity	Clean coal	IGCC	0.28
Industry	EE industry	Variable speed motor	0.39
Industry	EE industry	Improved waste management in starch factories	0.02
Industry	EE industry	Boiler improvement in palm oil plant	0.63
LULUCF	Afforestation/refore-station	Afforestation/reforestation	7.91
LULUCF	Avoided deforestation		71.98
Waste	Waste fuel utilisation	Waste incineration/ fuel switch in pulp & paper plant	0.44

Mexico

Sector	Type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	2.86
Agriculture	Agriculture CH4	croplands - improved fertilization practices, no tillage	2.86
Agriculture	CH4 livestock	livestock - improved feeding practices and anaerobic manure digesters A	1.36
CCS	CCS industry	capture at ammonia plant	1.17
CCS	CCS industry	Natural gas processing - existing fields	1.32
CCS	CCS industry	Natural gas processing - new fields	0.00
Domestic	DSM-lighting	Energy efficient lighting systems	2.48
Domestic	DSM appliances	Pumping	1.19
Domestic	DSM-lighting	Energy efficient lighting systems	1.19
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	1.02
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	1.35
Domestic	HFC avoidance	refrigeration & air conditioning - various technologies A	0.16
Electricity	CHP industry	Industrial Cogeneration	35.06
Electricity	FS power	Natural gas Combined Cycle instead of fuel oil termoelectric plants	69.33
Electricity	Wind	Wind Power	12.08
Fossil fuel production	Coal mine methane	coal mining - degasification, enhanced degasification, oxidation of ventilated air methane (VAM)	0.83
Fossil fuel production	Coal mine methane	coal mining - degasification, enhanced degasification, oxidation of ventilated air methane (VAM)	1.67
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	9.78
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	10.69
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	12.26
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	5.77
Fossil fuel production	Fugitive CH4 natural gas production	natural gas - production, processing, transmission and distribution - various technologies A	12.45
Fossil fuel production	Fugitive CH4 oil flaring	crude oil production - flaring, direct use or reinjection	19.78
Industry	Boiler replacement	Industrial Boilers	2.67
Industry	EE industry	Industrial motors	0.89
Industry	N2O	nitric acid production - catalytic reduction	0.56
Industry	HFC destruction	HFCF-22 production - thermal oxidation	0.28
Industry	SF6 power network	electric power systems - SP6 recycling & leakage detection and repair	0.60
Industry	SF6 power network	electric power systems - SP6 recycling & leakage detection and repair	0.10
LULUCF	Afforestation/refore-station	Afforestation/reforestation	0.17
LULUCF	Avoided deforestation		25.00
Waste	LFG	landfill - capture and flaring/use A	3.11
Waste	LFG	landfill - capture and flaring/use A	9.98
Waste	LFG	landfill - capture and flaring/use A	3.33
Waste	LFG	landfill - capture and flaring/use A	10.71

South Africa

Sector	Type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
CCS	CCS industry	capture at ammonia plant	0.27
Domestic	DSM-lighting	Lighting retrofit	1.14
Domestic	DSM-lighting	Energy efficient lighting systems	0.86
Domestic	DSM appliances	VSDs for fans	0.86
Domestic	DSM appliances	Heating, ventilation and air conditioning retrofit	2.23
Domestic	DSM appliances	Efficient new Heating, ventilation and air conditioning systems	2.72
Domestic	DSM other	Efficient use of hot water	1.19
Domestic	DSM-lighting	Energy efficient lighting systems	0.98
Domestic	DSM appliances	Energy efficient lighting systems	0.60
Domestic	DSM appliances	Heat pumps for hot water	1.03
Domestic	DSM appliances	Heat pumps	1.09
Domestic	DSM appliances	Hot plate to gas cooking	0.28
Domestic	FS public	Paraffin to gas cooking	0.11
Domestic	DSM appliances	Efficient wood/coal stove	0.28
Domestic	DSM appliances	Insulation of geysers	1.35
Domestic	DSM appliances	Hybrid solar water heaters	4.77
Domestic	DSM appliances	Elec to gas space heating	1.35
Domestic	DSM appliances	Solar water heaters	0.11
Domestic	DSM appliances	Solar water heating	1.19
Domestic	Biofuel	Jatropha	28.02
Domestic	Transport BRT	Bus rapid transit systems	5.87
Domestic	DSM-lighting		12.85
Electricity	EE energy	Combustion of discard coal	1.26
Electricity	Clean coal	super-critical coal	5.79
Electricity	Clean coal	IGCC power generation	6.97
Electricity	FS power	Fuel to natural gas	0.69
Electricity	Photovoltaics	Solar home system	0.11
Electricity	EE energy	improved mining operations - ashfilling	0.03
Electricity	Biomass power	Biomass power	7.42
Electricity	Agriculture CH4	Biomass power	4.53
Electricity	Biomass power	Biomass power	5.45
Electricity	FS power	New CCGT with refence PCC	7.62
Electricity	nuclear	Nuclear power	104.82
Industry	FS industry	Electricity to natural gas (for heating purposes)	0.30
Industry	EE industry	New building thermal design	1.34
Industry	FS industry	gas-coal substitution for synfuel feed	2.92
Industry	EE industry	Steam efficiency optimisation	11.79

South Korea

Sector	Type	Technology	Scaled abatement potential 2020 ($MtCO_2$-eq/yr)
CCS	CCS industry	capture at ethylene oxide plant	0.26
CCS	CCS industry	capture at hydrogen plant	1.25
Domestic	DSM appliances	Condensing gas boilers, solar hot water systems, insulation standards	9.57
Domestic	DSM appliances	Efficient air conditioners	0.68
Domestic	DSM-lighting	Energy efficient lighting systems	18.69
Domestic	DSM other	Condensing gas boilers	0.03
Domestic	transport efficiency	Lean burn engines, weight reduction, variable transmission, CNG, electric)	4.47
Electricity	Clean coal	New Power Generation Technologies: PFBC, IGCC, and Fuel Cell	3.76
Electricity	FS power	Gas combined	0.00
Electricity	FS power	Power Generation: LNG C/C	5.96
Industry	EE industry	Efficient motors and inverter systems	31.67
Industry	HFC destruction	HFCF-22 production - thermal oxidation	4.38
Industry	SF6 industry	semiconductor manufacturing - various technologies A	0.66
Industry	SF6 industry	semiconductor manufacturing - various technologies A	0.06
Industry	SF6 power network	electric power systems - SP6 recycling & leakage detection and repair	0.82
Industry	SF6 power network	electric power systems - SP6 recycling & leakage detection and repair	0.14
LULUCF	Afforestation/refore-station	improved management, urban forestry, enhanced regeneration	7.88

Appendix D Correction factors for CDM market potential estimate

Here we provide an overview of the correction factors applied to the remaining mitigation potential in the ECN MAC curve, to arrive to an optimistic and pessimistic estimate of CDM market potential after emerging economies domestic mitigation action. The factors presented here were originally developed by Bakker et al. (2007) and are in effect multiplication factors for the abatement potential. The 'high estimate' factors were used for the optimistic scenario and the 'low estimate' factors were used for the pessimistic one.

1.) Eligibility

Several technological options included in countries' mitigation potentials are not eligible under the CDM and are under discussion. Other technologies are only eligible to a certain extent. Table C.1 presents are assumptions on the possible outcomes of the eligibility discussion for some key mitigation options.

Table C.1 Eligibility assumptions for CDM technologies

Technology	Low estimate	High estimate	Explanation
Avoided deforestation	0	1	Under discussion (no official process under the UNFCCC yet)
CCS	0	1	UNFCCC process ongoing
Clean coal technologies	0.15	0.15	Approved baseline methodology (UNFCCC, 2007) determines that registered CDM projects need to be included in the baseline (sunset clause)
HFC-23 destruction from HCFC-22 plants	0.8	1	Low estimate refers to the potential if new plants are not eligible for CERs, which is being discussed within the UNFCCC

Project types not listed in table C.1 are assumed to be 100% eligible.

2.) Additionality

Table C.2 gives our assumptions regarding the stringency of the additionality criteria, where the low estimate show the share of technologies that pass the test in the most stringent case and the high estimate in the least stringent case.

Table C.2 Additionality scenario (correction factors) for selected technologies

Technology	Low estimate	High estimate	Explanation
Avoided deforestation	0	1	See Table AC.1
Renewable electricity	0.5	1	See ECCP (2007)
Cement blending	0	1	Projects are rejected by the CDM EB (CDM EB, 2007b), and additionality tool may be reconsidered
Waste fuel utilisation	0	1	

For all other technologies we have assumed that additionality is less problematic. For energy efficiency technologies - though additionality is debatable for many projects - no difference is made, because the arguments used in the barrier analysis of the additionality test are covered below in other technology barriers.

3.) Social technology adoption rate

The existence of a large no-regret abatement potential (both in Annex I and non-Annex I countries) suggests that there are non-financial barriers that prevent uptake of these technologies. Particularly energy efficiency technologies are faced with these barriers, which include:

- Split incentives (cost incurred by building owner, benefit by tenant).

- Information barriers (unfamiliarity with the option).
- Preferences that cannot be captured in economic cost (comfort rather than cost).
- Turnover of capital (the investment into a more efficient technology is only economical when investment in new equipment or buildings is done).
- More risky technology (less experience with operating a gasification plant compared to conventional coal combustion).
- Capital constraints.
- Higher discount rates.

As mentioned before, it is not possible to adequately capture these barriers in financial terms. Therefore we aim to include these barriers into the abatement potential by incorporating it into the scenarios. For all energy efficiency technologies in the industry, power, transport and buildings sector we apply a factor 0.5 to the technical potential in the low estimate and 1 in the high estimate.

It should be noted that the non-financial barriers are very much related to the additionality criterion. We assume however, that if these projects are able to overcome these barriers, they are also additional; therefore no correction is made for additionality of energy efficiency projects.

For avoided deforestation the maximum realisable potential is assumed to be 25% of the technical potential in the Rainforest Coalition, while the minimum is assumed to be 5% of the technical potential.

4.) CDM policy developments: Programme of Activities

Successful development of programmatic CDM (officially called CDM Programme of Activities, PoA) would increase opportunities for certain technologies to be developed under the CDM. Our assumptions (i.e. correction factors) for the impact on the market potential compared to the technical potential are shown in table C.3. A distinction is made between the industrial energy efficiency projects, biofuel and agricultural methane projects - which are relatively large and are already implemented to some extent under the current CDM - on the one hand, and the smaller and more intricate projects (building energy efficiency and transport) on the other hand. As transaction cost are already considered to be low (less than 1 €/tCO_2-eq) further reduction by PoA is not considered significant and therefore not taken into account.

Table C.3 Assumptions (correction factors) relevant to programmatic CDM technologies

Technology	Low estimate	High estimate
EE buildings	0.2	0.8
EE industry/power	0.5	1
Biofuel consumption	0.5	1
Transportation	0.2	0.8
CH_4 agriculture	0.5	1

Other barriers not taken into account

The barriers listed in the previous sections are considered in the scenario approach (explained below). Factors not taken into account include:

- Use of approved baseline and monitoring methodologies. We assume that approved baseline methodologies (AM) exist with sufficient scope to be applied to the technologies in the MACs. For CCS, biofuels, LULUCF and the entire transport sector no or few AMs exist, however the CDM Executive Board is moving towards more methodologies in these sectors as well. It is therefore very difficult to say to what extent this will continue to be a barrier.
- Performance of technology; although currently registered projects have generated significantly less CERs than projected in the PDDs, we consider this an issue not related to potential of the technologies (project developers have an incentive to be more optimistic about their particular project in order to attract investors). A correction for the striking underperformance of landfill gas projects (performance of ca. 30%) to the abatement potential may be considered.
- Scale of the project: large projects are in general more attractive for project developers, particularly if the upfront investment can be covered by (projected) CER revenues. However, transaction cost for different types of technologies and typical project sizes are already in the ECN MAC curve database.